DRIVEN

by maxon

The inspector

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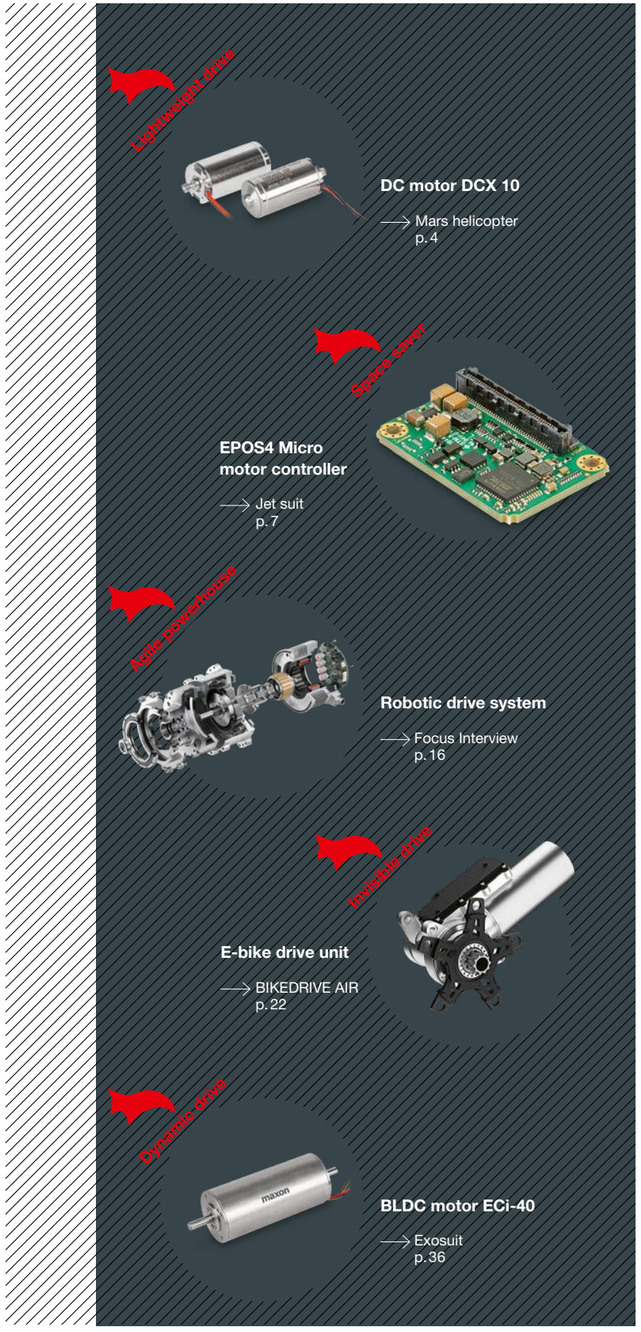
The heroes of this issue



Eugen Elmiger,
CEO maxon Group

Walking robots and invisible drives

Climbing, crawling, walking, or flying: Inspection robots can be found everywhere, and their numbers are expected to increase greatly in coming years. The red walking robot named ANYmal is an example of one designed to work in places that are dangerous for humans. Come with us to Zurich for a behind-the-scenes look at Swiss startup ANYbotics, and learn how they taught their robot to walk.

Those who prefer machines on wheels should read the report on the new, invisible BIKEDRIVE AIR e-bike system. It enables the production of lightweight electric sports bikes – for the mountain or the road. Plus, this issue of *driven* gives engineers an excellent overview of the various brushless DC motors made by maxon.

We also cross to Great Britain for a look at motor specialist Parvalux, which has been part of the maxon Group since 2018. Here, robustness and reliability are the key requirements.

I hope you all enjoy reading this issue of our magazine.

“Ingenuity”: putting expectations in the shade

It may have been only a short flight, but it was a giant success for uncrewed spaceflight: On April 19, 2021, NASA’s Mars helicopter “Ingenuity” hovered over the surface of the Red Planet for about 40 seconds before landing safely back on its four legs. This was the first controlled flight of a device on another planet – with the help of six DC motors from maxon. The DCX drives with a diameter of 10 millimeters controlled the tilt of the rotor blades and thus the direction of flight of the helicopter. Yet this was just the beginning of its story. Four more flights followed – each one a little higher and longer. Because this worked so well, it was decided to extend and expand Ingenuity’s mission. From then on, the helicopter no longer returned to its launch site, but flew to new locations each time, as the ground staff tested the technical limits of the components and software. Ingenuity’s ninth flight, for example, lasted almost three minutes, with the helicopter traveling 625 meters. Its camera is pointed downward, which is why the helicopter’s shadow can be seen. In this second phase, the helicopter acted as a reconnaissance aircraft to find the best routes for the Perseverance rover. The rover, in turn, is looking for interesting soil samples to be brought back to Earth.

Lightweight drive

DCX 10
The DC motors modified for this mission are not only reliable and energy efficient, but also specially designed to be light. We had to take off every tenth of a gram we could, so that the helicopter could fly in the thin atmosphere on Mars.

Photos: NASA/JPL-Caltech

Financials

Stable result for maxon

The maxon Group succeeded in largely keeping its revenue stable in the demanding year of 2020, in spite of the difficult market conditions caused by the COVID-19 situation. The revenue amounted to CHF 553.5 million, compared to CHF 567.8 million in the previous year. There were some revenue losses in the automotive and aviation sectors, however, the huge demand for drives for laboratory automation and ventilators in the fight against the coronavirus largely compensated this. maxon invested CHF 50.3 million in new factories, machines, and systems. The cash flow amounted to CHF 37.1 million, compared to CHF 44.9 million in the previous year. Under the difficult conditions maxon faced, the company launched several new products. These included micromotors for medical robots, multi-axis controllers for highly dynamic positioning tasks, and the BIKEDRIVE Air, a lightweight, invisible e-bike system (see p. 20). Worldwide, the maxon Group has 3,059 employees at nine production sites.

“2020 was a rollercoaster ride like none we experienced before”

Karl-Walter Braun,
Chairman of the board of directors
of the maxon Group

Switzerland

NASA research director visits maxon

In September 2021, maxon hosted a distinguished visitor at its headquarters in Switzerland. NASA research director Thomas Zurbuchen, who grew up in Switzerland, dropped by to learn more about one of the key suppliers to the current Mars 2020 mission. Group CEO Eugen Elmiger and project participants gave Thomas Zurbuchen a tour of the development and production departments that manufactured the precision drives for the Perseverance rover and the Mars helicopter Ingenuity. The NASA research director was full of praise: “The world knows how important your work is and how good you are at it.”

Drone market

Partnership with Auterion

maxon has entered into a strategic partnership with Auterion, a startup that specializes in drone software. This company is working to build an open-source future for enterprise-operated drone fleets. Customers will benefit from an open ecosystem for the integration of avionics and motors in the drone industry. It combines Auterion’s Skynode module with maxon’s BLDC motors and ESC controllers. Eugen Elmiger, CEO of the maxon Group, said, “Auterion’s expertise in drone software combined with our 60 years of experience as a global motor and drive specialist will produce promising solutions.” According to Kevin Sartori, founder of Auterion, “This partnership ushers in a new phase of software-based drones and open standardization. Together with maxon, we will offer a complete set of components for building state-of-the-art drones that are individually adapted to the needs of companies.”

Photos: maxon

Figure

3,400 km

Superwoman in action

Crossing Australia by jetsuit

Helicopter pilot Jen Bewes has an ambitious goal: She wants to fly all the way across Australia in two months – in a specially developed jetsuit. And that’s not all: While she’s at it, she wants to set the world record. Since the four thrusters that maneuver the jetsuit are located on the hands, the pilot’s body is subjected to correspondingly high loads. A force of 40 kilograms is exerted on the arms and shoulders. For this reason, Lorenzo Masia was brought on board. The professor of biorobotics and medical technology at Heidelberg University in Germany is developing a special soft suit for Bewes to reduce the forces on her arms. This involves integrating newly developed and reinforced protective parts into the arms and shoulders of a standard motorcycle jacket, in collaboration with the company Dainese. At the press of a button, these protective parts are stiffened by artificial sinews to create an artificial layer of muscle. This keeps the arm stretched out during flight, while the shoulder is stabilized by the reinforced armor. “It’s like being able to activate an extra tricep and a deltoid muscle,” explained Lorenzo Masia. For the drive system that powers the arm-stabilizing mechanism, he is using a DCX 19 DC motor in combination with a GP 22 gearhead and an EPOS4 Micro motor controller. The system has to be ready to go by spring 2022 at the latest, which is the date set for this world record attempt.

“This is the ultimate test of my theory that ‘impossible’ is just a mindset, and that we can defy what seems impossible.”

Jen Bewes, helicopter pilot

2 months

This is how long it will take Jen Bewes to travel across all of Australia – if she succeeds!

~1,000

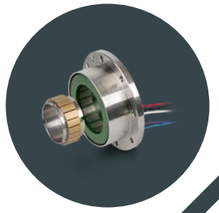
The number of flights Jen will need to cover the distance, as her flight system can stay airborne for only a short time.

Space saver

EPOS4 Micro
The micro version of the EPOS4 positioning controller combines an impressively compact design with an attractive price. This is especially good news for robotics applications with limited space.

Photo: Jen Bewes

New products



EC frameless DT
brushless

EC frameless DT

Dynamic and versatile

Ever-growing demands for dynamic response, compact design, and power density are creating a need for innovative new motors. With the EC frameless DT50, maxon is launching the first motor in a new product family that meets these demands to the highest degree. The brushless DC motor was designed as a frameless motor and integrates easily into applications. When installed, it effortlessly reaches a nominal torque of over 500 mNm at a nominal speed of 4,000 rpm. This is despite a stator outside diameter of only 50 mm. At the same time, the new winding technology enables a very short motor length with a very large hollow shaft of 28 mm.

TSX-MAG
enables large hollow shafts

TSX-MAG

The off-axis encoder

The TSX-MAG encoder is a configurable through-shaft encoder that is not installed directly on the motor axis (off-axis installation). This allows enormous freedom of design and permits large hollow shafts. The encoder can generate both Hall signals and incremental signals, which allows field-oriented commutation of the motor. In this initial stage, the TSX-MAG encoder is being offered on the EC frameless DT50M. Further encoder versions and additional combinations will follow soon.

The maxon online shop has more than 5,000 products, selection aids, combination tools, and comprehensive product information:
shop.maxongroup.com

Photos: maxon

#womeninengineering

Women make a major contribution to maxon's success. So it's all the more important to motivate as many women as possible to pursue a technical profession. We asked our female engineers about the hurdles and role models they've encountered.

