

DRIVEN

by
maxon



The field of the future

Help from above: How robots are revolutionizing agriculture. p. 8

Startup: When paralyzed children can stand on their own legs again. p. 38



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Heroes of this issue

Lightweight

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High performer

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Resistant

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Eugen Elmiger,
CEO maxon Group

Robots are conquering agriculture

Robots can already be found in many barns. They feed animals, milk cows, and remove manure. But we are only at the beginning of a robotic evolution that is spreading through all areas of agriculture. In the future, drones will monitor fields, spray plants with precision, or send important information to robot colleagues on the ground that pull out weeds and harvest fruit. This issue of driven explores where we are today when it comes to automated agriculture, and what the future holds.

We also present an inspiring application that helps children, developed by a Canadian company. We also asked maxon employees about their experiences during the most challenging time of the pandemic, when demand for motors in medical devices suddenly skyrocketed. And last but not least, we provide you, our dear readers, with helpful technical information for applications with highly dynamic controllers and networked bus systems.

Happy reading!

Touchdown!

Even in the era of COVID-19, Mars landings are highly emotional. There were no hugs, but plenty of relieved eyes and happy cheering when NASA's fifth rover, Perseverance, sent a signal to Earth on February 18, 2021. Soon thereafter, the first image the robot took of its new home turf appeared on the screens in the control room of the Jet Propulsion Laboratory on the west coast of the USA. A huge sense of relief was also palpable at maxon, as provider of ten electric drives in the Perseverance rover. Another six micromotors from maxon control the Mars helicopter.

For more information, visit:
mars.maxonworld.com



DCX 10

Six brushed DCX motors with a diameter of 10 millimeters control the tilt of the rotor blades of the Mars helicopter. The drives are energy-efficient, dynamic, and extremely lightweight. Every tenth of a gram has to be saved to enable the drone to take off on the Red Planet.



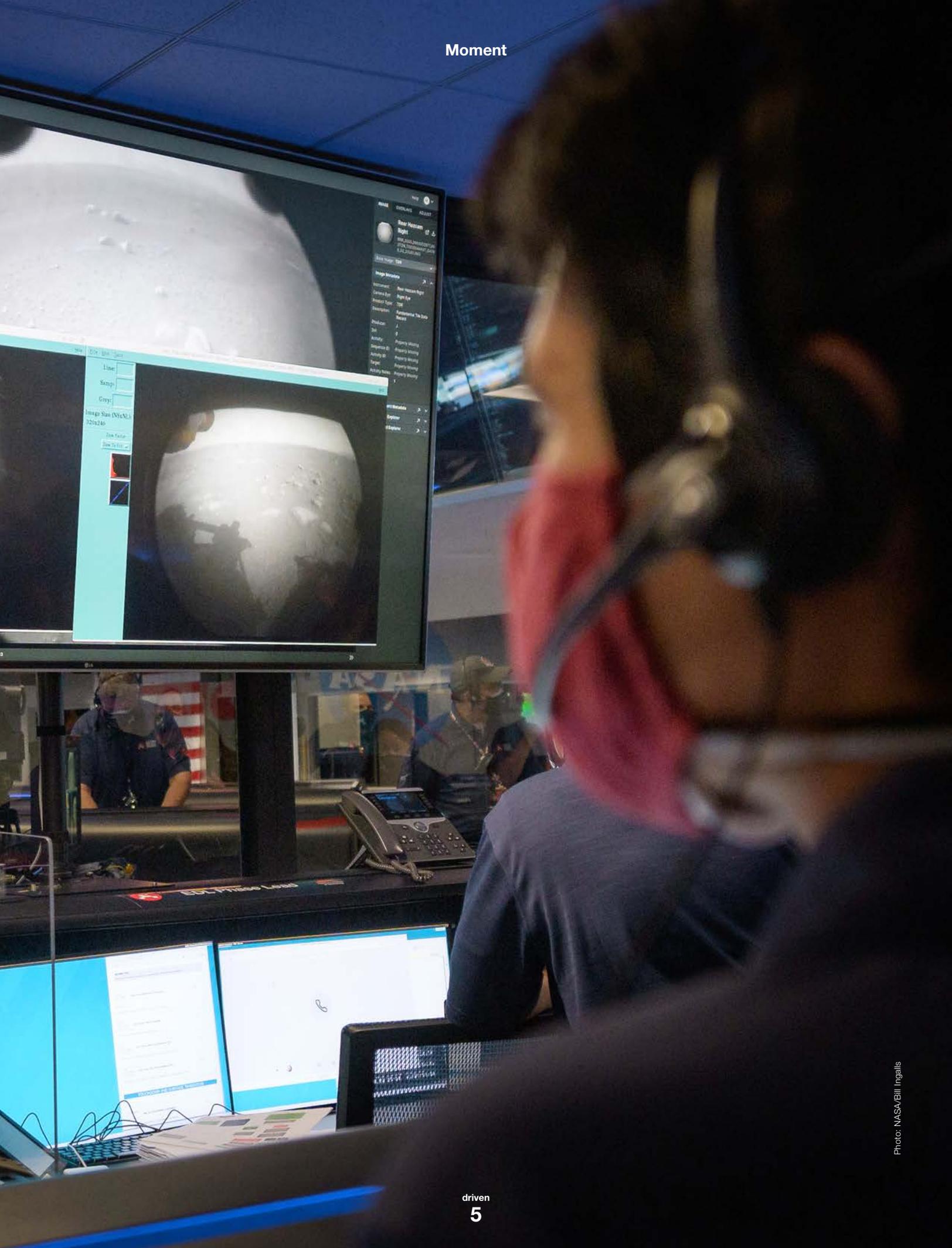
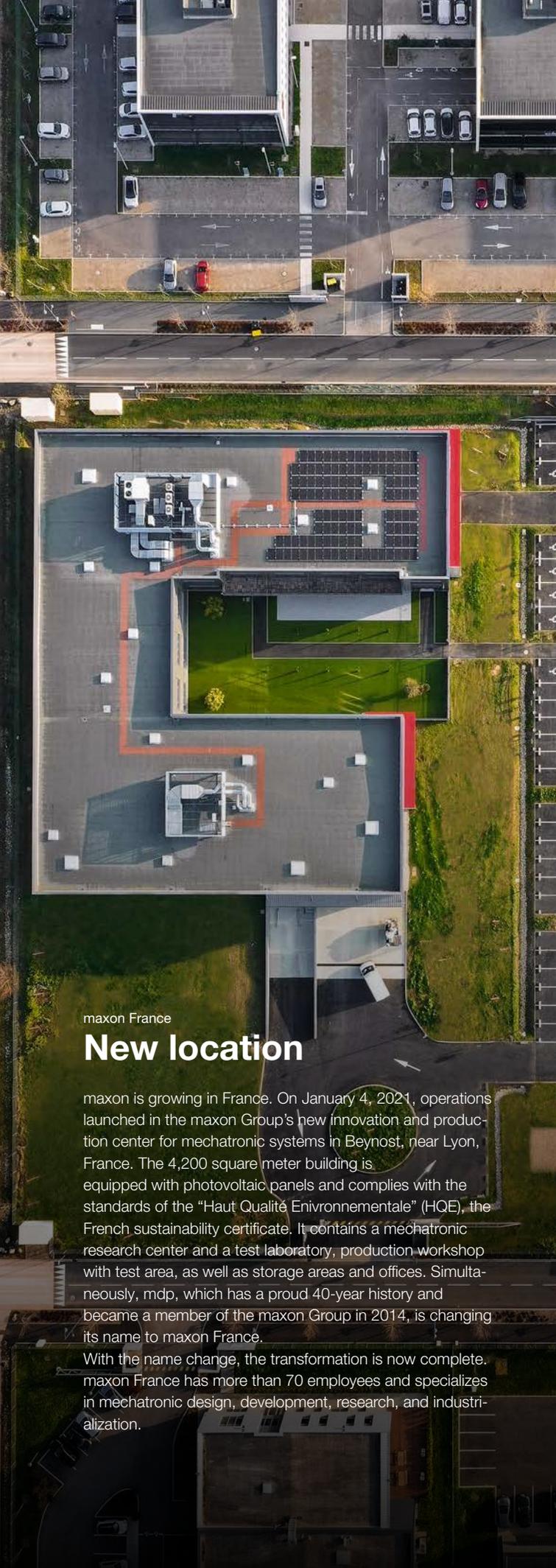


