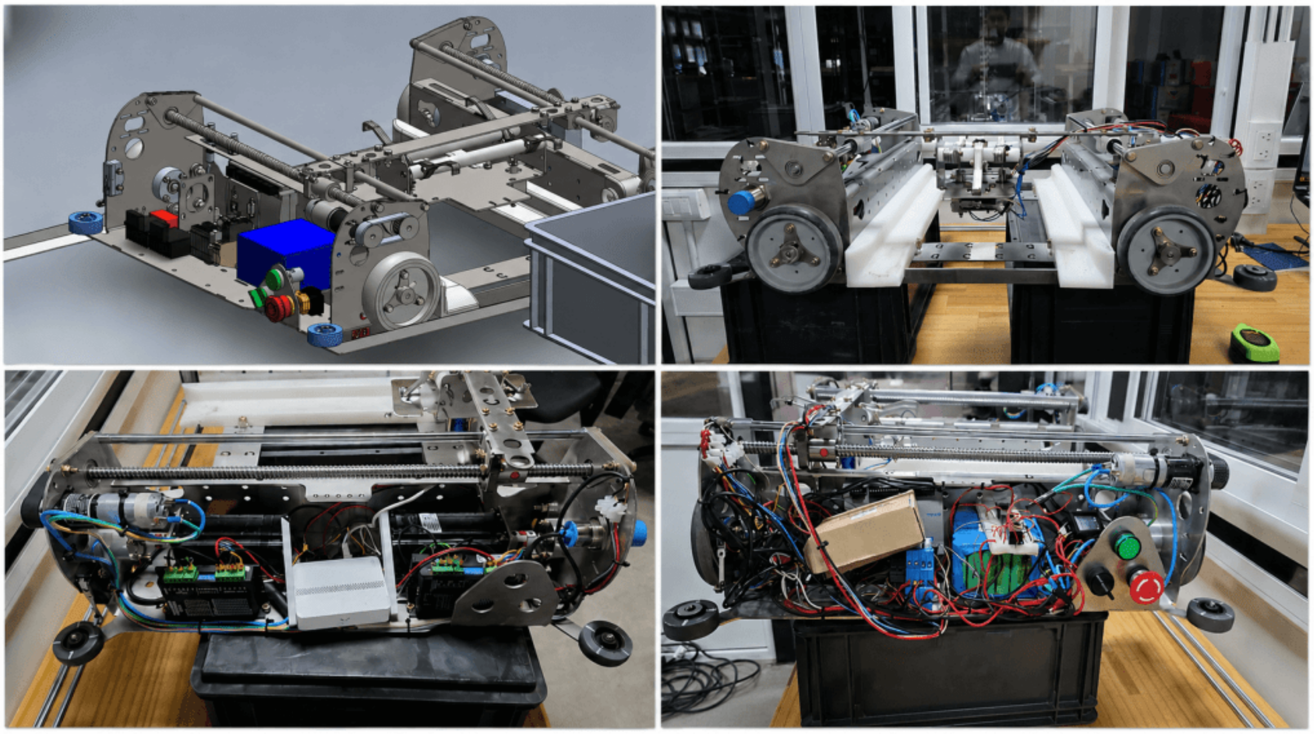
Parametric Adaptive Shell for an Autonomous Stock Handling Robot