I was really attracted by humanoid robots playing tai chi and table tennis, which was a very interesting and novel application in China at that time."

Singer Gong

Desire to become an engineer

"When I was a kid, I used to disassemble my electric toys because I really wanted to know how they worked."

Zeliha Yesilova

Who influenced you?

"I was blessed to have crossed paths with two strong women in the STEM field who ultimately led me to where I am now."

Nicole Mathieu

"There were not really "influential engineers" in my immediate surroundings BUT my dad always worked much at home, did many things himself and was the craftsman for anything. I liked working with him."

Lisa Eckle

"My father is an electrical engineer, so he was the one who influenced my decision to become an engineer the most. He never pressured me, rather he tried to spark my interest with fun tasks and by involving me in interesting projects he was working on."

Jelena Perkucin

"I was raised in a home where your passion is what drove your career, not your gender."

Angelica Perzan

"What I like about maxon are the possibilities of collaboration on innovative projects with high added value, built on multi-cultural (international) exchanges, which are made possible by our multi-expertise competence centers."

Virginie Mialane

Life at maxon

"I've never encountered a 'glass ceiling' during my entire time at maxon motor manufacturing Korea."

Kay Mun

"At maxon, women and male engineers are equal. maxon gives the same opportunity to men and women, we can cooperate and help each other."

Joorim Lee

Advice to girls interested in technology

"Do not be ashamed of not knowing something but instead take the chance to learn something new."

Noëlle Bracher

"If you are interested and talented in engineering topics, just do it."

Sandra Dettling

"You will make it if you are curious and open-minded, believe in yourself, and don't care about what others say. You are not alone, you will find a lot of other women on the same path."

Hannah Kleeblatt

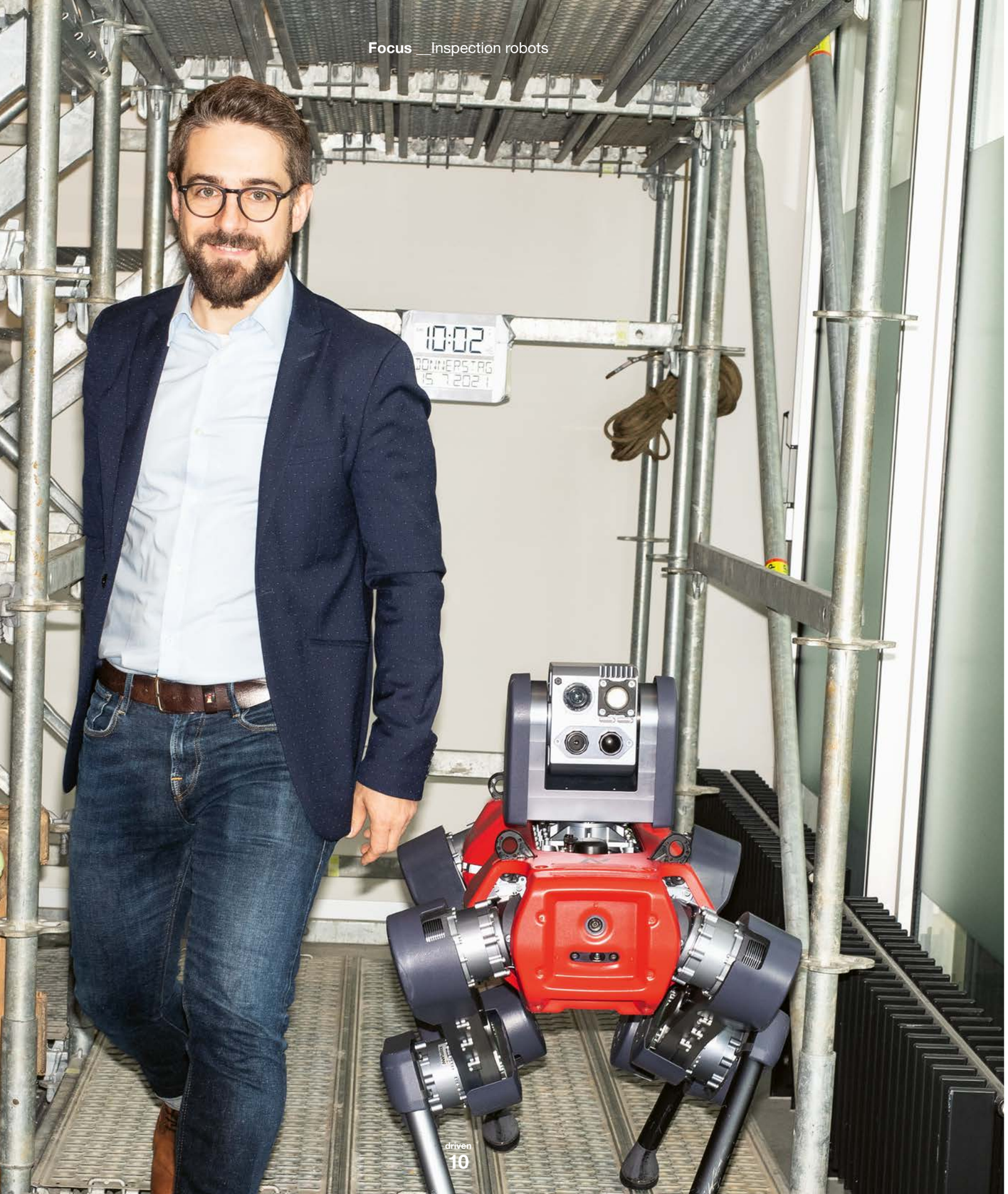


Photo: Dan Cermak

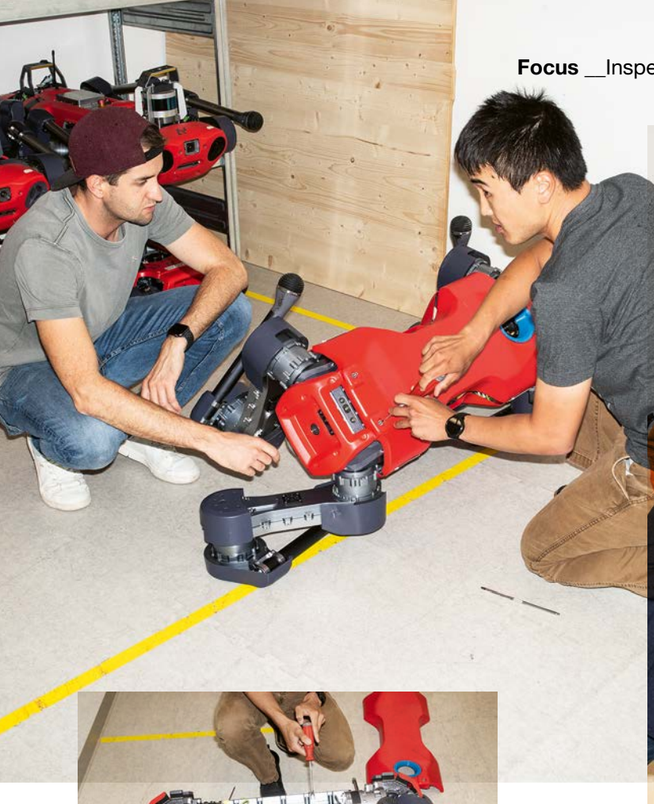
Robotic companion

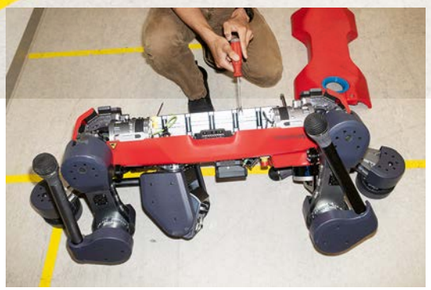
Remote offshore installations, dusty mines, dirty sewers: environments made by people for people. Yet operating them is dangerous. The solution? The robotic dog from ANYbotics, which can carry out inspections autonomously. We went to Zurich to visit one of the biggest robotics teams in Europe.

Text: Katharina Rilling

Fall down, get up again. Over and over again. How do I position my feet? How do I apply force? And how do I control my balance? When children are learning to walk, they feel their way into the movements over a period of weeks. Péter Fankhauser's "baby" learns in a similar way – even though its legs consist of springs, sensors, and motors. He proudly reports: "ANYmal taught itself to climb stairs in a simulation. It took the robot only a few hours. The fantastic thing is that, unlike humans, thousands of ANYmals learn right along with it. That's because we create virtual copies." These copies are each given the general goal, such as to climb a flight of stairs as quickly as possible. Then disruptions are added, such as sensor noise or wind. The programs consequently learn to handle such situations independently. "Once the simulated learning processes reach an optimum level, we transfer the control to all the real robots," Fankhauser says.

An engineer with a doctorate in robotics, he sits on a colorful lounge suite in the meeting room and speaks easily at lightning speed about the inspection robot. He developed it together with eight other founding members of ANYbotics, a spin-off of ETH Zurich college. The dog-like ANYmal, he says, can move autonomously – that is, without human control or wifi – in harsh industrial environments with no people present. What's really exciting is that the environment does not have to be specially designed to suit robots, as is the case in large factories or warehouses. No, the four-legged helper can find its own way, especially in spaces made for humans. Fankhauser points us to YouTube videos where we can see the machine clamber-





Left: Two companions in the test center: Péter Fankhauser with the latest version of ANYmal.

The employees of ANYbotics (still) produce the robot in Zurich themselves, test it, and collect data. The startup vibe is tangible.

Photos: Dan Cermak

ANYbotics: leading provider of mobile robotics

ANYbotics was founded in 2016 as a spin-off from ETH Zurich. Its purpose was to commercialize the technology behind the four-legged ANYmal robot. Péter Fankhauser is one of a total of nine founding members. Now, generation D of the robot is about to roll off the assembly line. One version is even explosion-proof – a new feature only available from ANYbotics.

ing up and down steep steel stairs, or taking forest walks over roots and gravel paths. It balances on narrow steel beams, crawls under trains, and makes its way safely across sausage-thick cable coils on the ground. ANYmal can easily wade through water, survive a sandstorm, and doesn't slip even on a blanket of snow. We even see it running backwards to deliver chocolate bunnies door to door at rush hour on Easter. Such situations require the highest concentration even from humans.