Photo: NASA/Bill Ingalls



maxon France

New location

maxon is growing in France. On January 4, 2021, operations launched in the maxon Group's new innovation and production center for mechatronic systems in Beynost, near Lyon, France. The 4,200 square meter building is equipped with photovoltaic panels and complies with the standards of the "Haut Qualité Environnementale" (HQE), the French sustainability certificate. It contains a mechatronic research center and a test laboratory, production workshop with test area, as well as storage areas and offices. Simultaneously, mdp, which has a proud 40-year history and became a member of the maxon Group in 2014, is changing its name to maxon France.

With the name change, the transformation is now complete. maxon France has more than 70 employees and specializes in mechatronic design, development, research, and industrialization.



Strong partnership

maxon and Fourier Intelligence to closely cooperate in future

The maxon Group is entering into a strategic partnership with Shanghai-based startup Fourier Intelligence, which specializes in exoskeletons and rehabilitation robotics. The two companies are joining forces to develop industry-leading technology products and platforms for treating patients.

Fourier already uses electric motors from maxon in its ExoMotus X2 exoskeleton. Additionally, maxon is joining EXOPS™ (Exoskeleton & Robotics Open Platform Systems), an open platform for the research and development of exoskeletons and robotics systems. Here, maxon will provide aspiring engineers interested in robotics solutions for rehabilitation services with a wide variety of custom drive options consisting of motors, gearheads, encoders, and controllers.

"The partnership between maxon and Fourier is a strong combination," says Eugen Elmiger, CEO of the maxon Group. "Fourier's understanding of the interaction between modern rehabilitation robotics and technological products perfectly complements maxon's philosophy of making the world a little better with our high-precision drive systems." Zen KOH, co-founder and acting CEO of Fourier Intelligence, says: "The partnership with maxon will enable us to provide the best technological portfolio, which will in turn serve as the basis for the next generation of transformative technological products and platforms."





Tough job

“Mars mole” ends mission

Although Mars is a hostile place for technology, more than a hundred maxon drives have already proven themselves on the Red Planet. This includes the now-complete mission of the HP³ measuring devices on board the NASA InSight probe. The measuring device, affectionately named “Mole”, was developed by the German Aerospace Center (DLR) and was designed to hammer its way several meters into the Mars soil.

The main goal was to derive information about the thermal conditions inside Mars by measuring the heat flow below the surface. Unfortunately, the soil on the Red Planet did not behave as expected, and the researchers never managed to dig deep with the Mole.

It now remains just below the surface and supplies measuring results from there. On the hardware side at least, the project was a complete success. The components proved themselves able to cope with much tougher conditions than originally planned. The maxon drive in particular provided impressive performance. This drive activated the hammer mechanism, which consists of a modified DCX 22 motor and a GP 22 HD gearhead.



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

shop.maxongroup.com

New products



ECX 22/32/42 flat
Brushless

ECX 22/32/42 flat

Brushless flat motors for maximum performance

With the configurable ECX flat product family, maxon is launching a new generation of external rotor motors in the fall of 2021. The ECX flat motors have been optimized for maximum performance by implementing a special winding technology and segmented magnets. The ratio of torque to weight and installation size makes them perfect for UAV and robotics applications. The iron core motors will be available in diameters of 22 mm, 32 mm, and 42 mm, each with a long and a short version. The short versions are just 14 mm, 16 mm, and 21 mm long. Additionally, there will be cost-optimized versions for each diameter. All versions are also equipped with integrated encoders or integrated speed controllers as a drive system.



IDX 70
Brushless

IDX 70

A compact drive powerhouse

The IDX 70 is the newest addition to the IDX series and continues in the footsteps of the IDX 56. The two sizes expand the performance range to up to 1 kW, with up to 4 Nm continuous torque and more than 8 Nm peak torque. To support this new drive, a new, brushless EC-i motor, supplemented by a specially designed positioning controller, has been developed. Together with the ENX 16 EASY encoder, highly dynamic positioning tasks can be performed with very high precision. Digital and analog inputs and outputs, as well as a wide range of functions and modes, are available to customers.

Support from the sky

Weeding robots, spraying drones, and remote-controlled mowers: modern agriculture is increasingly becoming an open-air high-tech lab. More and more farmers are using drones in areas as diverse as winemaking and pest control in corn crops.

Text: Astrid Tomczak

In July, the drones of Fenaco Agroline will be flying over the cornfields again. Their mission: to get rid of European corn borers – by means of biodegradable capsules that contain parasitic wasps (trichogramma). The wasps lay their eggs in those of the corn borer and thus parasitize them. In organic farming, parasitic wasps have been used for pest control for many decades. However, until recently, this required laborious manual work. The multicopter only needs four minutes to distribute trichogramma wasps over an entire hectare of corn – around five times less than a farmer.

Precise and quiet

In Switzerland alone, 25 drones are currently in use in agriculture. A second area of application is viticulture, in particular on steep hillsides, as Thomas Anken explains. He is head of the Digital Production research group at Agroscope, the Swiss center of excellence for agricultural research, and has been specializing in the topic of digitization in agriculture for many years. The drones spread pesticides over the vineyards. “This reduces the workload immensely,” says Anken. The advantage of the little helpers from the sky is that they do their work with high precision and very quietly – unlike helicopters, for example. Helicopters also cause wind drift, which means the pesticides end up where they don’t belong. The drones, on the other hand, can be



deployed exactly where they are needed, by using GPS-supported programming. However, this solution isn't cheap. A drone can only carry a load of 15 liters of pesticide and costs around CHF 30,000 to buy. Additionally, the user has to know the technology well.