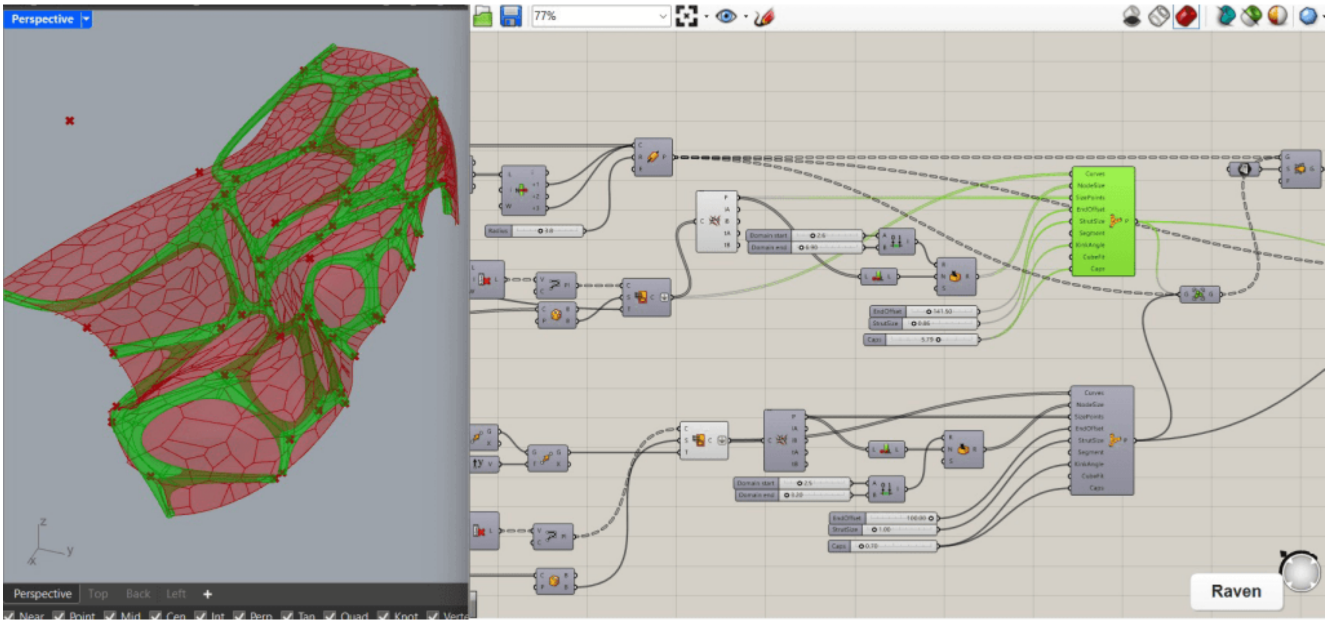
Industrial automation systems often require highly specialized components capable of adapting to constantly evolving mechanical configurations. Designed by [Carla Belatinez]() for AokiOne Robotics, this project focused on the development and fabrication of a custom protective shell for an autonomous stock-handling robot intended for warehouse and industrial distribution environments.



Initial technical references and existing mechanical configurations provided by the client. These materials were used to analyze clearances, electronics placement, and structural constraints before developing the adaptive shell system.

