RoLL Robotics Living Lab

Project Report:
Cobot end effector cutting tool

This project is a collaborative effort between POMO Robotics, a Glasgow-based robotics integrator, and the Robotics Living Lab at Manchester Fashion Institute. Funded by the Cotton Textiles Research Trust, the primary objective was to co-design and develop a rotary cutting tool for collaborative robots (cobots) over an 18-month period. The project aimed to facilitate small-batch, high-value garment manufacturing by integrating advanced robotic automation while preserving human creative expertise.

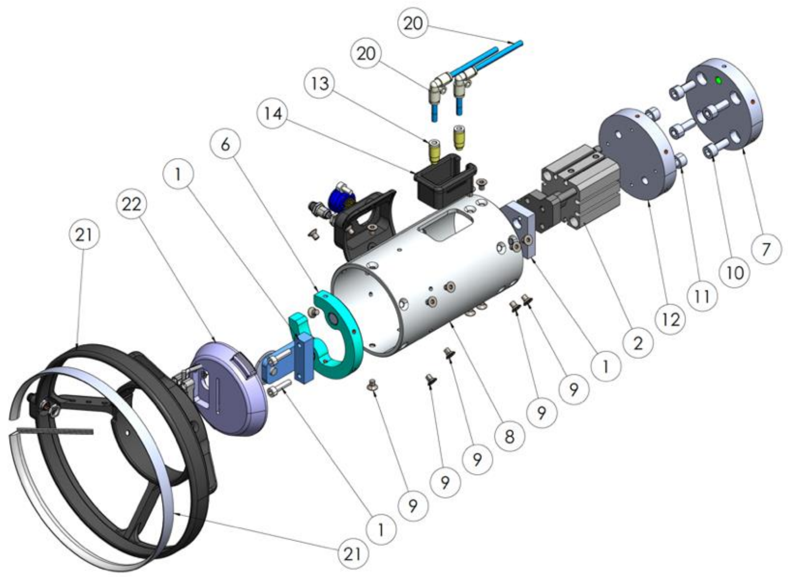
The cutting tool end effector underwent three iterative design stages, prioritising accuracy and repeatability, ease of use and health and safety. Currently assessed at Technology Readiness Level (TRL) 6-7, the tool is optimised for safe, single ply cutting, ideal for prototyping and testing in small-scale manufacturing environments.

	Stage 1	Stage 2	Stage 3
			
			
Key mechanical features	Unactuated rotary blade (45mm)	Pneumatically actuated rotary blade (45mm)	Pneumatically actuated rotary blade (28mm), improved blade bearing*
Blade cover/lid	No cover	Blade cover secured with 8x bolts > impairing access for blade changes	Blade cover, easily removable by magnets

Sensor	No sensor	Proximity sensor flush with blade cover to detect fabric at close range	Proximity sensor placement optimised, compromising clearance
Health and safety	No finger guard, exposed blade > high risk of injury, risk of blade shattering	Blade cover/lid provides stability for blade. Addition of finger guard/ring barrier equipped with status LEDs for visual inspection during operation	Physical ring barrier, with status LEDs, improved cable management
	No sensor	LEDs white: when blade is actuated, signalling cutting activity and providing light for visual inspection	LEDs white: when blade is actuated, signalling cutting activity and providing light for visual inspection
	No sensor	LEDs Red: standby mode where the blade is fully retracted, signalling readiness/tool is live	LEDs Red: standby mode where the blade is fully retracted, signalling readiness/tool is live
Blade	45mm Steel blade, bends on contact with table, force too high	Improved stability of 45mm steel blade on blade mount	Improved stability of 28mm steel blade through 3d printed blade bearings*
Compliance	No compliance	No compliance	Compliance adapter added*, improved pressure control and better cut results across larger perimeter
Electrical features	Control box connects to robot, all actions controlled by individual diodes via software input	Control box connects to robot, all actions controlled by individual diodes via software input	Simplification of the control box, tool controlled via sensor input separately from robot actions
CAD workflow	**CAD** > DXF, **Rhino3D**: DXF vector > solid object > .step, **RoboDK** load .step and trace path. CON: No scaling, no nesting of more than one geometry, very time consuming and error prone	**CAD** > DXF, **Rhino3D**: DXF vector > solid object > .step, **RoboDK** load .step and trace path. PRO: Scaling now possible, copy paste possible CON: no nesting of more than one geometry, very time consuming and error prone	**CAD** > DXF, **Rhino3D**: DXF vector loads in HAL grasshopper extension*> loads nested file PRO: File loads true to scale, easy automatic path selection, quick set up, no multi step file conversion, manual nesting possible