For these reasons, farmers are joining forces and hiring contractors for drone services. Even though this means that the farmers have to relinquish a certain degree of control, the feedback is “very good,” says Anken.

Switzerland is playing a key role worldwide in the development of drone technology. This concerns in particular the development of sensor technology, drone control, and data processing, where international standards are being set. It also applies to legislation.



Getting a bird's eye view frequently provides new insight – this also holds true in agriculture. How do drones help to make the hard work in the fields easier? Read on to find out.

Currently, Switzerland is the only European country with official approval of spraying drones in agriculture and is therefore in high demand as an advisor for international standardization.

Saving lives

Drones are frequently used as flying cameras. One example is the rescue of fawns with IR cameras. For large-scale recordings of agricultural land, satellite images are an economical alternative. “The European Space Agency (ESA) provides satellite images free of charge,” says Thomas Anken. However, they have a much lower resolution, and clouds can obstruct the view. Another application is determining how well crops are supplied with nutrients. This can be measured by means of multispectral images. It is thus possible to supply each area of the crop field with exactly the amount of fertilizer that the plants there will absorb.



This also helps to minimize adverse effects, such as nitrates leaching into the groundwater or nitrous oxide being emitted into the atmosphere.

In fact, drones are already being used for agricultural purposes all over the world. In Africa, it is considered a key technology and is used to map areas of land, so that farmers can assert their land rights. Drones are also used in the fight against drought. In Sudan, drones release acacia seeds in areas where there is risk of desertification, while the health of numerous plants is diagnosed by means of aerial shots. The collected information enables farmers, researchers, and relief agencies to reduce crop damage.

A look at Japan shows what the future of agriculture could be like. For the rice farmers there, using drones is commonplace. Yamaha launched its unmanned mini-helicopter on the market as early as 1990.

Top: Drones are increasingly being used to distribute pesticides over vineyards. The benefit: They work quietly and with high precision.

Right: In Japan, drones are commonplace. Rice farmers use them to accurately spray their fields, which are frequently quite small.





1



3



2

4



5



- 1** Capsules containing parasitic wasps are used to kill European corn borers.
- 2** Drones are ideal for use on steep hillsides.
- 3** Satellite images send important data to tractors, etc.
- 4** Fighting drought in Sudan by dropping acacia seeds.
- 5** Drones help to find wild animals.
- 6** Help on the ground: the unmanned Rowesys field robot (see page 16).

6



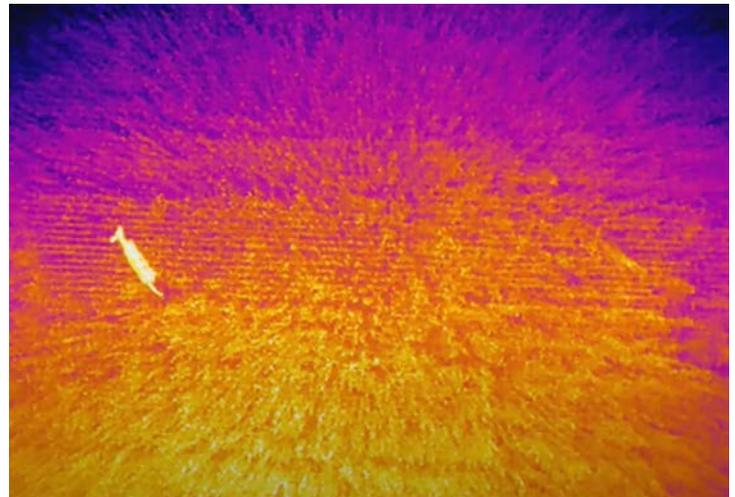
Today, more than 2,300 devices from various manufacturers are used to treat the rice fields. The Japanese drones will soon also be permitted in the USA. According to a study of the Association for Unmanned Vehicle Systems International (AUVSI), permitting civilian drones in the USA could result in the creation of 70,000 new jobs within three years, and revolutionize agriculture.

Slow adoption

Switzerland cannot yet compete with these statistics. And perhaps it will never be able to do so. Nevertheless, Thomas Anken believes that there is still potential for future applications, such as early detection of disease by means of targeted imaging procedures. However, the “integration of this modern technology in actual agricultural processes will tend to be slow,” as the “Technology Outlook 2019” of the Swiss Academy of Engineering Sciences (SATW) established. This is, in part, due to “agricultural subsidies that are only loosely tied to production efficiency,” as the report states. Thomas Anken assumes that the use of drones for pest control will remain a niche application in Switzerland in future. “But on steep hillsides, the drones could become standard.”

However, agriculture is not only being revolutionized from the sky – prototypes of digital helpers are also found on the ground, for example field robots (see the article on Rowesys) or remote-controlled mowers

on hillsides. Thomas Anken sees great potential for such unmanned vehicles. However: “There are legislative gaps, for example regarding liability in the event of accidents,” says Anken. For the time being, human farmers are still far from obsolete. ■



Top: IR cameras on drones help to rescue fawns.

Bottom: With satellite images from the ESA, large landscapes can be mapped.

“Electromechanical drives will continue to play a role in the future”

No harvesting robot or pesticide drone can operate without a drive. Roman Berger, Head of Business Development Robotics at maxon, explains what the future holds.

Interview Astrid Tomczak

Roman Berger, robots and drones are increasingly being used in agriculture. Can you give us examples that use maxon technology?

The agricultural robot market is growing worldwide. Usually the products come from startups, but they are increasingly being supported by big players. E-Terry from Germany is an example of such a startup. It is an autonomous carrier platform for devices for automated soil analysis, plant care, and harvesting. The drive axes are equipped with drives from maxon. The French company Vitirover also uses maxon systems for its mower robots. There are lots of other examples, but unfortunately many of them are still confidential.

Which special challenges do the drive systems face in this field?

In agriculture, the technology used has to be reliable and robust against environmental influences, such as relatively high ambient temperatures, yet also has to be cost-effective. This is a big challenge. maxon is meeting these requirements with new motor and gearhead products with significantly higher torque specifications, such as those produced by our subsidiary Parvalux. In comparison to conventional automation in industry, new communication bus systems – the hubs for data transmission, so to speak – such as CAN J1939 and ISO bus present new challenges.

What do you think the future holds?

The pressure to reduce pesticides will increase dramatically in the coming years, judging by the discussion regarding glyphosate, for example. In view of climate change, it is becoming increasingly important to reduce soil compaction, in order to better utilize – or

Roman Berger
Head of Business Development
Robotics at maxon.



retain – the soil’s ability to store water. Another sign of this development is the fact that large companies such as Bosch, Continental, BASF, and Fendt are advancing research in this field. Experts estimate that the market for agricultural robots will grow to EUR 12.4 billion by 2025. Software products such as smart farming solutions, including robot fleet management, will take up the lion’s share. But electromechanical drive solutions will also have a significant share, with an estimated EUR 1 to 2 billion.

How important is this market for maxon?