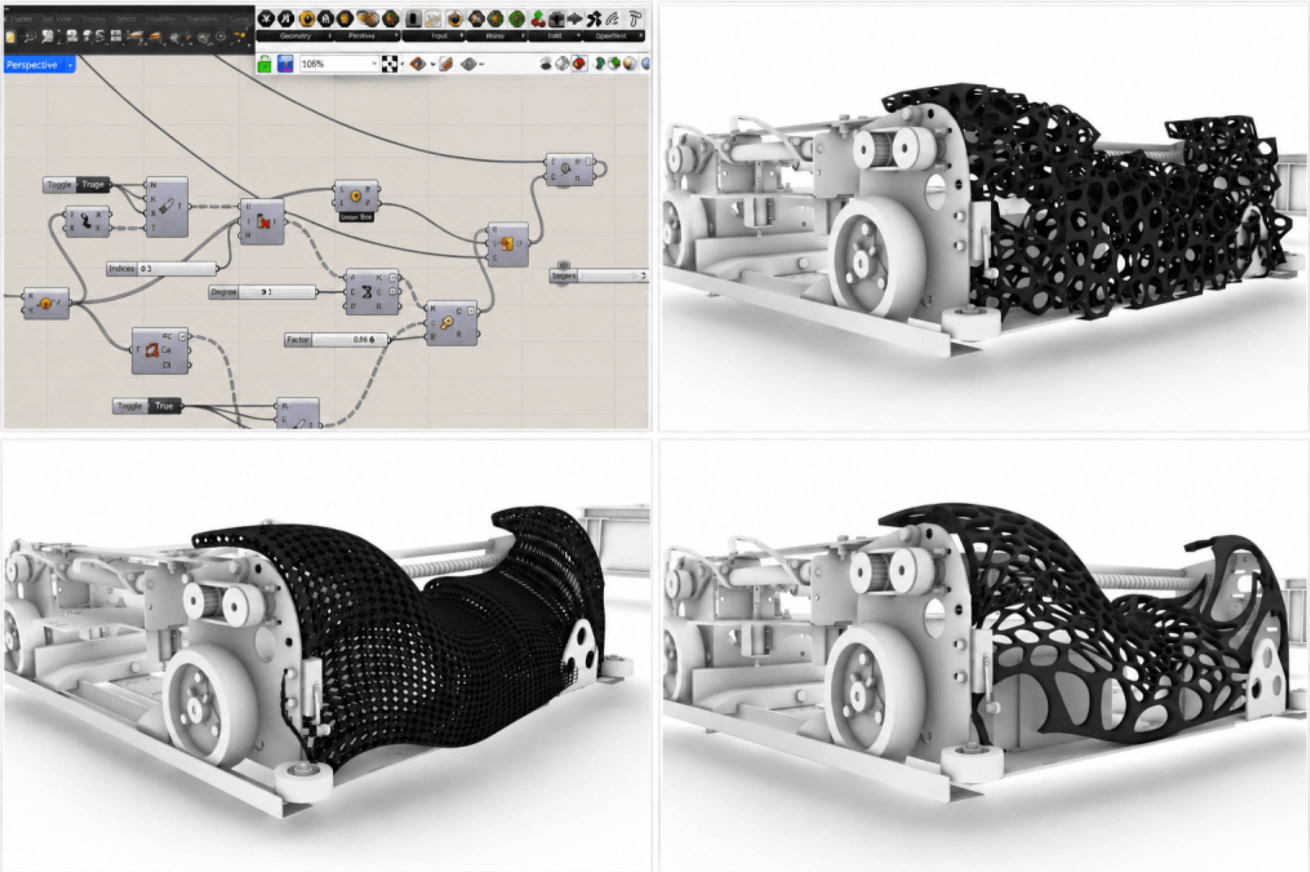
The robot is designed to transport and reposition storage bins within automated logistics systems. Because the platform operates continuously and contains exposed motors, electronics, cables, and moving mechanical assemblies, the shell needed to provide protection without interfering with mobility, maintenance access, or mechanical clearances.

The entire project was developed using [Rhino](#) and [Grasshopper](#) as part of a fully parametric workflow. Rather than modeling a static enclosure, the goal was to create a flexible geometric system that could adapt dynamically to engineering modifications. Internal components such as motors, guides, gripping mechanisms, and wiring layouts could vary between robot configurations, making adaptability a central requirement.



Grasshopper definition used to generate and control the adaptive perforation system and surface behavior. Attractor points and domain manipulation allowed dynamic control over density, rigidity, and airflow zones.