Smiling robot

How does the robot do it? Is the programming particularly difficult? "No, it's relatively simple," our specialist assures us. We learn more during a tour in Zurich. The ANYbotics complex houses not only offices and meeting rooms, but also the company's test center and production facility. When you enter, you notice that there's something in the air. Maybe it's the tingle you get when you're making progress. The excitement of imminent change – when you feel you're on the verge of a breakthrough, like you're part of something big. People in jeans and T-shirts greet you enthusiastically in English. 21 nations are represented here, with 25 more employees than a year ago. New spaces have just been leased, and ANYbotics recently raised 20 million Swiss francs from investors. This money is being used to commercialize the latest ANYmal model, the D version (to learn how maxon is helping with this, see the interview on pages 16–17). This will also bring a structural change: Currently, a small in-house team manufactures about one robot per week. From 2022, the inspection helper will be produced in higher volumes on an assembly line, by a partner in Switzerland.

But despite the upswing, ANYbotics has remained grounded. The startup vibe is still there. In the open-plan office, whiteboards hang with complicated formulas and diagrams, but every now and then a manga character, as if escaped from a comic, mingles among them. Plush animals dangle from desk lamps. In the kitchen, the winning artwork from the last team competition is on display, small framed oil paintings: ANYmal waving from the back of a unicorn, ANYmal crawling through the sea, ANYmal floating around in space. Right next to them, vast continents spread across the wall, covered with photos of customers from all over the world. In the midst of it all is the friendly-looking robot, running, sitting, waiting. "Even with the C prototype, we were concerned not only with the robot's function, but also with the emotions it arouses by its appearance. We were able to position its eyes so they look friendly. They are the cooling vents of the robot. The depth camera forms its mouth. A small bevel makes it look like a lip, smiling. Little things like that help evoke positive associations," Fankhauser says. The latest model has a completely different face because ANYmal D had to be made even more robust, for industrial use. Nevertheless,

the successor model looks benevolent too. “We wanted to create a friendly, reliable, and useful robotic colleague who helps out. After all, it is supposed to supplement the human workforce. So it has to give the impression: I’m here to help you. Incidentally, this rules out military operations and police missions.”

It sees, smells, hears – and calls out

Routine inspection work is especially suitable for automation using ANYmal. The ANYbotics CEO goes through the numbers, to show that this quickly pays off: “Every day lost to repairs costs the operators of industrial plants several hundred thousand francs. So the machines have to run with as few problems as possible.” Currently, it’s mainly people who do inspection rounds. “That works well – at least if they know the plant and have experience. But it takes a lot of time and money, and sometimes it’s highly dangerous.” On offshore installations, in sewers, or in mines, people are exposed to high pressure, electricity, hazardous gases, toxic substances, dust, and dirt. Therefore, if a person wants to inspect the facilities, they sometimes have to be switched off first – and that costs money. Then there is the issue of transportation costs. “Specialized people have to be transported to the plants, but each helicopter trip can easily cost more than CHF 30 thousand.” Shaking his head, Fankhauser adds, “Sometimes a flight to a drilling platform is necessary just to flip a single switch.” In the offshore sector, ANYmal therefore pays for itself within a few weeks.

Of course, there is also the option of equipping the plants with sensors to detect abnormalities in operation. However, that too is complex and costs a lot of money. “Each sensor also measures only a small part of the whole system, and has to be replaced over time,” Fankhauser observes. The robot, by contrast, has the advantage that it is designed for a relatively long time – three years of continuous operation, in fact – and can perform many tasks at the same time. The robotic dog is strong enough to carry loads. With its cameras and detectors, it sees, smells, hears – and “calls out” warnings: it reads and passes on data from measuring devices. It takes thermal images, and performs acoustic measurements. It will notice and report if there is gas escaping, or if the hum of a machine or the vibration of a pump suddenly sounds different.

Powerful motors, fast learning time

But how does this device manage to move so safely through difficult terrain? How does it learn its way around? Fankhauser says, “One option is to take ANYmal with you to the site and show it what it has to do, like with a new employee. We accompany the robot with a joystick while it walks the path and creates a 3D map. An hour-long inspection tour of a plant normally takes half a day of learning time.” Alternatively, the robot has the even simpler option of learning virtually. This is possible if a digital model of the plant already exists.

Orientation is achieved with sensors, while walking uses electric motors developed specially for the robot. “We realized that we needed our own drives, which had to be light, yet powerful. That’s why we entered into partnership with maxon. Our two companies are a very good cultural fit, and even work next door to each other now.” The robotic animal’s four limbs each contain three drives, meaning that a total of twelve actuators are installed in the ANYmal. They generate the walking motion, make the legs tilt out or back, and bend the knees. “Force control when walking on various surfaces is very important. When running, there is impact energy that has to be absorbed. To do that, we worked with maxon to develop a system with springs that mimics muscles and tendons.” (See interview on pages 16 –17)

Solution and tricky challenges

In the ANYbotics test center, the tower of pizza boxes reaching almost to the ceiling bears witness to long days and short nights. Here, chairs, tables, and computers are grouped into a kind of spectator arena where data is collected and analyzed. On the stage, the fifty-kilogram robot works its way up and down stairs and over obstacles like bricks. Keeping a safe distance from the machine is mandatory for all employees. Safety certification is something that cost the company a lot of time and energy. “But now it’s done. We worked with external specialist laboratories to implement a strategy for electrical and mechanical safety.” Training customers in safety precautions also helps to reduce risks to a minimum.

After 90 minutes, ANYmal runs out of energy. It notices this on its own, stomps to its docking station, and sits down on it like a hen on an egg. Fankhauser explains: “You see videos on YouTube of this cool robot running up the stairs like a dog. But that’s only one small part of the solution.” The CEO points to the live screens of the computers. “You have to be clear about how the inspection data is going to get to the customer. We offer an end-to-end inspection solution. The software comes with an annual user license, including software updates and technical support.” Some tricky challenges are still to be resolved: What if someone closes a door? ANYmal would be stuck standing in front of it. It is also not yet able to detect rust or cracks reliably. Also, it should really be able to do dangerous maintenance work right away by itself. The team in Zurich is now experimenting with gripper arms for this purpose. One thing’s for sure: this friendly robot is going to keep learning – and the pizza tower will keep growing.

Fokus __Inspection robots

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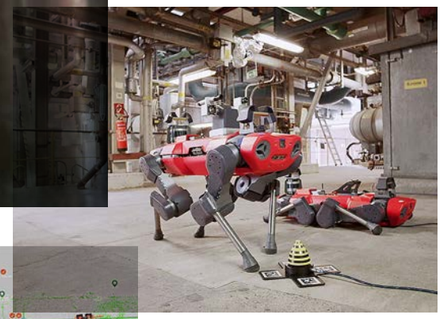

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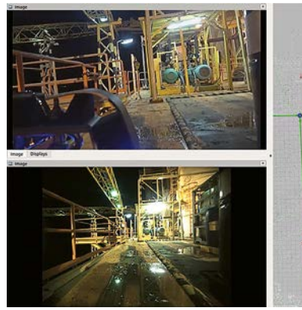

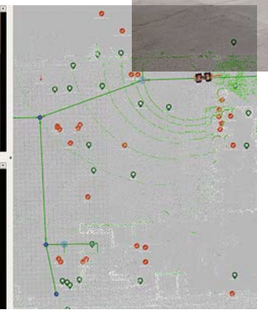

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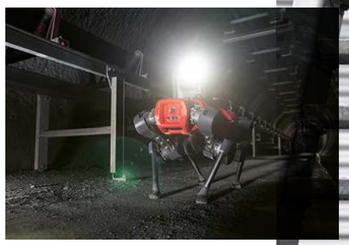


1 & 2 New employee induction: A prototype ANYmal C gets to know an inspection round. At first, he is controlled with a joystick.

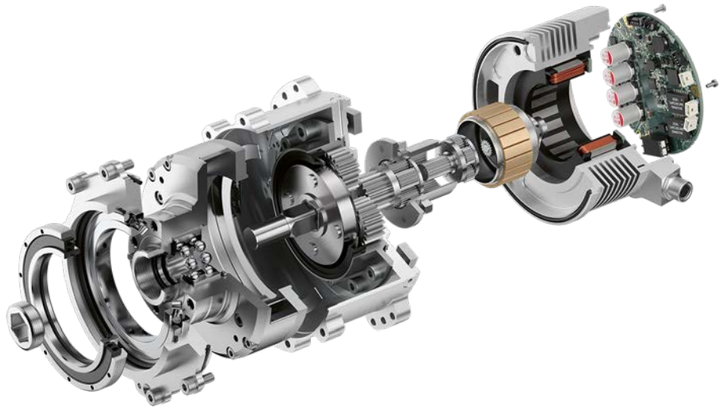
3 No energy? No problem: The robot immediately takes place on the yellow charging station, all by itself.

4 During its first round, the machine becomes familiar with the obstacles and routes and creates the digital map that it needs for working autonomously.

5 & 6 Offshore, it braces the wind and weather: The new ANYmal D model crawls up a flight of steel stairs by itself.

7 Despite the darkness and dust: The inspection robot can also be used in mines.

Photos: ANYbotics



Agile powerhouse

ANYmal drive system
The core of the customized drive package is the new EC frameless DT 50. The housing also contains a gearhead, spring, and encoder.

“We can change the game”

maxon has developed a customized drive system for the new generation of the ANYmal robot. Its core is the new frameless DT motor, which can now be used in totally different areas as well. What makes it special?

Interview: Katharina Rilling

If the frameless DT motor was a superhero, how would it be described?
As a super-agile powerhouse with super stamina, which moves much faster than the eye can see. It accelerates to top speed in four milliseconds and gets more than 1 hp out of 100 grams. It is fast and strong, but doesn't overheat. It's like a 100-meter sprinter and a marathon runner combined.

Max Erick Busse-Grawitz
is technology transfer manager at maxon and was responsible for the design of the customized drive for the ANYmal robot.

On YouTube, there are videos of faster four-legged robots. Why is ANYmal comparatively slow?
First of all, nobody wants the robot to come racing toward them in an industrial environment or on an oil platform. That would be far too dangerous. On the other hand, though, ANYmal can survive the harshest environments. It can't be harmed by rain, snow, salt water, or oil. Also, what's more important than speed is a firm footing. The robot needs to be able to climb outdoor stairs without falling.

maxon developed a completely new drive for ANYbotics. Why?
We developed an even better motor and gearhead. The drive is now smaller, lighter, faster, more efficient, and last but not least, lower priced than its predecessor. We're talking about doubling the peak power and tripling the range.

Photos: maxon

What is it exactly that makes the drive a super-agile powerhouse?
Due to its mechanical design, it does its job with very little friction. That means the robot runs more easily and doesn't heat up as much. We can take the human body as an example to follow: Friction in the human body is extremely low. That's the only way we can apply great force while at the same time moving carefully through our environment. Another advantage of low friction is that when humans walk, they get back through momentum most of the energy that they put into the walking motion. We are still a long way from being as good as humans, but we have at least tripled the motor's range. To get energy out, humans also use elastic elements. In the drive, this is achieved by a spring. We benefited a lot from ANYbotic's knowhow in this regard. Controlling a drive like this is anything but simple, and ANYbotics already had ten year's of experience in this area.