The market is young and it will take time until the means of communication for smart farming have been established. However, it is quite possible that the agricultural robot sector could account for 5 to 10 percent of maxon’s revenue by 2030, with intelligent and reliable drive systems and suitable communication interfaces as a bridge to smart farming solution providers.





1

Harvesting in the greenhouse

Ability:

The use of image processing software and robots has given rise to new harvesting systems for high-value crops such as tomatoes. The harvesting robots in the aisles of the greenhouse can distinguish ripe crops from unripe ones, and can harvest and package them in boxes.

Benefits:

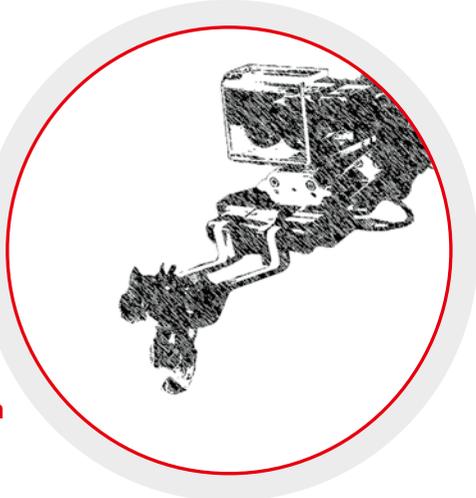
- > Around-the-clock harvesting
- > Decreased workload for harvesting staff
- > Data analysis



The future of farming



2



Material handling in the greenhouse

Ability:

Robots that safely work side-by-side with humans can handle manual tasks such as dividing plants. They can also optimize the placement of plants, for example.

Benefits:

- > Improved plant quality
- > Reduced use of water, pesticides, herbicides, and fertilizer
- > Lower production costs



3

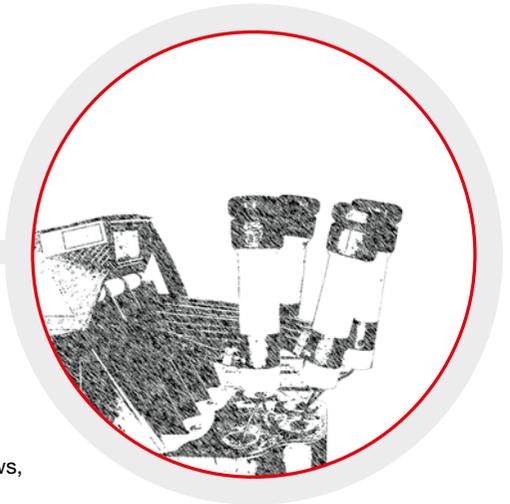
Barn automation

Ability:

In the barn, robots help with replenishing fodder, milking cows, and removing manure.

Benefits:

- > Increased performance
- > Reduced workload for farmers
- > Improved health and well-being for cows
- > Improved hygiene on different ground surfaces
- > Data analysis





4

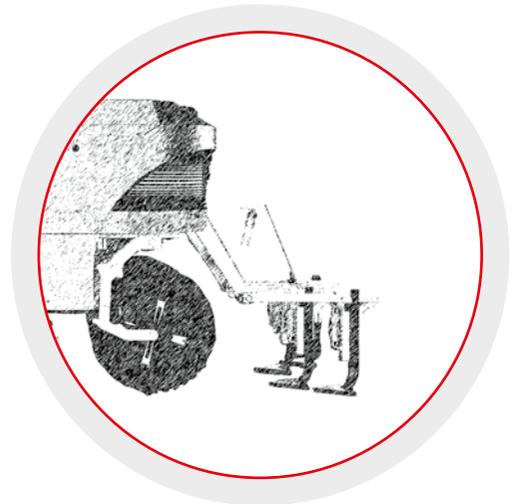
Aerial imagery drones and seeding drones

Ability:

Many drones are equipped with multispectral cameras and photo cameras, monitor the health and growth of crops, and can predict the crop yield. Drones can also carry and distribute payloads such as seeds, herbicides, fertilizer, and water. They are also able to charge themselves at weatherproof docking stations and transmit data for analysis purposes.

Benefits:

- > Very good cost-benefit ratio, information is gained and time is saved
- > Time and location-independent
- > Fast and efficient monitoring of large areas
- > High-resolution detailed recordings
- > Can be controlled with high precision
- > Documentation and analyses are performed in an environmentally friendly way that does not damage the vegetation



5

Spraying and weeding robots

Ability:

Robots are programmed to recognize weeds in the field. The goal: Pulling out weeds, or targeted application of pesticides.

Benefits:

- > Reduced use of pesticides

Whether in the field, in the barn, or in the greenhouse, robots and drones already handle a lot of tasks. Here's what they can do.



6

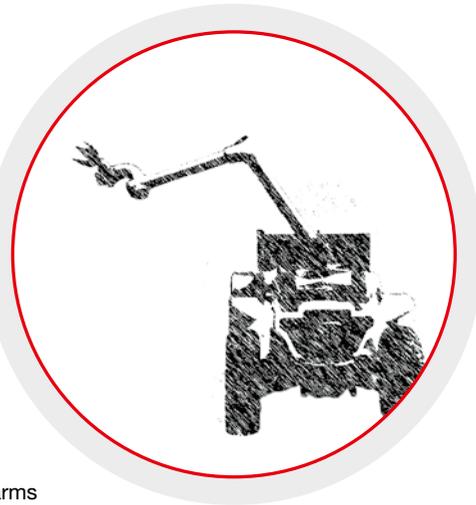
Robots for harvesting fruit

Ability:

Machines use a combination of image processing and robotic arms to harvest strawberries, cucumbers, or apples, for example. The robots also help out with quality control and sorting.

Benefits:

- > Around-the-clock harvesting
- > Decreased workload for harvesting staff
- > Data analysis of the harvest



7

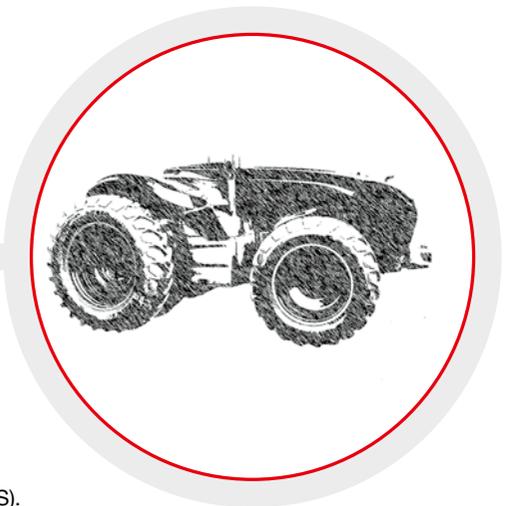
Autonomous navigation

Ability:

Tractors and other agricultural devices move around fields autonomously (e.g. by using GPS).

Benefits:

- > Reduced workload
- > Relatively precise positioning
- > Adapts to steep terrain
- > Teachable





Weeding today and yesterday: A blue signal and LED colors inform the farmer about the status of the autonomous crop helper. In the past, weeds had to be pulled out by hand without robotic assistance, or sprayed with herbicide.

