

Tendon-driven robot hand: executive summary

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Disclosure. The author runs Schicht-Werk, a commercial additive manufacturing business, and has an economic interest in the parts and services described. No part has been printed or tested. **Not a medical device:** the subject is a robot end effector for teaching, experiments and research.

Occasion

On 16 July 2026, Zurich-based mimic robotics presented the mimic hand M1: a tendon-driven industrial hand with 15 actuated joints, motors in the forearm and a payload above 25 kg (manufacturer figure). It comes with an exoskeleton that lets people demonstrate tasks and so supply training data for robot AI.

Findings

1. **Do not copy it.** The M1 relies on pulley-guided tendons, joint encoders and a metal structure. Printed parts cannot match that.
2. **The surrounding field is the market.** Robotics teams change their hands constantly and need printed prototypes, fingertips, mounts and wear parts. The installed base is growing and prices are falling: in 2026, hands with 20 to 22 degrees of freedom start at USD 6,500.
3. **An own hand is feasible as a teaching and maker product.** Level A with five actuators costs roughly EUR 70 to 125 in material, level B with ten bus servos roughly EUR 330 to 650. Level B reaches a calculated 4.4 N continuous fingertip force, about 18 % of the M1 manufacturer figure.
4. **Starting without electronics is legally the simplest route.** A mechanical kit falls under the General Product Safety Regulation and needs no CE marking.
5. **The hand is run as a kit of modules.** Fifteen modules connect through thirteen named interfaces. Each module can be sold, replaced and tested on its own; other projects link in through the module pass (FP04).
6. **The basic building block is the link chain.** The same chain yields a hand, a gripper, an excavator arm and further machines. A shared description and a motion test bench show the motion before any part is printed; the test bench does not calculate forces (FP06, German). The hand remains the first goal.
7. **The first hand has six actuators.** Palm and thumb exist as a draft design and have been checked numerically for interference (FP07, German). One tendon per finger flexes all three joints; the ten-actuator arrangement needs a solution for the coupling at the base joint. Nothing is printed.

8. **The chain down to the servo exists as a draft.** Fingertips, a flange adapter, a remote drive unit for six bus servos and a controller that turns the actuator table of the motion test bench into commands (FP08, German). The tendons run to the drive unit in tubes; this solves the routing at the thumb and costs force that still has to be measured. The controller has been checked in a dry run and has not been tried on any device.
9. **A teaching pack with five units is available.** It works with the calculator and the motion test bench and needs no printed model. It has not been tried in class.
10. **The same description now feeds simulation and operations as well.** Every machine is available as a URDF file for rigid-body simulation; the tendons are tensioned through the controller; internal documents cover production, inspection, maintenance and staff training (FP09, German). None of this has been tried in practice.
11. **The tubes cost less force than feared.** In one fully calculated set-up, 81 to 88 per cent of the tendon force arrives; the fingers reach a calculated 3.9 to 4.1 N at the tip instead of the 4.4 N of stage B, and about 3.5 to 3.7 N after deducting the return force (FP10, German). The friction value behind this is unverified; a measurement series on the test finger with a tube will settle it.
12. **The finger has become an open construction kit.** A standard line provides the links in any length from 24 to 120 mm. In a workshop in the browser, users assemble their own machines, move and program them and pass them on as a file; the printed parts are generated from that file (FP11, German). Ten example machines can be made entirely from the standard line; for flat arrangements the carrier plate is generated as well, and the workshop reports when links come too close to each other. A trial with four user groups is prepared and has not started; nothing is printed.
13. **The print files exist without OpenSCAD ever having run.** A mesh kernel of its own derives a closed mesh in print orientation from every solid and checks the written file against the solid and against the design file; 44 meshes, no findings. A prototype plan leads in eleven stages from four gauges via the hand to end pieces, carrier head and swivel base, with a print list and inspection sheets per stage; what the gauges show goes into the data as a printer allowance. For upright arrangements a carrier base is generated, so all example machines can be printed completely. A rough strength estimate at stall torque shows two places below the target: the bearing of the joint screw in the tongue (safety factor 1.7) and the carrier plate when held at a single hole (1.1 to 1.4). Both rest on assumed strength (FP12). Nothing has been opened in a slicer, printed or measured.
14. **Chains no longer end only in a tip, and no longer sit only on the body.** Gripper jaw, bucket and foot sit on the tip mount and grip the back of the end link with a saddle. A carrier head lets one chain carry further chains, for example an arm carrying two fingers; workshop and build chain decide by the same rule when it is generated (FP13). In the rough estimate the web of the carrier head has a safety factor of 1.5, also below the target. For sensing there is a concept in four stages, with component values from datasheets: a travel sensor at the finger does not resolve more finely than the actuator feedback, but it reveals stretch and slack of the tendon. Instead of a glove, a lead hand made from the same building blocks is foreseen, because this strand offers nothing that is worn on the body. None of this has been bought, printed or measured.
15. **The joint about the vertical axis is now a building block too, and the hand revealed an error in the process.** The thumb base of the hand serves as the swivel base of the standard line; the carrier plate gets a lug, a tendon block and an anchor for it (FP14). Since

then the hand with six drives runs through part generation as a trial, like a kit example. This showed that in the program "Fist" the thumb grazed the index finger on its way to the end position; the order of the thumb movements has been corrected. The controller logs actual position and load of the drives per event, checked without a device. None of this has been printed, connected or measured.

Recommended order

Step	Content	Prerequisite
1	Offer contract manufacturing and accessories; flyer and calculator as door openers	Release of the flyer
2	Design, print and measure finger, guide insert and test stand; this fixes finger base, guide insert and tendon passage	Decision on template
3	Fingertip, palm and thumb; mechanical kit as a module set, pilot series with a school or university	Measurements, risk analysis, patent clearance
4	Try drive unit and controller on a device; sensing and data glove	one servo to take dimensions from, EMC assessment, possibly a funded project

Limits

- No offer as a body replacement, for treatment or to be worn on the body.
- No work for defence, military or weapons.
- Designed as a teaching and maker product for ages 14 and up, not as a toy.
- Templates that exclude commercial use are ruled out.

Open

Price and delivery status of the M1, the patent situation, the licence of some open templates, the machine hourly rate for costing, the interface dimensions and the brand name. The full list is in `04_META/offene-punkte.md`.

Sources

See FP01, FP02, FP04 to FP12 and `literatur.md` (German).