What happens when the robot runs into something?
A spring provides the robot with a kind of built-in intelligence. Instead of attempting some cumbersome software fix, we worked on the hardware. Let's make the comparison with humans again: Our skin has sensors. If we collide with an object, those sensors give us feedback in an instant. Our body adjusts its behavior, removing the energy in time before we seriously injure ourselves. This largely happens without us being aware of it. The brain alone would be too slow to protect us from sudden injury. It works much the same way with robots. In a collision, tension is first built up in the spring that protects the gearhead from force spikes. Meanwhile, the system regulates the motor position, which in turn releases the spring tension. As I said, the motor reaches its maximum speed in four milliseconds, which means it can compensate the collision forces faster than the eye can see.

So the robot protects itself?
Exactly. The technology used is known as a series elastic actuator (SEA). It sounds simple, but requires intensive company-wide cooperation: gearhead, motor, mechanical components, electronics, sensors, and software are closely interconnected.

Sounds complex. How fault-prone is that technology?
In the worst case, collisions are mechanically cushioned by the spring, as I said. So the drive is robust. The entire system is highly developed, if also highly complex mathematically. The expertise required for this was honed at ETH and ANYbotics and then transferred to us in our collaboration.

Where else can the new drive be used?
ANYbotics received a customized system solution with coordinated components. However, the motor at the core of it is our newly developed EC frameless DT 50, which we offer to other customers too. It is basically suitable for applications with dynamic movements where speeds change in an instant. In such cases, drives with low inertia are at an advantage.

Can you give us a specific example?
In addition to robots, the motor can also be used in exoskeletons. The DT 50 has a lot of power but not much inertia, so it doesn't fight against the wearer when they make an unexpected movement. A drive this efficient also has advantages for the larger system that it forms part of: It conserves battery power and generates less heat that could require removal with loud fans. Especially in the case of exoskeletons, we don't want to operate at the thermal limit: Who would want to walk around with a thing on their body that heats up to 100 degrees Celsius?

What is the future of the robotics market?
Robotic assistants will increasingly be able to relieve us of unpleasant tasks. As for the drive of the future, we will move closer to nature by using even smaller motors and even more sensors. However, unless someone discovers a new law of physics, I don't foresee any great leaps in terms of power density. Robots, by the way, are lagging behind expectations in technical terms. This is probably because they are difficult to program and make quite clumsy movements. The big industrial robots are productive but also dangerous, and only work in protected environments. The collaborative robots are often not useful enough. maxon's new technology could now change that. Our robotic drives have less momentum, they use less mechanical energy, and, if a collision were to occur, they cause less damage. So, in the robotics market around unstructured environments, we could change the game to some extent.

4D

THE NEW WORKFORCE

Will all human tasks be done by robots someday? These helpers are most likely to establish themselves in jobs that no human wants to do:

DULL
Monotonous and boring tasks, such as loading and unloading machines

DIRTY
Work that can have a negative impact on our health, such as soldering processes

DANGEROUS
Dangerous jobs, such as handling hot objects

DISALLOWED
Such as handling caustic chemicals

They’re everywhere

A world full of robots: just science fiction? Not at all. Robotic helpers are already working to make life easier for humans, in pipes, under water, and in the air.

Nuclear power plants
HiBot’s robotic arms move like snakes to reach places that are too narrow or too dangerous for humans. The arm was used during the decommissioning of the Fukushima nuclear power plant.

Pipes
A small caterpillar robot that magnetically sticks to metal walls and is able to move in all directions. It carries cameras, sensors, and tools for inspection and maintenance work in narrow pipelines and on the outer shells of tanks and hulls of ships. The practical caterpillar works both in the air and in the water.

In the air
Flybotics drones were developed for inspections in tight spaces: chimneys, shafts, tanks, etc.

Dangerous spaces
The caterpillar robots from Invert Robotics are inspection tools for reservoirs, tanks, and all kinds of cramped or dangerous spaces.

Wind turbine
The robot from Helical Robotics climbs up wind turbine towers to carry out inspections quickly, reliably, and economically.

Facilities for humans
The dog-like robot ANYmal moves autonomously in environments that are not designed for robots, performing tasks like data readouts, inspections with a thermal imaging camera, and acoustic measurements. See also p. 10.

Roads
Top Hat Robotics’ device is about as wide as a sidewalk, and can generate reports on their condition faster than its human colleagues.

Underwater
2000 m under the sea? No problem for this inspection robot from Eca Group, which is used in the oil and gas industry.

High voltage
This robot from Security Robotics is equipped with a metal fence detector to work on the grounds of power substations. It features automated thermography and infrared inspection. Its body is made of fiberglass, with a coating that protects it from strong electromagnetic fields.

Sewer systems
Whether it’s for inspections or to repair damage, iPEK’s sewer robots are able to meet a variety of needs.

Start-up company Eelume has developed an underwater robot in the form of a snake, for use in inspections, maintenance, and repairs. The slimline, flexible robot can cross large distances and reach places that aren’t accessible to conventional underwater robots.

Photos: zVg

Infographic: Corrina Vögele

Lighten up!

I sometimes forget I'm sitting on an e-bike.

The next stage in e-bike evolution is here: moving away from heavy behemoths to light, agile bicycles. These bikes are bringing back the natural feeling of riding – even when the battery is empty.

With commentary by
Ralph Näf,
maxon test rider
+MTB WORLD CUP COACH

The system doubles my pedal force, but the bike still has a playful feel to it.

The pace at which electric bikes are becoming part of our everyday world is breathtaking. They are in our cities, out in the countryside, and in the mountains. There is now an electric version of every category of bicycle. Not all e-bikes are created equal, however. There is currently a trend on the market toward lightweight systems that can hardly be distinguished from a regular bicycle. This development is supported by ever smaller yet powerful motors, plus better batteries. "Integration is the key word," said Michele Tittonel, R&D coordinator at Cipollini, an Italian manufacturer of racing bikes. "The second generation of electric racing bikes will be powered by motors that are fully integrated into the bike design and complemented by high-end components."

Cipollini has set itself the goal of developing one of the lightest electric racing bikes in the world, without compromising on the reliability and duration of the electric support. In the summer of 2021, the bicycle manufacturer finally unveiled the new models – equipped with the BIKEDRIVE AIR system from maxon, which weighs just 3.5 kilograms, including the battery. At its heart is a mid-mounted motor that delivers 30 Nm of torque. It's easy to pedal even without electric assistance, thanks to special freewheel technology. In Michele Tittonel's words, "The natural feeling of riding is absolutely crucial. Ultimately, physical exertion should remain part of the experience." Which is to say, even riders going up a mountain on their electric racing bike still want to get a good workout. "But with the maxon system, you can simply enjoy the riding experience even more."

The natural riding experience is also a top priority for Transalpes, a Swiss manufacturer of mountain bikes. As co-owner Michel Juhasz explained, their aim is no less than building the best electric mountain bike in the world. In the past, Transalpes was hindered by the fact that motor manufacturers didn't listen to the small company. "With maxon, we now have a partner who is pursuing the same goal. With no ifs or buts." Almost at the same time as Cipollini, Transalpes launched the new TRANSALPES E1 in the summer – with the BIKEDRIVE AIR system. "It rides as naturally as a mountain bike without a motor," said Michel Juhasz confidently. "We've not only built the best e-mountain bike in the world, but perhaps also the lightest." This was only possible because the collaboration with maxon worked extremely well. "We were able to achieve great things in a short time."

At Cipollini, it's a similar story. In Michele Tittonel's words, "We had the same ambitious goal right from the start. Of course, there were some challenges for maxon during the two-year development phase. But at the end, we shared that beautiful feeling when everything just comes together. We now want to pass that feeling on to our customers."

More to come

System BIKEDRIVE AIR

The light e-bike system from maxon has been available to bicycle manufacturers worldwide since the summer of 2021. For slimline racing, gravel, urban, or mountain bike designs.

As soon as the support kicks in, it feels like having a pleasant tailwind.

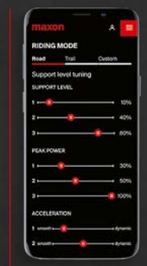
Drive unit
The centerpiece: A brushless DC motor and a low-noise planetary gearhead supply a torque of 30 Nm. The integrated electronics and sensors provide very natural support. And should the riders feel like cycling without the electric boost, the freewheel ensures that they do not feel any resistance.

Invisible drive

Photos: maxon; iStyaphong/istockphoto.com; Pattadis Walaiput/istockphoto.com

Interface
The control element on the top tube shows the battery status and allows riders to select between three support levels: Cruise (gentle tailwind), Push (sport mode), Blast (for steep inclines). Easy smartphone connection via Bluetooth. Other devices via ANT+.

All important information at a glance!



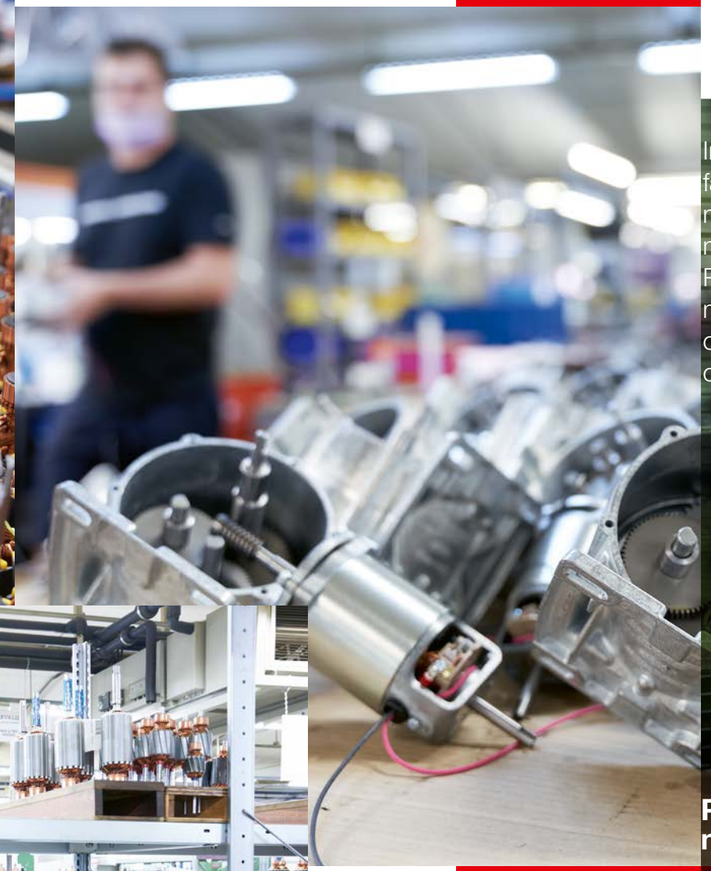
Apps
With the Rider app, the users can individually configure the support levels and select preset riding profiles. The Service app in turn is tailored to mechanics and enable them to perform analyses and order spare parts. Both apps are available for iOS and Android.