Autonomous field helper

At the ETH Zurich, a robot has been developed to mechanically destroy the weeds growing between crops. “Rowsys” is conveniently started via remote control – and makes herbicides unnecessary.

Endangered species diversity, overburdened ecosystems, and too much pesticide in the groundwater and in the air: the world urgently needs more sustainable agriculture. This transformation is possible, as proven by the growing number of innovative approaches – such as the Robotic Weeding System, or Rowsys for short, developed at ETH Zurich. This project shows that forgoing chemicals that kill weeds, fungi, and pests does not mean forfeiting profits. The prototypes of Rowsys are especially suitable for use in sugar beet fields, which require very intensive weed control. Whereas other solutions only concentrate on reducing pesticides, for example by means of more accurate spraying methods, the ETH robot makes the use

of herbicides obsolete. It pulls the weeds out of the soil between the rows of plants, makes a turn at the end of the field, and continues along the next row. The autonomous robot can even handle mud or rocks in its path. Pascal Lieberherr, initiator of the project and a master's student in Robotics, Systems, & Control at ETH Zurich, became aware of the challenges in the food chain during his apprenticeship in food processing. Today, he is particularly interested in a key question: How can we feed humankind without burdening the nature of our planet?

Efficient cultivation

The team, which consists of mechanical and electrical engineering students from ETH Zurich and industrial





For the ETH team, it was important that the robot is user-friendly. It does not need GPS navigation and the developers are planning a future version that will even be able to return from the field to the farmstead by itself.

design students from the University of Applied Sciences and Arts Northwestern Switzerland (FHNW), developed a robust locomotion concept. The vehicle is driven by four e-scooter hub motors that have a compact transmission, due to the small distances between the crop rows.

A mechanical spring-damper system ensures that the individually controllable wheels are always in contact with the ground and continue to work reliably even if the plowshares are immersed. This is important, on the one hand, because faulty operation would damage the crops and reduce the yield. On the other hand, the well-balanced weight distribution reduces localized soil compaction.

In addition to process reliability, user-friendliness was another aspect to which Pascal Lieberherr and his team gave high priority. As a result, Rowsys does not need GPS and can be conveniently remote-controlled. For a future version of the robot, it is planned that the robot will drive itself from the farmstead to the field and back again. Two powerful batteries ensure that an eight-hour shift is possible.

Wind, disease, and pests

Two visual sensors take care of navigation in the field. While the front camera detects the rows of plants, the one facing the soil distinguishes between weeds and crops. The software, which was programmed especially for this purpose, analyzes the images of the front camera for green areas and thus detects the direction of the crop row. It is planned to implement teachable software for analysis of the soil image. The purpose of this is to widen use of the software to other crops, such as corn. Developing the software presented several challenges.



RE 50 DC motor

Each wheel axis of Rowsys can be rotated 180 degrees on both sides and is controlled by a drive unit that consists of an **RE 50 DC motor** with a **GP 62 planetary gearhead** for the speed reduction and an encoder. This motor offers high efficiency, is energy-efficient, and extremely powerful.

Young Engineers Program

With its Young Engineers Program (YEP), maxon supports innovative projects with discounted products and technical advice.



Apply now:

www.drive.tech

One such challenge were the strong gusts of wind that blow the leaves into new positions within seconds. The system then has to immediately reinterpret the rapidly changing images and react accordingly. Work is still required in the area of detection of diseased plants, or those affected by pests.

The enthusiastic response to the project when it was presented in the summer of 2020 convinced Pascal Lieberherr that development of the intelligent agricultural robot is set to continue. In June 2021, the Agri-food Competition for Robot Evaluation (ACRE) will be held. This initiative is supported by Horizon, the EU Framework Program for Research and Innovation. Here, mobile robots for agricultural use will compete with one another, providing the perfect opportunity for Rowsys to show its strengths on the international stage. ■



Information on the project:
<https://rowesys.ethz.ch>



Special edition

As was the case four years ago at the first Cyathlon, the competitors solved everyday tasks with the aid of modern assistance systems. However, due to the COVID-19 pandemic, the teams completed their tasks in a specially designed “lockdown mode” in their own countries. Until the races were broadcast, the results remained a secret – even to the teams themselves. Viewers watching on their computers and mobile phones were therefore able to witness the emotion as the winners were announced.



“This was a resounding success for maxon. We are very proud to be a partner of such an important project, which is now into its third round. Let’s keep on setting new standards for the future of assistance technology.”

Eugen Elmiger, CEO maxon Group



Missed the live stream?

Want to know more about the teams and the races? For all videos, visit: <http://cyathlon.com>



Great news!

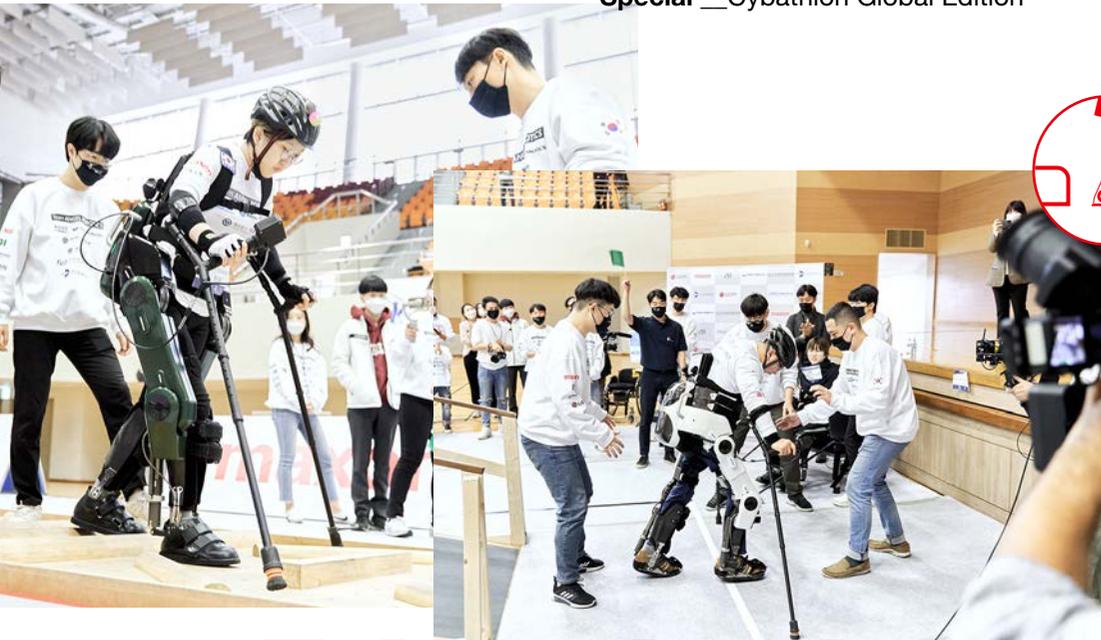
The next Cyathlon will take place in 2024 – once again in Switzerland.