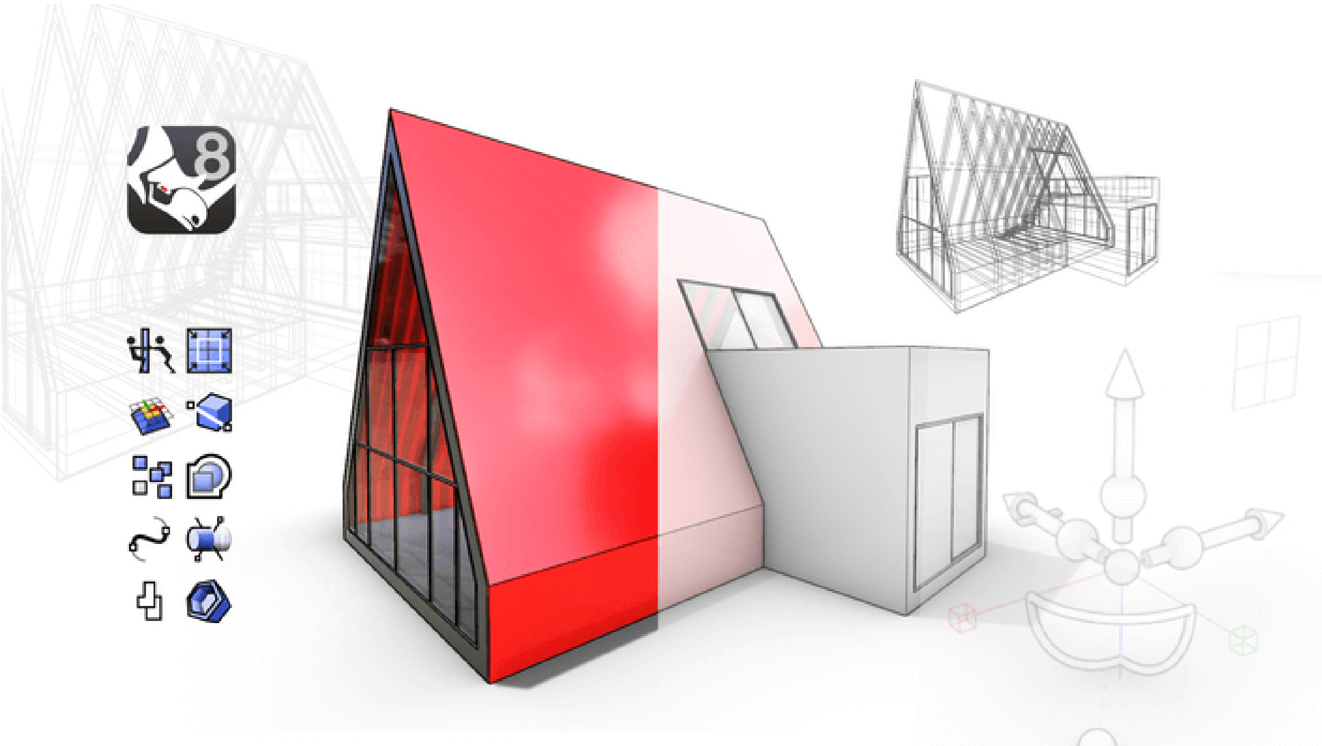
The primary surface was generated parametrically in Grasshopper using base curves modeled in Rhino. This approach allowed the overall shell geometry to remain continuously linked to the internal mechanical layout throughout the design process. Instead of finalizing a fixed outer surface and later applying detailing, both the global form and the structural perforation system evolved simultaneously.



Exploration of alternative shell configurations during the design process. Multiple geometric and structural variations were evaluated parametrically to balance printability, ventilation, and mechanical performance.

One of the key design objectives was to protect the interior electronics while also improving passive ventilation. The shell incorporates an organic perforation system inspired by cellular structures, helping reduce weight and allowing airflow around motors and internal components during prolonged operational cycles.