Battery
36 V. A capacity of 250 Wh. Fully charged in 3.5 hours. The lithium-ion battery is permanently mounted in the down tube and weighs no more than a large bottle of water.

“The natural feeling of riding is absolutely crucial. Ultimately, physical exertion should remain part of the experience.”

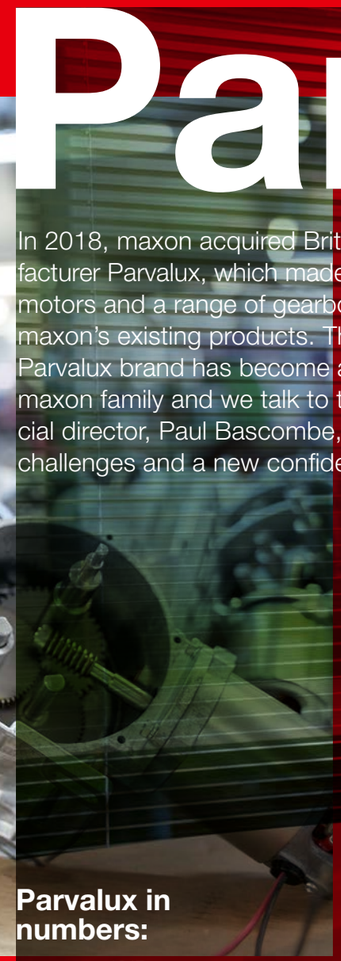
Michele Tittonel,
R&D coordinator at Cipollini

Want a video? But of course!
See for yourself and share it!
youtu.be/c2dp8p01KXo



Introducing Parvalux

In 2018, maxon acquired British geared motor manufacturer Parvalux, which made larger, more powerful motors and a range of gearboxes that complemented maxon's existing products. Three years later, the Parvalux brand has become an integral part of the maxon family and we talk to the company's commercial director, Paul Bascombe, about integration, challenges and a new confidence.



Parvalux in numbers:

_Founded in 1947
_200+ employees
_Three factory sites in Dorset, UK
_More than 20 million units produced
_Products shipped to 80+ countries

Photos: Peter Otto

Text: Dave Hitchins

Paul, as commercial director, you've probably had a busy few years, recently?
Yes, it's certainly been busy! The acquisition by maxon in late 2018 has been great for Parvalux; it's helped us open new markets and take the Parvalux brand global. Moreover, our business processes are becoming much more streamlined and we're on a pretty steep new product development trajectory, which is all very exciting. We were already pretty busy in the run-up to maxon taking over, but this has been a step change for us.

What has changed since Parvalux became part of the maxon family?
One of the more visible changes is that we are undertaking a lot more marketing activity, which hadn't really been a priority before maxon's ownership. We certainly did do some marketing but not a huge amount, as most of our business was repeat and new business was won by reputation, recommendation and word of mouth. As we seek to promote Parvalux to a wider, global audience, we start to encounter well-funded and capable competitors who have already got a good head start, particularly online. This is why we've invested significantly in a brand-new website with an online shop. There's now a superb online product configurator. Customers can select a motor, add a gearbox and a range of accessories, such as brakes and encoders. As each component is added, the on-screen graphic changes to show the addition and the graphic can then be manipulated in a 360-degree fly-around. Engineers get a rapid understanding of how our units will fit in the space they have available. At the same time, we're providing better support to our customers by sharing a lot more performance data. We've revisited each of our products and published a new set of 2D datasheets that includes product dimensions and performance data in metric and imperial sizes. We are also making 3D CAD files available directly from the website to make the engineer's design process that much quicker. I'm not aware of any other geared motor manufacturer that offers the sort of functionality and choice we're now able to offer through parvalux.com.

It sounds like a lot of effort has been put into differentiating Parvalux from other manufacturers?
Parvalux operates solely in the fractional horsepower sector and we've always designed and built superb motors and gearboxes, but we haven't been that good at shouting about our successes or explaining the benefits of our products. maxon actively encourages us to do more and to shout louder.

Parvalux history:

In the late 1940s, the world was a very different place; a world war had decimated the manufacturing industry across Europe. For years, 'make do and mend' had been the norm; repairing something was considered a better option than throwing it away. So in 1947, Leslie Clark started a business for rewinding motors. He initially operated from a small building near London and he called his business 'Parvalux', derived from the Latin words 'Parva', meaning 'new' and 'lux', meaning 'light'. In 1957, Parvalux relocated to Bournemouth. With plenty of space to expand and a growing order book, the company developed from simply rewinding and refurbishing motors, to designing and manufacturing geared motor units for industrial applications. Since those early days, Parvalux has grown to become the UK's largest manufacturer of fractional horsepower AC and DC motors and gearboxes. The company's products are popular in patient care, industrial automation, leisure and e-mobility applications, where power, smooth operation and reliability are all prerequisites. To date, Parvalux has built and shipped over 20 million units, to over 80 countries worldwide, where they power train and elevator doors, enable solar panels to track the sun, and power the windscreen wipers on ocean-going ships.

Parvalux offers 5000+ product lines, including AC, PMDC and BLDC (EC) motors, right-angle, inline and planetary gearboxes, encoders, and brakes.

Photos: Peter Otto, maxon

Paul Bascombe has worked at Parvalux since 2011. He started as a senior design engineer and now leads the company's Sales & Commercial function and a team of 13 from Parvalux headquarters in Bournemouth.

Can Parvalux and maxon products be mixed and matched?
Actually, yes and we're making great headway down a joint development path. We've recently completed an interesting project to integrate Parvalux gearheads with maxon drives, which offers the potential to provide benefits across each of our respective customer bases. Parvalux is specifying maxon controllers for our DC drives and we are having conversations about developing products that can be used by both brands. Parvalux is developing a brand new range of industrial BLDC motors which will be compatible with a new maxon-developed controller range. Working together has actually turned out to be a productive process because we have the same ambitions and share a similar appetite for success.

What's it been like in general working with a new team of colleagues?
Daily collaboration with our colleagues throughout maxon is second nature now. At no point has this ever felt like an 'us and them' situation but rather, we're treated like valued colleagues and friends and it's been this way since the first day. maxon expects every employee to contribute to the overall success of the business and the company has created an environment that supports continuous improvement and learning. We're encouraged to experiment and think longer-term and as a result we're able to plan more effectively, which is important as we start to grow more quickly and enter new markets.

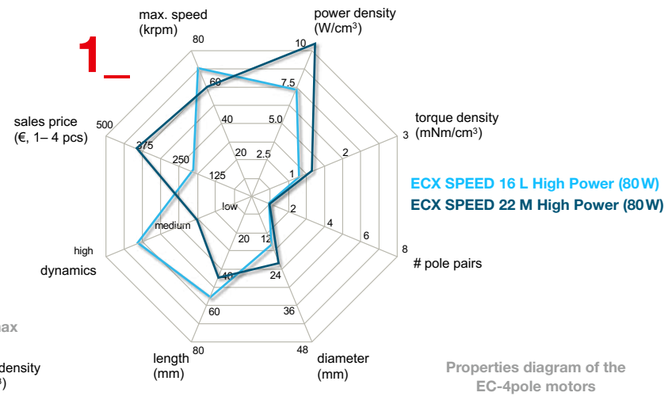
What does the future look like for Parvalux over the next few years?
We're focused on growing the business and establishing ourselves in several emerging markets we've identified both directly and, through the maxon subsidiaries, globally. To support this, we're placing emphasis on new product development. As a natural component of this, we're always exploring how we can harness technical innovation. We have some very exciting product developments that are keeping our engineering development teams busy, some of which I can't talk about yet, but I can say that they centre on new products that will take the Parvalux AC and DC motor ranges to a new level of capability.

Speed or torque – or both?

The maxon catalog contains a large number of brushless motor types that are called EC motors. This article briefly describes their properties and possible areas of application.

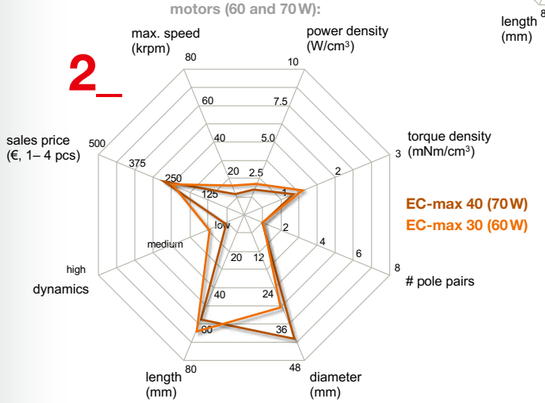
Properties diagram of the ECX SPEED motors (80 W):

1_



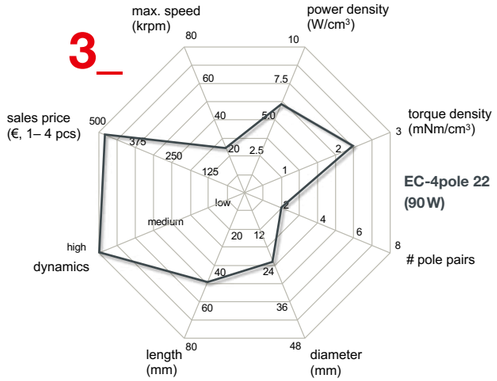
Properties diagram of the EC-max motors (60 and 70 W):

2_



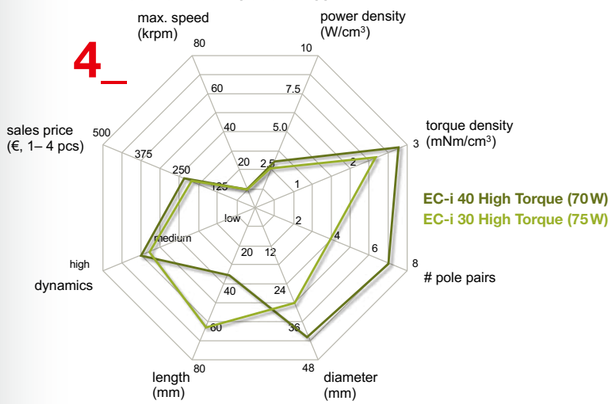
Properties diagram of the EC-4pole motors

3_



Properties diagram of the EC-i motors with power of approx. 70 W

4_



Properties diagram of the EC 45 flat motor with power of 70 W.