Six disciplines

The event saw people and technologies compete in six disciplines: a virtual race using a brain-computer interface (BCI), a bicycle race with electrical muscle stimulation (FES), and an obstacle course with arm prostheses (ARM), leg prostheses (LEG), robotic exoskeletons (EXO), and motorized wheelchairs (WHL). The six disciplines were expanded to include new challenges with relevance for daily life – reflecting the technological progress made in recent years. For example, competitors in the wheelchair discipline now had to open a door using a robotic arm. In the obstacle course for arm prostheses, there was a “haptic box” in which the competitor had to identify the shape of an object by touch.

Photos: ETH Zurich



“The teams in the Cybathlon are fighting not only for victory, but also for progress in assistance technologies for people with disabilities.”

Roland Sigrist, Director of Cybathlon

Bionic heroes in lockdown mode

The Cybathlon 2020 Global Edition has come to an end. The second edition of the Cybathlon concluded on November 13 and 14, 2020. 50 teams from 20 countries competed. But this time, everything was different.



Out of the **50** teams taking part, one in **four** teams were using maxon products. **Five** of them even made it onto the podium.



**“Initial doubts
gave way
to a ‘can-do’
attitude”**

Edith Leisibach | Strategic purchaser at maxon



“Every delivered motor was a success”

Silvio Michel | Production engineer at maxon



**“It’s great that we
were able
to play our part”**

Christian Fritz | Director of Business Development at maxon

Getting through it together

During the pandemic, demand for life-saving medical devices – and thus for suitable motors – has increased. Three maxon employees tell us about their experiences.



1 Edith Leisibach

Strategic purchaser at maxon, Switzerland

“The pandemic presented us with major challenges. We had just four weeks to organize all the components needed for starting production on large orders of the ECX 16, ECX 22, and EC 22 brushless motors. Some of our suppliers were struggling with tough conditions such as lockdowns or severely limited production capacity. Additionally, global transport logistics were massively restricted. Eighty percent of all planes were grounded, ports were closed, and regular transport had slowed down significantly. Transport that usually took three days suddenly required ten. However, maxon has a strong supplier network, with which we in the Purchasing department kept in regular contact. We were thus able to quickly assess production progress, material availability, and other influencing factors, and initiated the necessary measures. It also helped that we reported early on that our motors are used in COVID-19 medical devices. As a result, our orders were given the highest priority. Personally, my experience as a member of the task force team has been positive. I got the chance to cooperate with colleagues from other countries and departments. We supported each other, and everyone involved, from sales and development to production, quality assurance and the entire supply chain, worked hard on the medical fast track orders. My doubts regarding the high quantities and scheduling vanished – because we employed solution-oriented thinking, took action accordingly, and embraced a ‘can-do’ attitude.”

2 Silvio Michel

Production engineer at maxon, Switzerland

“At the beginning of the 2020 pandemic, customer demand for drives for ventilators and laboratory devices increased massively. This was particularly noticeable in our department, because we produce brushless DC motors that are ideal for such applications. As part of the medical fast track process, our task was to supply the products as quickly as possible, with the desired quality. The question was never whether an order can be fulfilled, but when. There were several challenges to overcome. For example, the new safety measures to prevent infection involved wearing masks, keeping our distance, and a shift system that prevented the different teams from having contact with each other. This also meant that no overtime was possible. With the assistance of temporary staff, we succeeded nevertheless. Luckily, cooperation within the team was great. Everyone knew that I needed their support and that time was of the essence. Together we developed new processes, organized additional workstations, and

produced new equipment. The situation demanded a lot of flexibility from us all. At times, it was necessary to invest all available capacities into the medical fast track orders. We maintained close contact with customers throughout the entire production process. This sometimes led to customers’ process steps being performed by us to accelerate the supply chain. In hindsight, it was a very strenuous but instructive and interesting time. Every delivered motor was a success. And it felt good to be needed in these extraordinary times. For me, the high time pressure at work also helped to distract me from all the coronavirus stress outside of work.”

3 Christian Fritz

Director of Business Development at maxon, USA

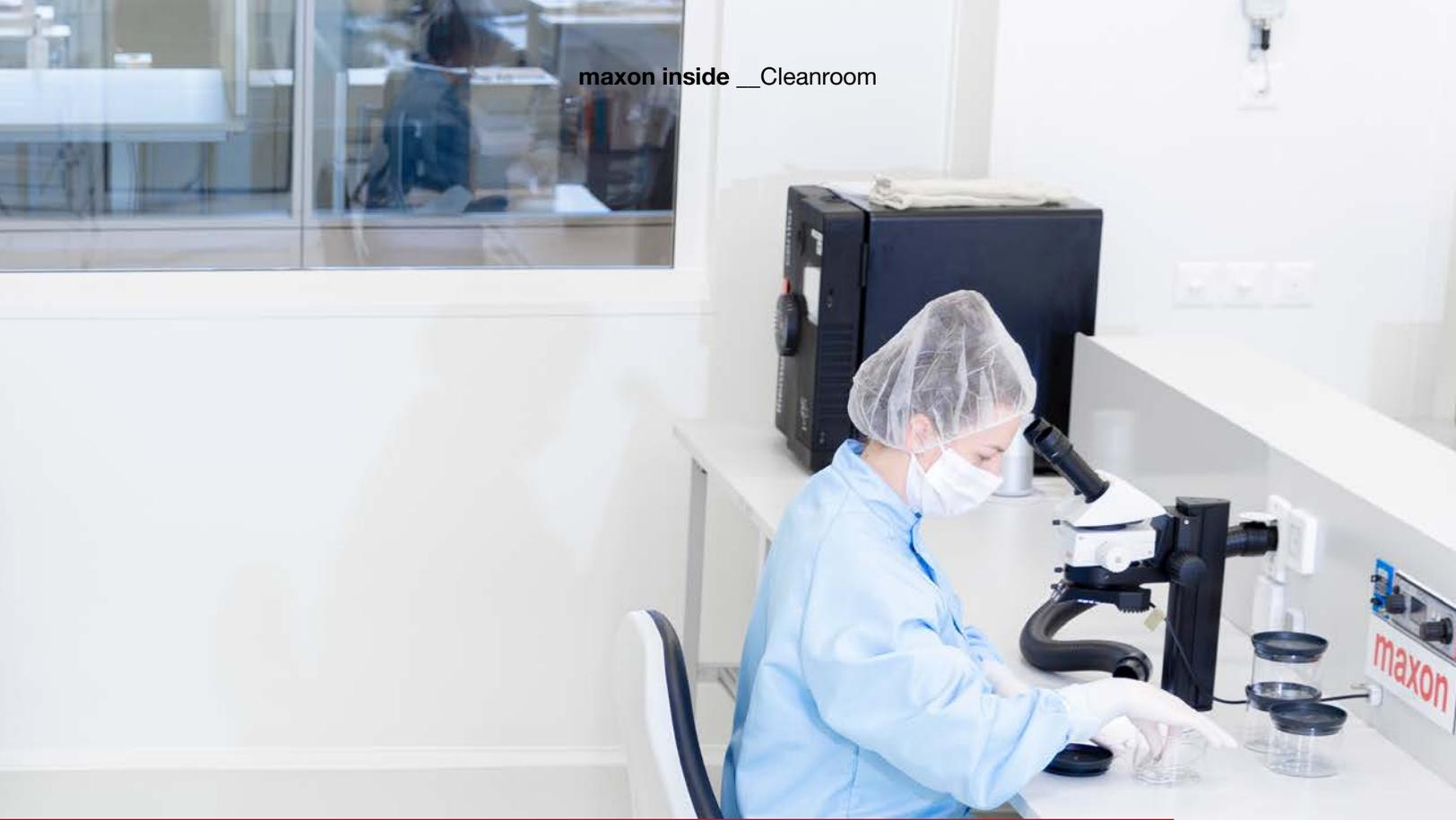
As the world identified the most urgent needs to combat the COVID-19 pandemic, maxon was confronted with an influx of requests for motors. With the help of our local marketing and business intelligence teams, we quickly compiled a list of customers that provided critical equipment such as respirators, laboratory and analytics devices as well as production machinery for PPE (personal protective equipment). This allowed our US sales team to analyze incoming requests and proactively reach out to companies. Using the “medical fast track” process, we engaged the global maxon team and ended up with a handful of intense customer projects. I had the honor to handhold one of these projects through its lifecycle and help an existing customer through the process of massively scaling up their production output for one of their life-saving respirator devices. Since the device leveraged two different maxon motors – one produced at our facility in South Korea and one produced at our Headquarters in Sachseln – it became immediately clear that communication was a critical factor for success. The fact that I was located in California, half-way between South Korea and Switzerland, allowed me to help minimize communication delays. My day typically started with an early morning status update call with the customer and ended with a short call with the business unit and production team at 11:00 in the evening. Due to the urgency and the massive scale of their requests, the relationship with the customer quickly turned into a true collaboration. Our customer helped us overcome some of the raw material shortages by providing access to their supply chain and we helped them with engineering questions, optimizing their design for manufacturability and specifying alternative products. The project introduced me to a lot of new colleagues from around the globe. I am most impressed with the dedication and energy everyone at maxon put into supporting not just this, but all of these critical customer projects – serving a cause beyond ourselves to do our part in helping combat this global pandemic.