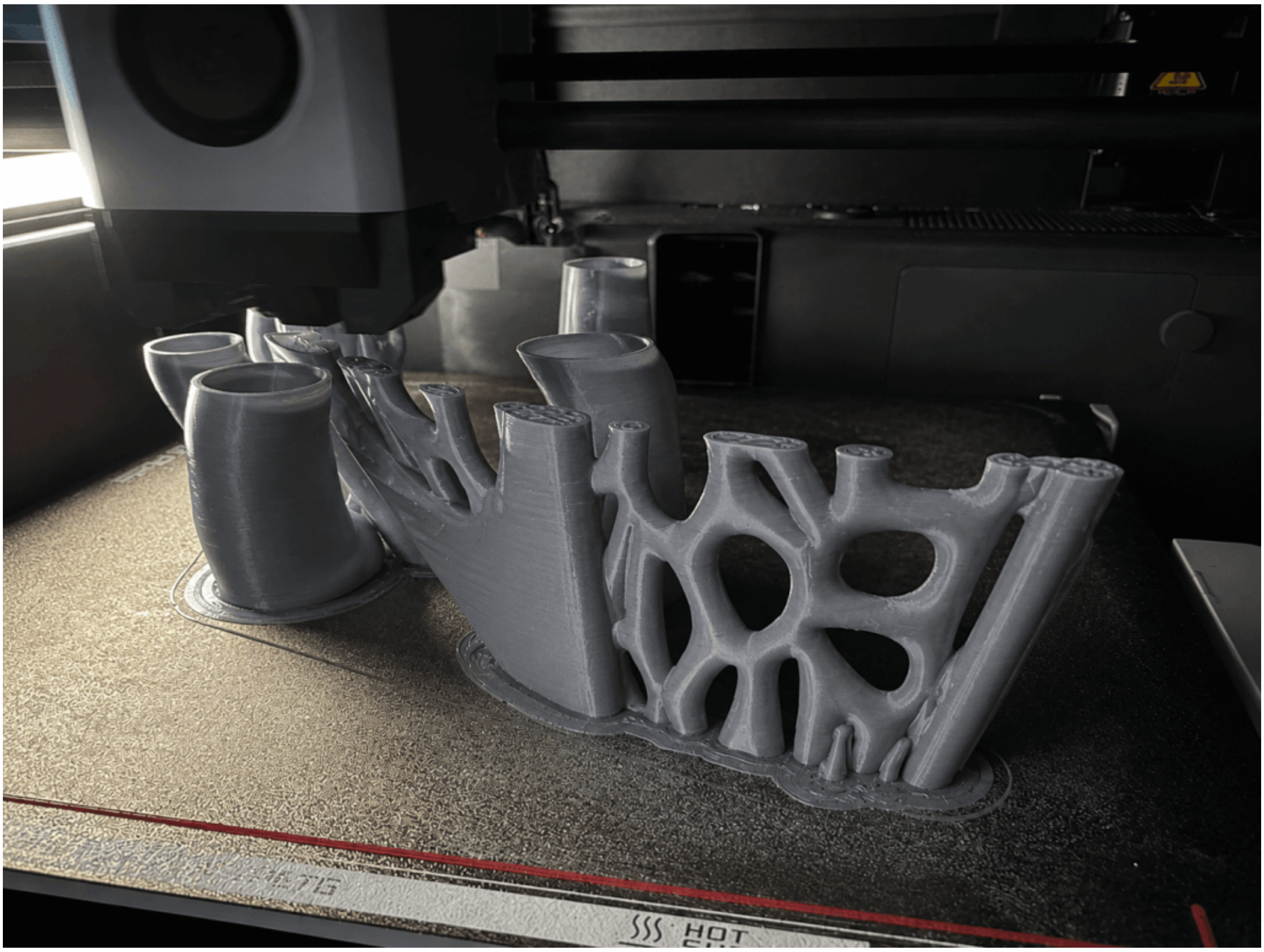
The perforation logic was controlled parametrically through attractor points and domain manipulation within Grasshopper. Mesh density changed dynamically according to proximity conditions: areas closer to attractor points produced tighter and more rigid structures, while regions farther away opened progressively to reduce material usage and improve ventilation. This system allowed for exploration into multiple structural and visual behaviors in real time without manually remodeling the geometry.



