Whitepaper

Envalior
Imagine the Future

MATERIAL SOLUTIONS FOR COST EFFICIENT ROBOTICS

Advancing robotics starts with smarter materials.

Robots are ready for the real world. With AI capabilities advancing and actuator architectures stabilizing, demand is accelerating across industries. Yet, while software scales at near-zero marginal cost, hardware does not. Actuator gearboxes remain a stubborn constraint.

Every robotic arm depends on high-torque, low-backlash gearboxes for precise, repeatable motion—often over 30 actuators per humanoid unit. These gearboxes add significant cost, weight, energy use, and design complexity.

Traditionally made from machined metal, classical gearboxes are proven performers, yet they are heavy, expensive, and difficult to produce at volume. Limitations of metal gearboxes ripple across platform design, impacting everything from thermal management to battery size.

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To shift robotics from small–batch innovation to true mass deployment, the actuation concept itself must be reimagined. This transformation is only possible when paired with a material rethink — moving from traditional metals to advanced plastics to enable entirely new design possibilities that balance performance with scalable production. This is where collaboration becomes critical. By bringing together material expertise, design innovation, and manufacturing know–how, new concepts can move from theory to reality.

The collaboration between SENTImotion, Frencken Group, and Envalior has produced a new gearbox design with a revolutionary toothing geometry that delivers the required torque and durability in a lighter, more scalable form. The new design combines perfectly with the performance of Stanyl®, a high–performance polyamide that is able to replace metal while maintaining the precision robotics demands. It allows for injection molding, supports rapid iteration, and opens the door to meaningful cost and weight reduction while improving recyclability and lowering environmental impact.

As robotics moves from prototype to production, materials will define what scales – and what stalls.

WHY METALS CAN'T *TAKE ROBOTICS FURTHER*

In robotics, actuation is where ambition meets friction – both literally and financially.

Every movement a robot makes relies on a coordinated system of motors, gearboxes and controllers. The more capable the robot, the more actuators required. There can be 30 or more gearboxes per platform. These components drive much of the platform's mechanical cost – and their collective weight impacts everything from motor sizing to battery runtime.

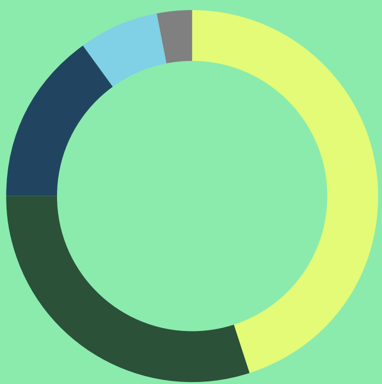
Metal gearboxes are widely used because they deliver the torque and control required for advanced robotics. But they also introduce constraints that don't translate efficiently to higher volumes. Machining is time–consuming and very costly. The parts themselves are heavy, as lightweighting would require additional machining.

These aren't edge cases – they are recurring blockers to volume production – and they directly affect how quickly and affordably robotic platforms can reach the market.

Many developers are targeting a humanoid platform with a price point below $10,000 – a threshold widely seen as key to unlocking mainstream adoption. Hitting that mark demands a step change in how actuation systems are built and sourced.

Engineering teams have long explored polymer–based alternatives, yet conventional designs converted to plastics have failed to meet the torque, stiffness and durability requirements needed for demanding robotic motion. To move robotics from small–batch innovation to mass deployment, the core actuation architecture needs a material rethink – one that doesn't ask developers to trade performance for production.

Figure 1
Approximate bill of materials cost breakdown for a humanoid robot



Component Category	Est. Share of Cost	Components
Actuators (Motors + Gearboxes)	~ 45–50%	Dozens of high–torque precision components
Sensors & Electronics	~ 30%	Cameras, controllers, AI compute, encoders
Structure & Mechanics	~ 15%	Frame, housings, bearings, cooling
Battery & Power	~ 5–10%	Cells, BMS, power distribution
Outer Shell & Other	< 5%	Exterior panels, cosmetic parts

STANYL® AND THE *REINVENTION OF THE ROBOTIC GEARBOX*

To bring down the cost and weight of actuators without compromising torque or control, something more than a design tweak was needed. It required a new approach — not just to geometry, but also to materials.

Our collaboration resulted in a high–performance plastic gearbox engineered specifically for robotics and capable of drop–in replacement within existing actuator architectures.

At the core of this design is the combination of Stanyl®, selected for its exceptional mechanical and thermal behavior, and a custom tooth geometry with tribology–optimized lubrication to deliver a rare combination of precision, durability, and torque density — at dramatically lower weight and cost.