No access

Tiny drive systems for use in the human body have to be built in a clean environment, free of microbiological contamination. Welcome to the GMP cleanroom of maxon, where discipline and gelatin meet.

Text: Stefan Roschi



for bacteria

Behind the glass pane, in the white, light-flooded room, is a world very different from the rest of the production areas of the maxon Group. Here, at the drive specialist's headquarters, nestled between lakes and mountains, a production area for drives to be used in medical applications recently commenced operation. The particle concentration in the air is low and constantly monitored. This clean environment is usually perfectly adequate because motors for insulin pumps, medical dosing units, etc. do not have to be completely free of germs and bacteria. However, applications in the field of high-tech medicine are another story altogether, especially when it comes to implantable drive systems. For these applications, assembly is being moved to the new GMP area (good manufacturing practice). In this cleanroom class, not only the particle concentration, but also the microbiological contamination of surfaces and the air is measured and examined for traces of spores, bacteria, or fungi. This clinical environment places high demands on the ventilation technology, the instruments, and especially the people that spend time inside it.

The GMP cleanroom of maxon covers an area of more than 175 square meters.



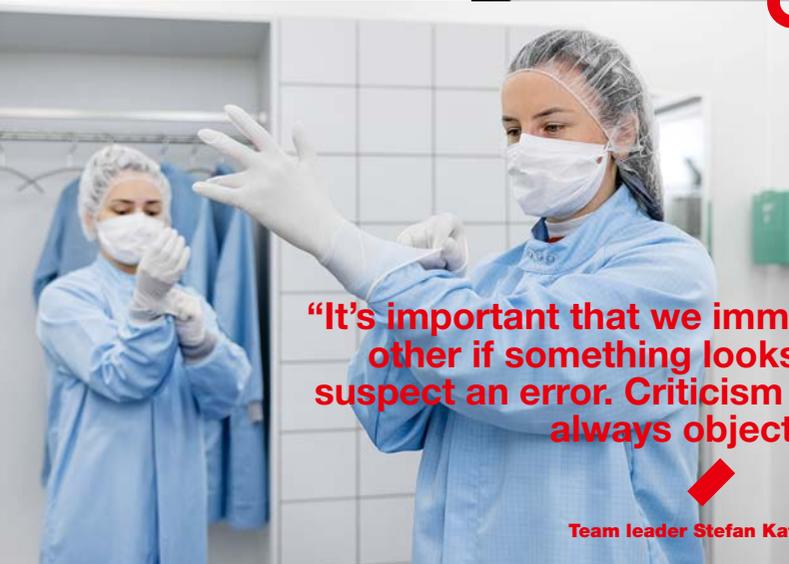
Getting to work step by step

Currently, three people at maxon are qualified to perform regular work in this room. Countless hours of training are necessary.

Cleanliness starts and ends with discipline. People who work in this environment always have to observe the same strict processes and rules. The two production staff members, Albane Lloqanaj and Ruth Da Silva, put on special pants and tops that arrived vacuum-packed from a cleanroom laundry. The high-tech materials that this clothing is made from make it anti-bacterial. The two staff members then put on special hygiene masks, hair nets, gloves, labcoats, and antistatic shoes.



Additionally, they have to disinfect their hands for at least 30 seconds using skin-friendly disinfectant in a six-step hygienic hand disinfection procedure. Subsequently, the gloves are disinfected with pure alcohol that evaporates without leaving any residue. This ensures that neither particles nor germs can stick to the gloves. All these process steps occur in a defined order. Additionally, care has to be taken that no contaminated air enters the GMP room from the outside. To this end, three zones that are separated by automated airlocks have to be crossed. It is only possible to open one door at a time, because the further you go in, the higher the air pressure in the respective room becomes.



“It’s important that we immediately alert each other if something looks strange or we suspect an error. Criticism is never personal, always objective.”

Team leader Stefan Kathriner

In the cleanroom

Inside the cleanroom itself, the staff also have to be highly disciplined. For example, they are not allowed to touch their faces. And if they do, it must always be consciously, so that they can immediately disinfect their gloves again.

To ensure that the amount of germs or bacteria on the work surfaces or in the air does not exceed a certain threshold, maxon regularly conducts tests with a nutrient-rich gelatin. These so-called agar plates are pressed onto surfaces or left open around the room. The gelatin serves as breeding ground for micro organisms. After 72 hours in the incubator, it is possible to see with the naked eye whether there is contamination and how high it is.



“I like this kind of work very much, because it's challenging, varied, and responsible. No mistakes are allowed when our drives are being used for implantable systems.”

Albane Lloqanaj

The effort involved in operating such a GMP environment is immense, which is why only a few special customer orders for implantable systems are processed there. In the past few years, the cleanroom specialists at maxon have learned a lot from these projects. Stefan Kathriner says, “We have comprehensive know-how and hope that we will be able to handle more customer orders of this kind in future.”