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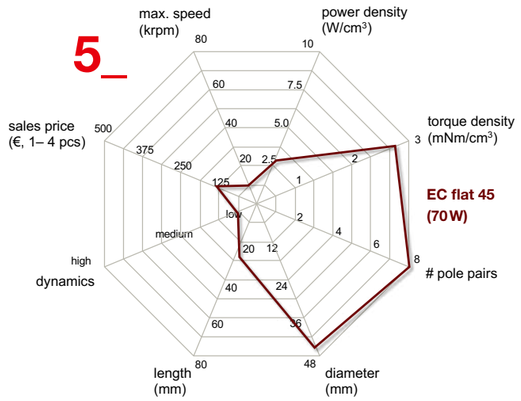


Photos: maxon

Expertise

Urs Kafader,
head of technical training at maxon

SUMMARY

_Motors are not all the same – their characteristics vary depending on their design type.

_The motor type is selected according to the case-specific requirements:
> High speed or high torque
> Direct drive or with gearhead
> With or without closed-loop control
> sterilizable, integrable, …

1_ ECX SPEED

_Ironless maxon winding with low inductance
_2-pole magnet on internal rotor
_Standard and high-performance versions with various magnet strengths
_Sterilizable versions with hybrid ball bearings (ceramic balls) for even higher speeds
_Combination with GPX gearheads and ENX encoders
_Configurable output shaft and electrical interface

Characteristics

As the name suggests, the main feature of this motor range is the high speed that can be achieved. This gives extremely high power density (power per unit volume) despite relatively low torque density. However, this seemingly high power cannot be utilized with standard gearheads and mechanical devices, due to their limited input speeds. Operation with both high torque and high motor speed is only possible with the special GPX SPEED planetary gearheads with input speeds of 50,000 rpm and more. The relative dynamics are in the medium range. Incremental or single-turn absolute encoders can be integrated into ECX SPEED motors, even in sterilizable versions.

Applications

Typical applications for the ECX SPEED motors are handheld tools with high speeds, such as grinders. Sterilizable versions of the motors and even of the motor-gearhead-encoder combinations allow the products to be used in surgical tools. Here the configuration with pluggable connections is an attractive option.

Special point of note:

ECX SPEED motor windings have very low inductance because of their ironless design. Supplying such a motor with a PWM power stage, as with most modern controllers, results in current ripple. Various applications have shown that such current ripple can lead to undesired heating of the motor by 40 degrees or more. Losses of this kind can even become the dominant heating factor in no-load operation. Increasing the PWM frequency helps, but the best way to eliminate current ripple is to add inductors.

2_ EC-max

_Ironless maxon winding with low inductance
_2-pole magnet on internal rotor
_Range of diameters: 16 mm, 22 mm, 30 mm, and 40 mm, each in a short version and a long version
_Standard combinations with gearheads in ceramic versions and encoders. Holding brakes are also possible.

Characteristics

The EC-max range offers cost-optimized motors for standard applications that require a brushless motor with long service life. Since the focus is on cost, their torque and speed attributes are moderate, with low power density and low dynamic response. EC-max motors can be combined perfectly with maxon's ceramic gearheads to create gear motors with long service lives. The relatively low motor speeds match the limited input speeds of standard gearheads, which raise the moderate motor torques to a usable level.

EC-4pole

3_ EC-4pole

_Ironless hexagonal maxon winding with optimized winding segment arrangement for 4 magnetic poles
_4 magnetic poles (2 pole pairs) on internal rotor
_Range of diameters: 22 mm and 30 mm, the latter also in sterilizable version.
_Combinations with high-precision optical and robust ENX encoders. Holding brakes are also possible.
_Combinations with gearheads are possible

Characteristics
The EC-4pole has a power-optimized motor design, delivering both high torque and a relatively high speed (25,000 rpm) at the same time. The result is a highly dynamic motor with high power per unit volume. The use of high-performance magnetic materials, the complex winding arrangement, and the optimized commutation result in a complex design.

Applications
The EC-4pole is a motor for dynamic, high-precision direct drives. Its relatively high torque can render additional mechanisms and gearheads superfluous. The high-resolution optical encoders are perfect for precise and stiff positioning and for controlling low speeds.

Special versions
The 30 mm motor forms the basis of several more specialized versions that are used in the aerospace industry. Special models in 4-pole design include the 32 mm heavy-duty motors for extremely tough environmental conditions (in terms of temperature and pressure), or even immersion in an oil bath.

EC-i motor

IDX motor

4_ EC-i, IDX

_External iron core winding with relatively high inductance
_Multi-pole internal rotor with up to 8 pole pairs
_Range of diameters of EC-i: 30 mm, 40 mm, and 52 mm; various lengths
_EC-i 52 available with open housing and ventilation
_IDX: square cross-section with integrated encoder in industrial housing, with electrical connections, 2 lengths (M,L)
_All kinds of combinations with encoders, brakes, and gearheads

Properties and applications
EC-i is a range of powerful motors with especially high torques. This is achieved with a high number of pole pairs and a relatively large diameter. You could say they are the big brothers of the ECX TORQUE models. The small diameter of the rotor results in a medium to high dynamic response. EC-i motors are typically used in automation and production systems, and in relatively large laboratory devices.
The IDX is a motor for industrial use. In these larger models, note the substantial deviation of the motor parameters from a simple linear relationship. This is due to the high inductance of the iron core.

EC flat frameless

EC flat

5_ EC flat

_Internal winding with iron core
_External multi-pole rotor with high mass inertia
_Open design for improved heat dissipation by airflow through the motor at high speeds. Can be improved further by an open rotor design and additionally by the use of a fan
_Combinations with all kinds of gearheads. Integrated MILE encoder
_Frameless versions available, with separate rotor and stator for integration into the application

Characteristics
As their name implies, these motors are short but have relatively large diameters. The combination of the large external rotor with a high number of magnetic poles gives them high torque. However, the high mass inertia results in comparatively low dynamic response. Flat motors are cost-effective: They are the most economical maxon motors by far. Note the deviation of the motor parameters from a simple linear relationship, due to the high inductance of the iron core.

Applications
Flat motors are the perfect cost-effective solution for all applications where installation dimensions (especially length) are critical, and where the dynamic response does not need to be extremely high. Pumps are a good example. The flat motors often do not require an additional gearhead. However, combinations with standard planetary gearheads result in relatively short units with high torque. For robotic joints and exoskeletons, these motors are often combined with short, specialized gearheads (such as Harmonic Drive®) to meet high torque requirements and length constraints.

Photos: maxon

ECX TORQUE

_Iron core winding with relatively high inductance
_Multi-pole internal rotor with 4 magnetic pole pairs (8-pole)
_Only 22 mm diameter, with 3 different lengths (M, L, XL)
_Same or similar configurable shaft and electrical interfaces as ECX SPEED
_Combinations with configurable GPX planetary gearheads
_Integrated incremental or single-turn absolute encoders (EASY)

Properties and applications
The name itself indicates the characteristic feature of this motor: It is developed for relatively high torques and moderate speeds. Its long and slim design makes the ECX TORQUE a perfect motor for handheld tools that require higher torques but not very high speeds, such as power screwdrivers.

EC frameless DT

EC frameless DT

_External iron core winding with relatively high inductance
_Multi-pole internal rotor
_Flat, short, frameless design, with separate rotor and stator for integration into the application

Characteristics
The EC frameless DT design combines high torque with dynamic response. It is a further step toward so-called “torque motors” that are integrated into the applications and provide direct, stiff, backlash-free control. The first standard model will be presented in the course of 2021.

Comparison of design options

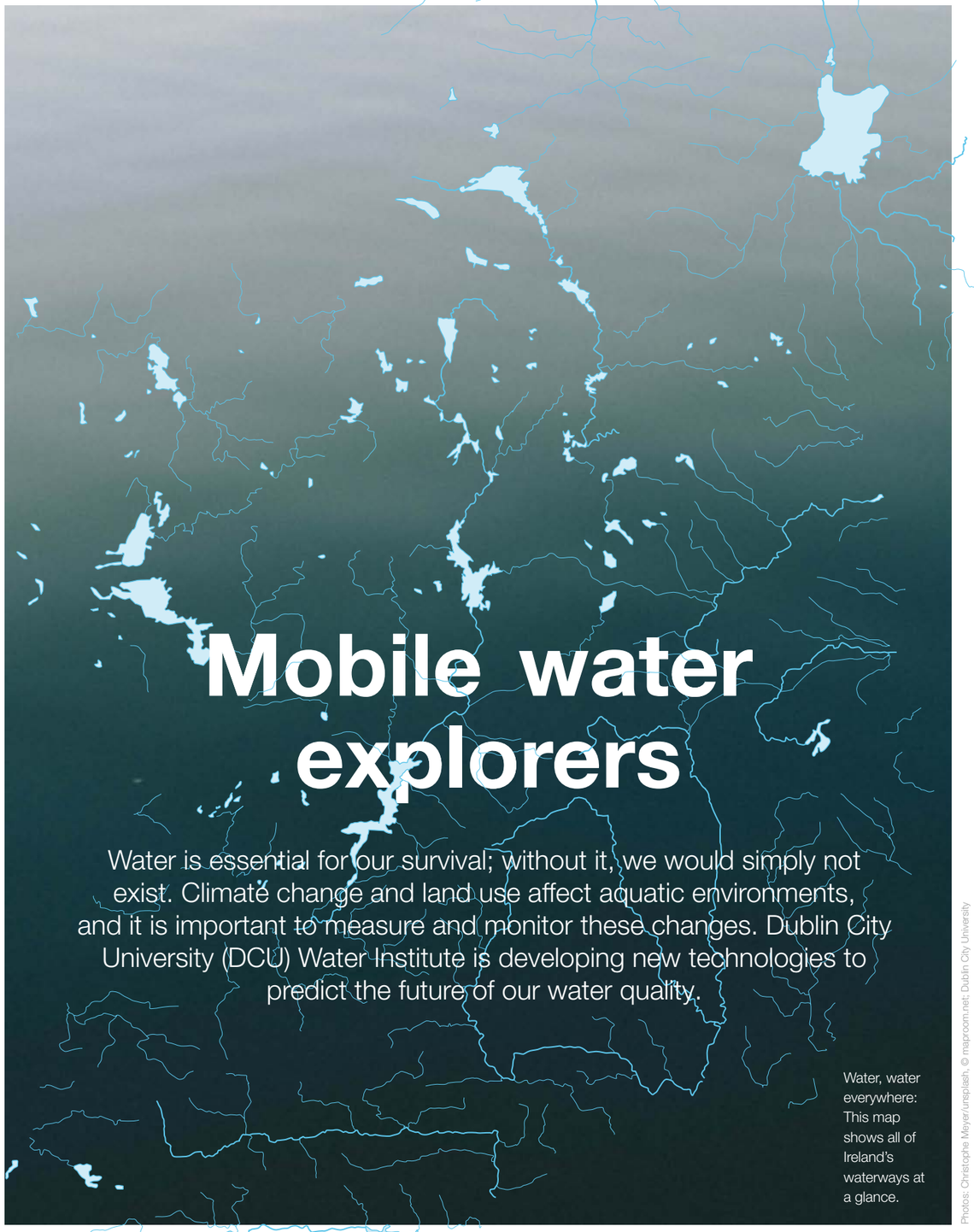
Iron core or ironless winding
maxon motors are customarily made with a self-supporting, diamond-shaped winding without an iron core, which enables cogging-free motor operation. Ironless windings are best suited to long motors that run at high speeds. They are used in maxon’s ranges of long-design EC motors with 1 or 2 pole pairs, such as the ECX SPEED, EC-max, and EC-4pole.