In testing, the 10cm gearbox demonstrated output torque up to 120Nm within a 0.6kg envelope — a power–to–weight ratio that outperforms many metal alternatives. Injection molding enables tighter tolerances, faster production, and reduced part complexity. The result is a design that achieves 50% less weight and up to 50% lower cost than traditional metal systems.

Just as critical, the gearbox maintains a form factor compatible with standard architectures, making it a viable upgrade path without requiring system redesign. When you're under pressure to get to market, that compatibility matters. This is a validated leap forward — and a clear signal that gearboxes built with Stanyl® are ready for commercial–scale robotics.

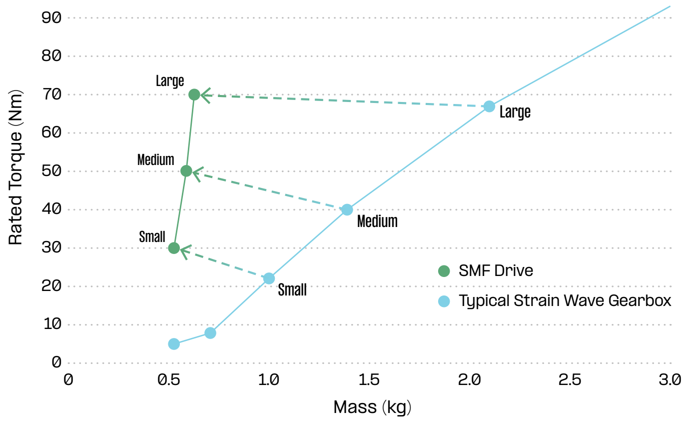
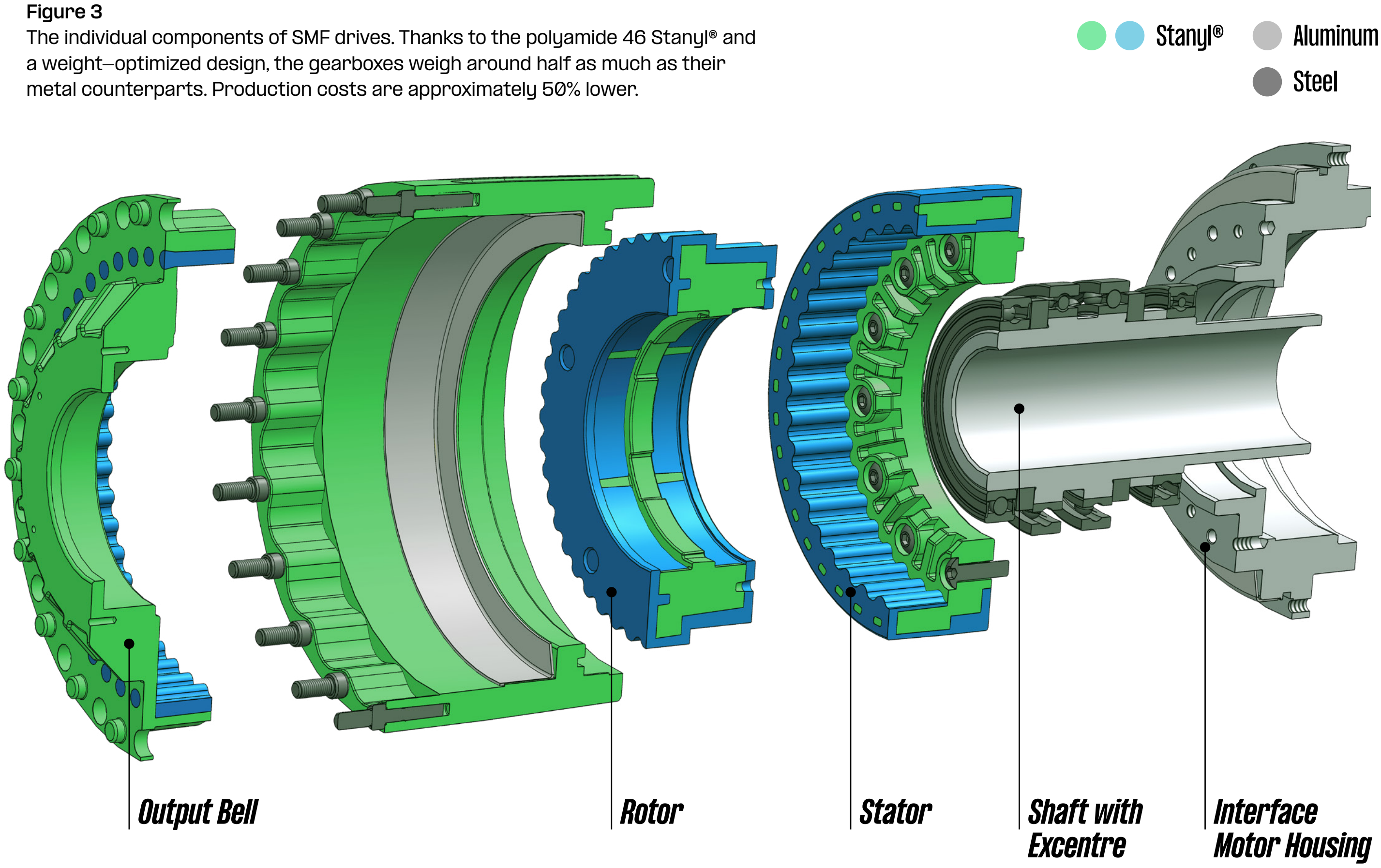