See Also

INTRODUCTION TO RHINO 8

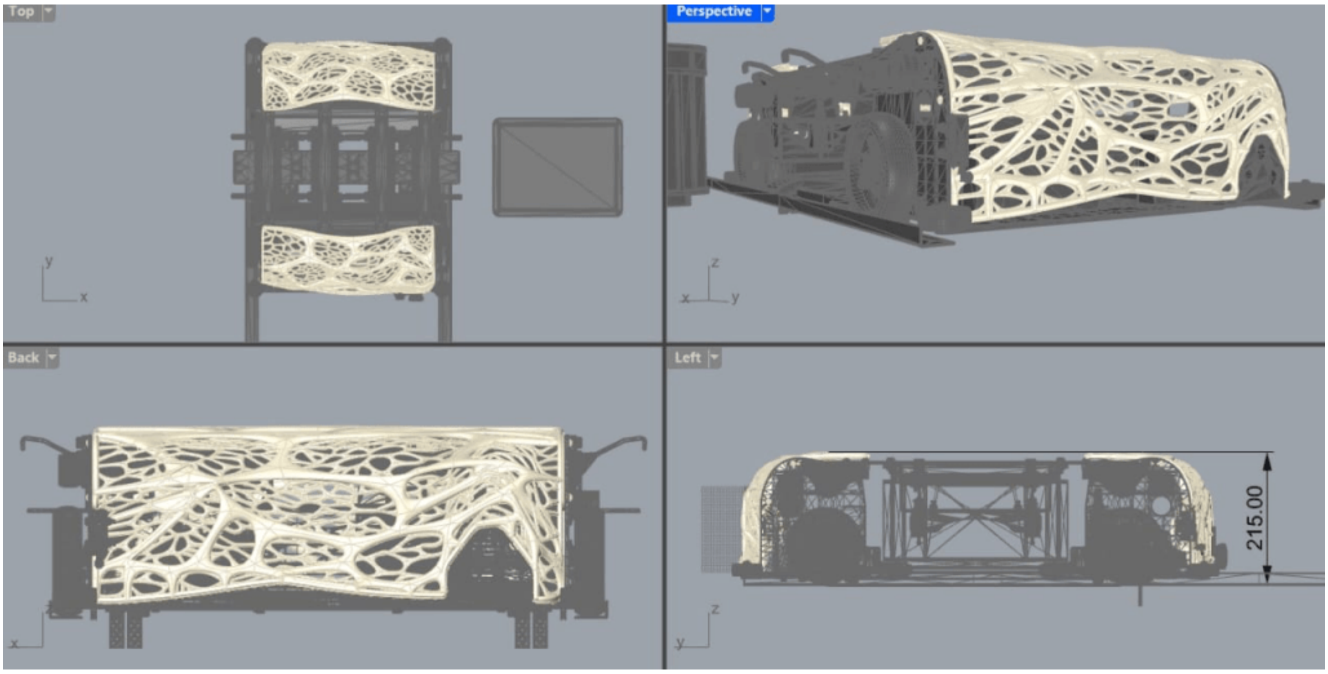
Several complementary plugins were integrated throughout the workflow. Grasshopper handled geometric logic, deformation systems, and parametric controls, while plugins such as Weaverbird, LunchBox, and Kangaroo were used to smooth transitions, manipulate meshes, and study surface behavior. Rhino remained the primary environment for precision modeling, tolerance management, and fabrication preparation.



Large-scale 3D printed prototype used to validate geometry, assembly behavior, and structural continuity before final implementation.

One of the main technical challenges was balancing three competing requirements simultaneously: mechanical clearance, structural rigidity, and printability. An overly open shell could compromise stiffness, while a completely closed surface would increase weight and internal heat accumulation. The final solution involved strategically varying the material distribution across the shell — reinforcing fastening zones and edge conditions while allowing more aggressive openings in central areas.