Shorter motors in multi-pole designs for high torques use windings with iron cores, such as the ECX TORQUE, EC-i, and EC flat ranges. The additional iron losses in the core put a limit on the top speed of these motors.

Multi-pole or 1 pole pair
One of the main questions when designing motors is whether the motor is to be designed for high speed or high torque. A higher or lower number of magnetic poles can be selected accordingly. Generally speaking, the more magnetic poles, the higher the motor’s torque and the lower the speed. Consequently, maxon’s EC motor ranges for high speeds – especially ECX SPEED – have only 1 pole pair, or a maximum of 2 pole pairs, as in the case of the EC-4pole.

maxon’s high-torque EC motors, such as the ECX TORQUE, EC-i, and EC flat ranges, are equipped with 4 or more magnetic pole pairs.
So-called “torque motors” often have an even higher number of magnetic poles. They are often designed for a specific application, in the form of high-torque direct actuators that do not require any additional gearheads or mechanisms. This enables stiff and highly precise control without any disruption from mechanical backlash. maxon’s frameless motors are a first step toward such torque motors.

Internal or external rotor
The dynamic response of a motor depends on the ratio of the torque to the rotor inertia, and is expressed by the mechanical time constant. The rotor inertia, in turn, is heavily dependent on the rotor diameter. The smaller the diameter, the lower the inertia and the more dynamic the motor, meaning a shorter response time.
Therefore, for a highly dynamic response, the diameter of an EC motor must be small. To achieve this, the magnetic rotor has to be close to the shaft inside the stationary winding. If multiple magnetic poles are used, such a design with an internal rotor can still generate high torque.
In products with an external rotor, such as the EC flat motors, the magnetic rotor surrounds the winding from the outside. This results in high inertia relative to the generated torque. Accordingly, the mechanical time constant is considerably higher.
Note that there are other important factors influencing the motor’s dynamic response besides the rotor inertia: the strength of the magnet, the available current, the dynamics of the current rise (i.e. the electrical time constant), all kinds of losses, etc.



Mobile water explorers

Water is essential for our survival; without it, we would simply not exist. Climate change and land use affect aquatic environments, and it is important to measure and monitor these changes. Dublin City University (DCU) Water Institute is developing new technologies to predict the future of our water quality.

Water, water everywhere: This map shows all of Ireland's waterways at a glance.

Photos: Christophe Meyer/unsplash, © maproom.net; Dublin City University

Author: Karen Whittaker

The project, sponsored by the Irish Marine Institute, involves studying freshwater sites where the quality is very good and monitoring any changes that could affect the ecosystem. Led by Professor Fiona Regan, Joyce O'Grady, a PhD student at Dublin City University (DCU) and Dr. Nigel Kent, director of the Centre of Research and Enterprise in Engineering at the Institute of Technology Carlow, have developed a sensor to detect low phosphate levels in selected catchments for real-time monitoring. Phosphates are a measure of nutrient pollution and control the pace at which algae and aquatic plants are produced. To mix and measure the water sample and the reagent fluid, Joyce and Nigel developed a centrifugal microfluidic disk that acts like a mobile lab, with six tests per disk. The ability to use a mobile lab reduces the risk of contamination, delivers a faster turn-around for results and produces real-time data. Dublin City University (DCU) is part of 'Beyond 2020', a research cluster consisting of six Irish and UK institutes examining new technologies for monitoring environmental waters to understand the role of aquatic ecosystems in a changing global environment.

Nigel Kent contacted maxon in Ireland, and maxon helped specify a maxon DC motor DCX 22 mm, together with the robust ENX 10 EASY 3-channel encoder for the necessary high-precision and speed control. Modifications were made to the shaft length, since a longer shaft was required with a flat edge to mount the disk. It was critical that the motor could spin above 5000–6000 rpm to drive the fluids towards the outside of the disk for a minimum of 60 seconds and, at the measurement stage, index the disk through 60 degree increments with sub 1 degree precision. The DC motor and encoder form part of a more extensive integrated firmware system. The system needed to be fully integrated with minimal sample handling to lessen contamination.

maxon also introduced the team to the Young Engineers Program (YEP). The program, aimed at students and start-up companies, supports innovative projects with electric drive systems. It offers technical support and maxon products at discounted prices. Nigel had previously only considered maxon products in final applications but not for prototyping. He says: "I assumed pricing would be a barrier, but the YEP program made it a no-brainer, as maxon products would have always been on my wish list. The level of customization available, especially at such low volumes, was impressive, and maxon's advice has been invaluable to the project."

The sensor is now fully validated, and studies are continuing in other areas with the full device. One study has been completed on a river, and another is due in a lower catchment area. The system will be replicated for four more studies to complete the project in its fifth year.

Nigel concludes, "Industry 4.0, or IoT, is finding its way into many different industries. The kind of system that Joyce is developing will be prevalent; autonomous sensors that you can leave out and get real-time feedback on the state of rivers or lakes will play a huge role in areas such as Agri 4.0. For example, the interconnected nature of technology, using drones for smarter spraying, reduces water runoff, which helps prevent water pollution and protects our drinking water resources. This will be the industry focus for the next 10–15 years."

Joyce O'Grady, PhD student at DCU, collecting data with the centrifugal microfluidic disc she developed.

More information:
dcuwater.ie

Zurich-based startup MyoSwiss has developed a lightweight exoskeleton that works like an e-bike for the legs. It assists the wearer's movements with electronic reinforcement.

"A fantastic feeling!"

Text: Anja Wieder

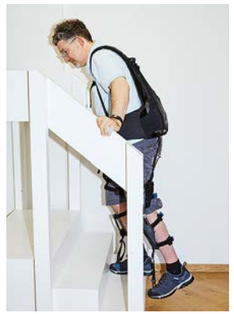
Thinking about every single step as you walk? Who does that? Most of us take the ability to walk for granted. For Matthias, however, it's a task requiring great concentration and effort, because he suffers from the autoimmune disease multiple sclerosis (MS). Nevertheless, he always has a goal to strive toward – to get up the 135 steps to his vacation home in southern Switzerland without being "totally wrecked" afterwards. So, once a week, the 56-year-old Matthias trains with the Myosuit.

Mobility despite weak muscles

The Myosuit is an exoskeleton for people who need extra strength and support in everyday life. It is a training device for people with movement restrictions in their legs, resulting from an accident, a chronic disease such as MS, or age-related muscle weakness. A certain degree of residual muscle function is a prerequisite for using this soft exoskeleton, which was developed by Zurich-based startup MyoSwiss. "Everyone should have the privilege of being able to move freely and without restriction, because movement is central to life and crucial for independence and quality of life." This is the company's guiding principle, according to CEO and co-founder Jaime Duarte.

An "e-bike" for the legs

Sitting down, standing up, walking, and climbing stairs all become much easier with the Myosuit. The exoskeleton provides localized support and strength in the hip area and in the legs – only ever as much as the wearer needs in certain situations, such as standing up.



Lunges, rowing, climbing stairs: Once a week, Matthias trains with the exoskeleton to build up muscle strength. His big goal: to make it up the 135 steps to his vacation home without being totally exhausted afterward.

"Patients have more stamina because of the electronic reinforcement of their muscles. It works a bit like an e-bike for the legs," explained Gleb Koginov, senior mechanical engineer at MyoSwiss.
The Myosuit, which weighs only 5.7 kilograms, is placed on the hips and legs, over normal clothing. The two electric motors and the control are housed in a small backpack. They use cables and passive elements to support flexion and extension of the hip joint and knee joints. The intensity and sequence of the electrical support is controlled with the help of motion sensors on the torso and legs.

Powerful drives for strong legs

"For our exoskeletons, we need compact, quiet drives and motor controllers which can be integrated directly

Photos: Claudia Klein

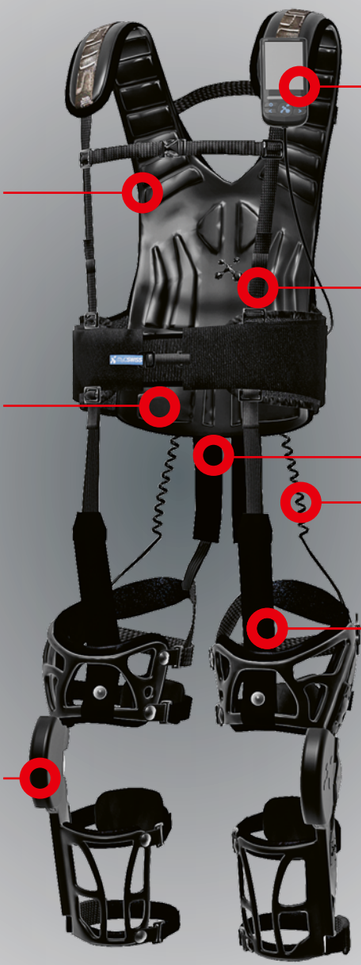
Myosuit: Assistant for greater movement

When muscles are weak due to
- **Age**
- **Injury**
- **Genetic diseases**

Weight: 5.7 kg
(like a light hiking backpack)

The technology – machine learning and AI

- **Personalized algorithm –** the suit adapts to the user's individual gait pattern and activity
- **Support –** every 10 ms, the system looks at what the user is doing and calculates the optimal support at that moment
- **Real-time tracking –** enables detailed gait analysis and visualization of progress



Backpack
Comfortable and as light as a small hiking backpack

Rear side of drive unit
Two maxon BLDC motors operate the sinews that assist the user's movements

Knee braces
The forces are channeled from the drive unit into the legs

Remote control
The Myosuit controller

Harness
Holds the drive unit and battery of the Myosuit. It consists of shoulder straps, hip belt, and chest strap

Guide element
Guides the sinews along the back of the legs

Sensor cable
Conducts the data from the sensors in the knee braces to the drive unit

Passive components
Elements like rubber bands support the flexion of the hip, knee, and ankle joints

Dynamic drive

EC-i 40
The brushless drive EC-i 40 features impressive dynamic responsiveness and high torque. It really comes into its own when space is at a premium.