*Additions made at RoLL, out of scope of the CTRT funding

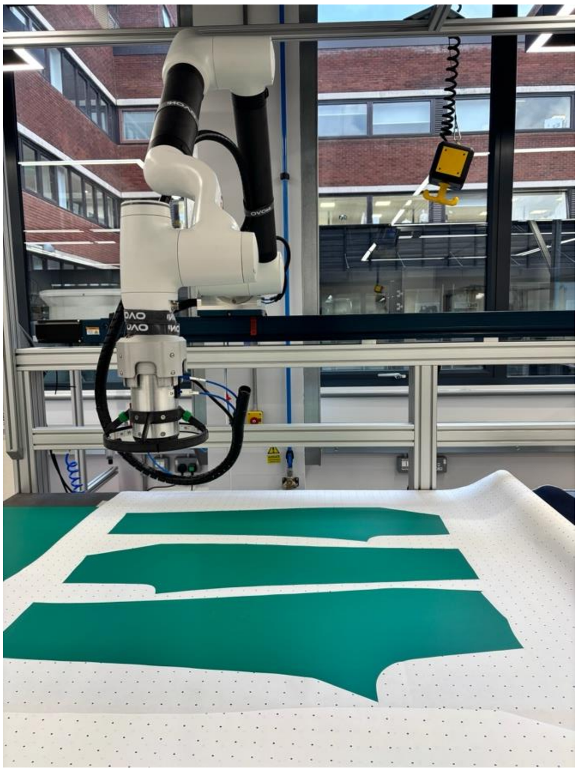
Initially, Stage 1 featured an unactuated 45mm steel blade with no safety mechanisms, requiring high cutting force and offering limited CAD workflow capabilities. While the cuts were promising, the blade was fully exposed and needed protection to be safe to operate. In Stage 2, a pneumatically actuated 45mm blade was introduced, along with a bolted cover and a proximity sensor for fabric detection. Safety improved with a finger guard and status LEDs indicating cutting activity or standby mode. However, the CAD workflow remained inefficient in RoboDK, though scaling became possible and simple fashion patterns were tested and cut successfully. Stage 3 further optimised the tool with a smaller, 28mm blade allowing more intricate and complex shapes to be cut, a magnetically removable blade cover for easy access to the blade, and enhanced proximity sensor placement. Compliance was added via an adapter tool separately developed by Inovo Robotics which significantly improved force control and cutting performance overall. Crucially, the control system was simplified, allowing independent tool operation, while the CAD workflow was significantly streamlined by shifting robot path control to the HAL plugin in Rhino3D. This allowed loading nested files directly, leading to a significant reduction in setup complexity. These advancements transformed the tool into a safer, more adaptable solution, supporting precision cutting in small-scale garment production.



ITEM NO.	PART NUMBER	QTY.
1	BLADE ASSEMBLY - 3	1
2	CDQMB25-10	1
22	END CAP ASSEMBLY	1
4	M8x1_female_panel_mount_1	1
21	Guard-GA-1	1
6	Magnetic band inner	1
7	MOUNT-2	1
8	BODY-76-3	1
9	M4x6-CSK_1	22
10	M6x14-CAP_1	4
11	M6x20-CAP_1	2
12	CYL MOUNT-2	1
13	KQ2S04-M5A_1	2
14	AIR-SHROUD-1	1
15	Spacer HPS-6-3.2-5-N_1	1
16	M3x10-CAP_1	1
17	CONNECTOR MOUNT-2	1
18	M4x8-CAP_1	2
19	KFV_120_1	1
20	KQ2L04-00A_1	2
21	LED LIGHT STRIP	1
22	BALLUFF SENSOR	1

Cobot cutting tool components exploded view

The tool is designed to be agnostic and compatible with most cobot models, ensuring seamless integration within diverse production setups. The tool adapts to varying specifications (e.g. material and geometry complexity), ensuring reproducibility, accuracy and precision. Cutting is considered one of the biggest bottlenecks in fashion manufacturing due to its labour-intensive process as most cutting especially in smaller businesses is still done by hand, often in singly ply lays. Cutting requires precise material handling as well as high levels of accuracy and nesting skills to ensure efficient use of material. The cobot cutting tool is designed to reduce the physical strain on designers and manufacturers by handling repetitive and labour-intensive tasks for them. Integrated protection mechanisms such as proximity sensors and the physical ring barrier ensure that human operators can work alongside cobots without compromising safety.

Examples of different pattern nesting in paper and calico.

Cobotics enhance creative potential by enabling designers to execute complex patterns, intricate cut sequences, and experimental garment forms that were previously difficult to cut by hand or small handheld cutters. This interplay encourages creative risk-taking, as designers can rely on robotic precision to bring unconventional ideas to life.

The funding supported significant steps towards demonstrating how collaborative automation can enhance human creativity while increasing efficiency and precision in garment manufacturing. By emphasising collaboration over replacement of human skills, collaborative automation necessitates an engagement with new technical capabilities, presenting an opportunity for upskilling the workforce and developing a positive new narrative around modern manufacturing practices.

The development of the cutting tool directly supports a reshoring agenda. Using cobots in manufacturing settings and maximising the equipment utility by quickly swapping end-effectors designed for different tasks presents a clear advantage for cobots over costly mono solution machinery. The ability to efficiently process varied tasks without extensive reconfiguration makes local manufacturing not only viable but also competitive. Small manufacturing units could transition to localised production by producing closer to the point of sale which can significantly reduce dependency on offshore labour while maintaining or even improving quality and consistency. This reduces lead times and transportation costs associated with offshore production, further strengthening the economic case for reshoring.

The cutting tool has garnered interest from Fashion and Textiles Industry professionals, with over 30 businesses representatives engaging with it during a workshop/ demonstration at the Manufacturing Technology Centre (MTC) in May 2024. This showcase of the cutting tool allowed designer/manufacturers to explore its potential for using cobotic solutions in garment production. Several participants had specific hardware questions about the cutting tool. They imagined implementation in various use cases and suggested mechanical adjustments and system extensions to enable pattern recognition and material quality checks through vision systems. A direct result of the workshops at the Manufacturing Technology Centre, RoLL, together with UKFT and the MTC launched a new report in January 2025, outlining strategic pathways for the integration of automation and robotics in UK Fashion and Textile manufacturing.

Additionally, the tool was presented at the Future Fabrics Expo in London in 2024 to over 2000 attendees, and at Innovation Showcase during the Institute of Positive Fashion Forum (London, March 2025), where it was highlighted as a key innovation supporting sustainable and localised manufacturing. These engagements have demonstrated growing industry interest in adaptable, automation-driven solutions. The positive response suggests potential for adoption among independent designers, small-to-medium enterprises, and established brands seeking to transition towards more flexible and sustainable manufacturing models. Moving forward, further research and development will focus on optimising the tool for broader adoption.