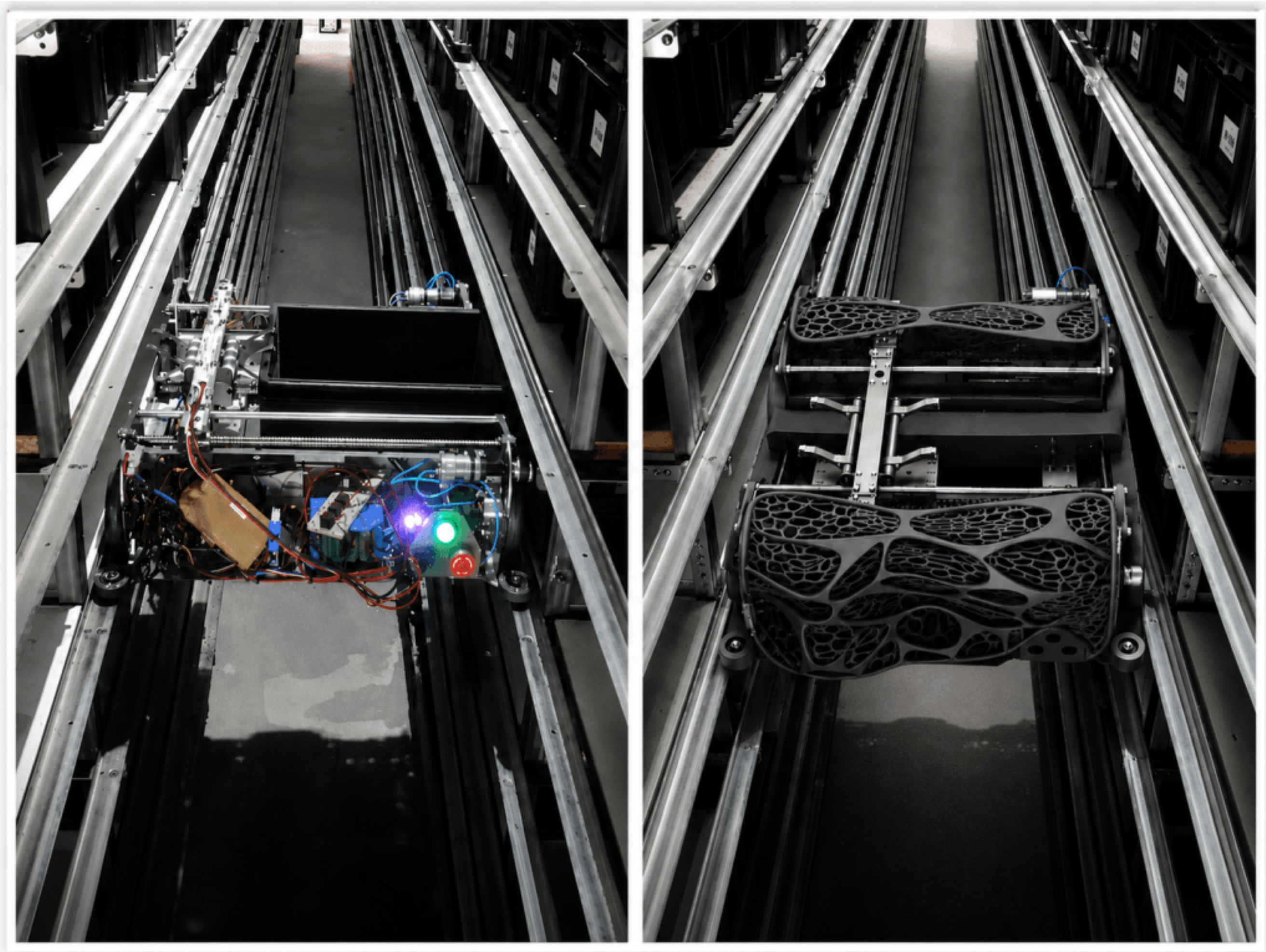
The project was fabricated using 3D printing, enabling rapid prototyping and iterative testing throughout development. Early versions of the shell were produced in three separate sections due to printer size limitations. Once the geometry and assembly logic were validated, the final prototype was manufactured as a single large-format print, improving structural continuity and surface quality.



Rhino visualization showing the shell integrated over the robot chassis while maintaining mechanical clearances and access to critical moving components.

The shell also integrates a custom snap-fit mounting system. Small flexible protrusions were incorporated into the geometry, allowing the enclosure to flex slightly during installation and automatically lock into place once mounted onto the metal chassis. This reduced the need for additional fastening hardware while simplifying assembly and maintenance operations.

Because the robot platform itself may evolve in response to operational requirements, the enclosure was conceived as a customizable system rather than a single fixed product. The parametric workflow made it possible to rapidly generate new variations adapted to future configurations without restarting the design process from scratch.



Comparison between the uncovered robot platform and the final integrated enclosure during operational testing within the automated storage system.

Developed for AokiOne Robotics in Mar del Plata, Argentina, the project forms part of a larger automation platform intended for industrial distributors and logistics environments. The system is currently moving into real implementation stages, with an initial production target of 100 robots and their corresponding adaptive shells.

The project demonstrates how computational design workflows can bridge industrial engineering, fabrication, and product design through adaptable systems that respond simultaneously to performance, manufacturing, and aesthetic requirements.

CREDITS

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Company: AokiOne Robotics