Figure 2
The average robotic arm contains 2 small, 2 medium, and 2 large drives. Stanyl® gears reduce weight by an average of 5.5kg per robotic arm with even higher torque than metal drives.

Figure 3
The individual components of SMF drives. Thanks to the polyamide 46 Stanyl® and a weight–optimized design, the gearboxes weigh around half as much as their metal counterparts. Production costs are approximately 50% lower.



BEYOND THE GEARBOX: *STANYL® IN ROBOTICS*

The gearbox may be the most visible breakthrough, however, it's only one example of how Stanyl® enables next–generation robotics.

The same material properties that make Stanyl® ideal for high–load, high–precision gear systems apply to a wide range of components under stress.

Stanyl®'s high stiffness and fatigue resistance make it well–suited for parts subjected to continuous motion and cyclic loads – the exact environments found in articulated robotic arms and mobile platforms. Its thermal stability and dimensional accuracy under heat and load allow for tight tolerances, even in compact, enclosed systems with minimal airflow.

In dry and lubricated conditions, Stanyl® exhibits proven tribological performance – delivering low wear rates, stable friction coefficients, and reduced maintenance demands. And with excellent flow characteristics, it supports complex geometries, thin–wall sections, and tight–fitting interfaces –giving designers greater freedom to optimize for weight, strength and integration.

Typical applications include:

- Gearbox housings and gear teeth
- Structural actuator components
- Sensor and electronics brackets
- Snap–fit covers and lightweight shielding elements

Each application benefits from the same foundation: a material that performs under pressure, enables efficient molding, and integrates cleanly with electronics and mechanical systems. Combined with Envalior's advanced CAE tools and design support, Stanyl® becomes part of a development ecosystem built for speed, precision and volume production.

THE PRODUCTION ADVANTAGE OF POLYMER DESIGN

Material selection is no longer just a mechanical decision – it's a business one. The choice of polymer affects more than just part performance. It shapes the bill of materials, the manufacturing model and the speed at which a platform can reach the market.

By replacing machining with scalable molding, Stanyl® enables faster iteration cycles, tighter process control, and a more efficient path from prototype to production – along with support for localized manufacturing, reduced part variability and simplified logistics.

The value extends beyond the material itself. Early engagement with Envalior connects development teams to deep expertise in CAE, tribology, fatigue and process simulation. That insight helps reduce overengineering, prevent failure modes and fine–tune parts for function, manufacturability and moldability – before tooling is even cut.

As robotic platforms move toward mass deployment, materials that support large–scale manufacturing and partners that can grow with you are what separate concepts from commercial systems.

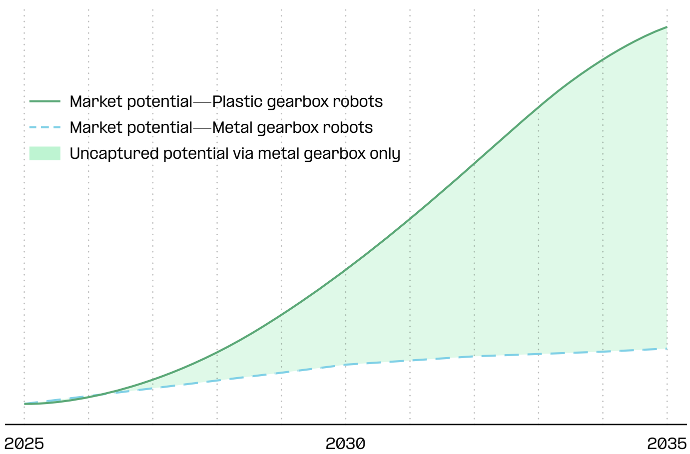


Figure 3
Unlocking the mass production potential of robotic platforms with Stanyl® gears.

READY TO BUILD *WHAT'S NEXT?*

Stanyl® helps robotics developers cut weight, reduce cost and accelerate production timelines — without compromising performance. If you're rethinking your actuator architecture or planning for volume, let's talk. Gearboxes are just the beginning.

To learn more about our materials for robotics, contact us via Envalior.com.