See the Myosuit in action now:
https://www.youtube.com/channel/UCvuxVbn9u7T7r6EP2LH6P3w

Information:
www.myo.swiss

Depending on use, the battery lasts up to
4 hours

Facts and figures on startup MyoSwiss

- **2017:** Founded in Zurich by Kai Schmidt and Jaime Duarte with support from Robert Riener, professor for sensorimotor systems at ETH Zurich
- **12** employees – a team of engineers, designers, and medical specialists
- Start of **2020**: Certification of the Myosuit / first commercial version

into the device, and have high energy efficiency and power density," said Koginov. These requirements are met by the drive combination of BLDC motor EC-i 40 and GP 42 C gearhead plus maxon's EPOS4 Module 50/8 digital motor controller. The brushless EC-i40 is the world champion when it comes to dynamics and high torque in tight spaces. Jaime Duarte said, "For us, maxon simply has the best and most powerful motors we have found on the market. In addition, the support from the local engineers is very professional."

Vision of an everyday exoskeleton

The MedTech company MyoSwiss grew out of an ETH spin-off in 2017. The team, which now has twelve members, is comprised of young engineers, designers, and medical specialists. They work on further development of the Myosuit every day. It is already being used in rehab centers and hospitals in Switzerland and Germany.
The goal that Jaime Duarte and his team have set themselves is high: "An exoskeleton that can be worn every day just like a shirt or pants."
Until that time comes, Matthias keeps training. He is making progress: He can now get up the stairs to his vacation home without taking a break. He is less out of breath and in better shape. "I still have to catch my breath at the top, but who doesn't after 135 steps?"

"Movement is central to life and crucial for independence and quality of life."

Jaime Duarte, CEO and co-founder of MyoSwiss AG

Photos: Myoswiss, Claudia Klein

"Running the Joggathlon with the Myosuit"

Matthias was diagnosed with multiple sclerosis in 1997. The first few years were not very difficult, but then his ability to walk deteriorated more and more. For him, this was no reason to give up his love of exercise and nature. That's why he's been training with the Myosuit for about two years.

Text: Anja Wieder

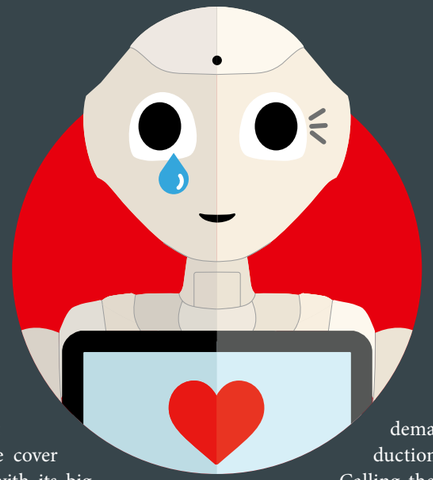
How did you find out about MyoSwiss?
About two years ago, MyoSwiss presented the Myosuit at my multiple sclerosis support group. I tried it out right there, and walked dozens of times around the table. My legs felt very light afterwards. That was something special, because my disease usually makes them very heavy. That effect of "light legs" lasted a long time.
At that point I knew right away that I wanted to be a tester for MyoSwiss.

How does the Myosuit make your life easier?
It increases my quality of life and maintains it at a certain level. It supports me in movements that are otherwise fairly difficult for me. What I lose through MS, I can restore through training with the Myosuit, at least for a certain time.

What is the furthest distance you have gone so far?
After the strength, endurance, and balance exercises with the Myosuit, I was able to run 1.8 kilometers with the Myosuit at the Joggathlon in Zurich in 2019. I made the finish line in 2.5 hours – I had sore muscles the next day but I was only slightly exhausted. A fantastic feeling!

Now what, Pepper?

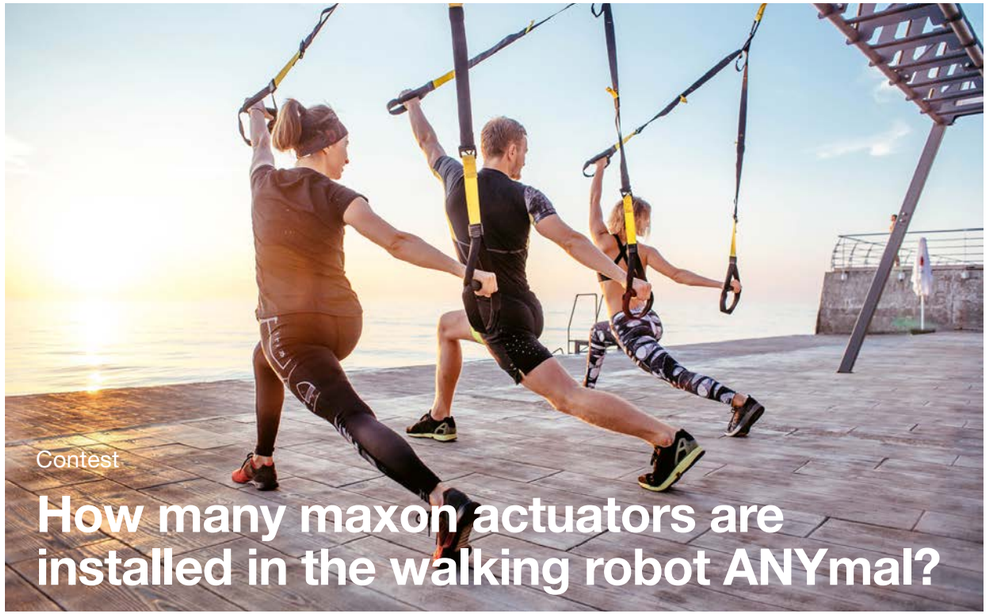
Text: Stefan Roschi



In 2015, the humanoid robot Pepper looked out from the cover of our customer magazine with its big round eyes. I met it for the first time not long before, at a robotics fair in France, where I watched in suspense as the 120-centimeter-tall robot was wheeled out of its transport crate. Head hanging, lifeless – but then it began to move around, talking to people and gesticulating wildly with its arms. Pepper was without a doubt the star of the show. I was fascinated and at the same time a little disappointed, because I wasn't able to have a real conversation with it due to the noise in the hall. However, the world – and especially its Japanese manufacturer SoftBank – had great expectations of the world's first mass-produced social robot. Pepper could be deployed as a receptionist, a social facilitator, or simply a friend at home. It could read the gestures and facial expressions of those around it and react to them. It could sing, dance, and give you the weather forecast. The first 1000 units sold in just one minute.

Six years have now passed and the euphoria has evaporated. SoftBank announced back in 2020 that it would stop producing Pepper – because of insufficient demand. Should that change, production would be ramped up again. Calling the venture a failure would be an oversimplification. Pepper did show us the possibilities of the future. Of course, at fewer than 30,000 units, production of the robot was well below expectations. There's also no question that many people were disappointed by Pepper's actual abilities. The first encounter might have roused a certain enthusiasm, but even the second or third encounter tended to be noticeably cooler. Conversations were hardly better than with chatbots, namely superficial and not very personal. Also, Pepper could only wave its hands around, it could not grasp anything. Perhaps its human appearance was its undoing, because that led us to demand human abilities. Robots still can't come close to matching our brains or bodies. However, we don't expect that from a vacuum-cleaning robot, nor from a digital assistant in a small loudspeaker. So this is perhaps Pepper's greatest success. It has shown us what it means to be human.

Illustration: Peter Kruppa



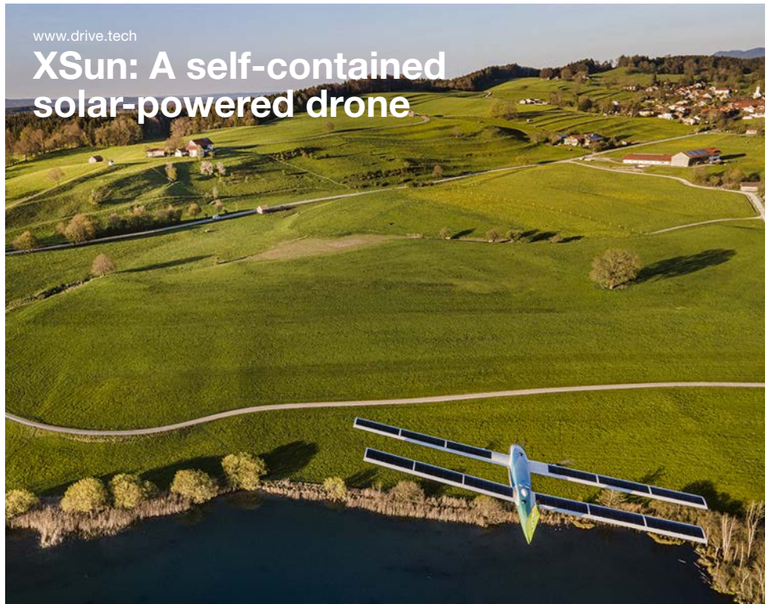
Contest

How many maxon actuators are installed in the walking robot ANYmal?

All participants with the correct answer will be entered into a draw to win **three suspension trainer sets from TRX.**
Good luck!

E-mail your answer to:
driven@maxongroup.com

The deadline for entries is January 31, 2022
Winners will be notified. maxon employees are not eligible to participate.
No correspondence will be entered into in regard to the contest. All decisions are final.



www.drive.tech

XSun: A self-contained solar-powered drone

Photos: Olga Osadchaya | Dreamstime.com; XSun

www.drive.tech

Why not take a look at our blog?

The maxon corporate blog **www.drive.tech** has many exciting reports, videos, and technical articles in which maxon experts offer their knowledge. Get excited, learn new things, and discuss with our bloggers.

For example, take a look at this article about an autonomous, solar-powered drone from the company X-Sun.

Tough opponent

Ceramic has a lot of great properties such as immense hardness, wear resistance, and temperature resistance. For this reason, it is often used to make motor shafts, gearhead parts and other components. maxon specialists are experienced and adept in working with this material – just like chess grandmasters.

Photo: Jeremias Wieland, maxon