“
**Compact
and resilient**
”

These properties characterize the indoor inspection drones of Samir Bouabdallah. With Flybotix, he founded an exciting startup. How will the drone market develop, in his opinion, and what is required of the motors in the flying robots?





Samir Bouabdallah is the founder and CEO of Swiss startup Flybotix, which specializes in the development of indoor inspection drones. At the Swiss universities EPFL and ETH Zurich, he has acquired 15 years of experience in the field of drone technology.

Photos: Sébastien Agnelli

Interview: Stefan Roschi

Samir Bouabdallah, why do you find drones fascinating?

When I started working on the topic of drones 20 years ago, it was a new, exciting field. Everyone in research knew that this technology would have a major influence on society. For me, it is very rewarding to be involved in this development.

How do you go about becoming an expert in unmanned aircraft?

As a student in Algeria, I followed the development of robotics in Europe with rapt attention and was fascinated by it. I wanted to also develop something from scratch that can move. Right after I graduated, I went to Switzerland – with little money in my pockets. At the EPFL in Lausanne, I met a professor who took a look at my work. He introduced me to robotics expert Roland Siegwart, who offered me an internship and later made it possible for me to write my doctoral thesis. He was also the one that advised me to focus on flying robots. That was 2002 – at the beginning of the drone era. In hindsight, I was lucky. I was in the right place at the right time.

How has drone technology developed since then?

At the speed of light! Back when we started our work, there were only around four academic groups worldwide who were working on drone technology. Based on this groundwork, the first companies were founded four to five years later. Many professors then started to pick up on the topic. At first, the focus was on how quadcopters can be stabilized, then it shifted to GPS-based control. Later, image-based navigation was added, and today, people are working on artificial intelligence for the control systems. The topic was and still is attractive for student projects. At the start of each semester, I have a line of students outside my office, all of whom want to work on drone projects.



How did electric motors contribute to this development?

The transition from brushed to brushless DC motors was key. Efficiency was significantly improved. The higher continuous torque of the motors made gearheads superfluous, reduced the weight, and increased reliability. All of this – along with improved battery technology – resulted in a significantly longer flight time.

What requirements do motors have to meet with regard to drones?

In most cases, you need high torque, high power density, vibration and temperature resistance, as well as durability. Another equally important aspect is the interaction with the electronics, i.e. the ESC (Electronic Speed Controller), and the right propellers.

With Flybotix, you have founded your own startup and at the end of 2020, you introduced an indoor inspection drone to the market.

What's special about it?

Most commercially available drones are quadcopters. These are relatively easy to build, but not very efficient when you reduce their size. The alternative helicopter approach is more efficient, but also more complex – in particular the so-called swashplates. I wanted to combine these two worlds and develop a drone that is compact and can fly as long as large quadcopters. The drive system of our ASIO drone is unique. It is an algorithmically controlled propulsion and steering mechanism with two degrees of freedom. That gives the drones the aerodynamic performance of a helicopter and the mechanical stability of a quadcopter. And efficient components such as the maxon BLDC motors enabled us double the flight time in comparison to conventional models.

What are the areas of application?

Our drones are intended for performing inspection tasks in constricted environments, such as chimneys, shafts, and tanks. On the one hand, this reduces the risk of accidents, and on the other, it saves money. During chimney inspections, for example, production comes to a complete standstill, potentially for several days. With a drone, a quick visual inspection can be performed to determine whether a major inspection is necessary at all.

How did the partnership between Flybotix and maxon come about?

I was looking for a partner that could develop the best motor for my project. At the EPFL, I met a sales engineer, because maxon has an Innovation Lab there

for opening up new markets and projects. What a great concept! I presented my ideas, which were met with considerable interest, and we decided to cooperate. maxon developed modified BLDC motors for my drones, and I was available as a drone technology expert. Our startup also found its first home in the maxon Innovation Lab, for which I am very thankful. Without this partnership, we wouldn't be where we are today.

What role can maxon play on the drone market?

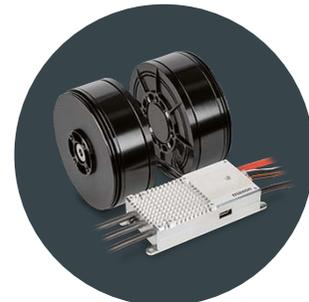
The market for drones more and more requires reliable suppliers such as maxon, who can guarantee high quality with regard to products, processes, and certification. That's why the market offers big opportunities for maxon's drive systems consisting of motors, ESCs, and propellers.

Let's look ahead to the future. How do you see drone technology developing?

From a technical point of view, the development of AI (artificial intelligence) will play a major role in the navigation of drones. It will make human intervention superfluous and, in combination with miniaturization, offer interesting new fields of application. Examples include logistics and delivery services, as well as agriculture and industrial inspections. And last but not least, transport of people using drones will soon become reality – perhaps in as little as ten years. ■



EC 69 flat UAV motor plus UAV-ESC 52/30 controller
maxon offers custom drive developments for UAV projects and is constantly expanding its range of products for this area. The image shows the new EC 69 flat UAV motor with the UAV-ESC 52/30 controller. Both achieved exceptional results in service life tests.



The ASIO drone of Flybotix is equipped with an algorithmically controlled propulsion and steering mechanism with two degrees of freedom, and has been developed for inspections in constricted environments.



“We were able to double the flight time, also thanks to maxon”

Samir Bouabdallah,
CEO & founder of Flybotix



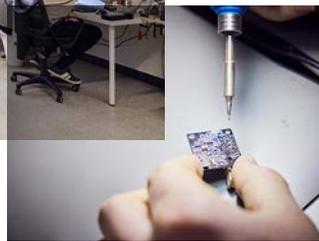
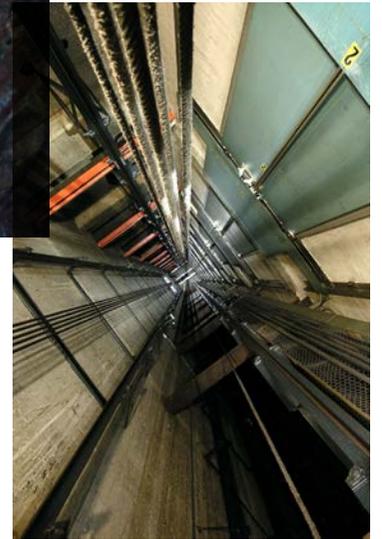
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Flybotix

A startup takes off

Flybotix Inc. is a startup located in Lausanne, Switzerland, and is one of the TOP 100 Swiss startups. The company develops the inspection drone ASIO, which operates in industrial facilities and was launched on the market at the end of 2020. Flybotix's vision is for drones to autonomously navigate, inspect their environment, and interact.

1 ASIO drones are used in chimneys, silos, and tanks.

2 A protective frame enables the drone to navigate safely even in constricted environments.

3 The drones can also be used to inspect elevator shafts.

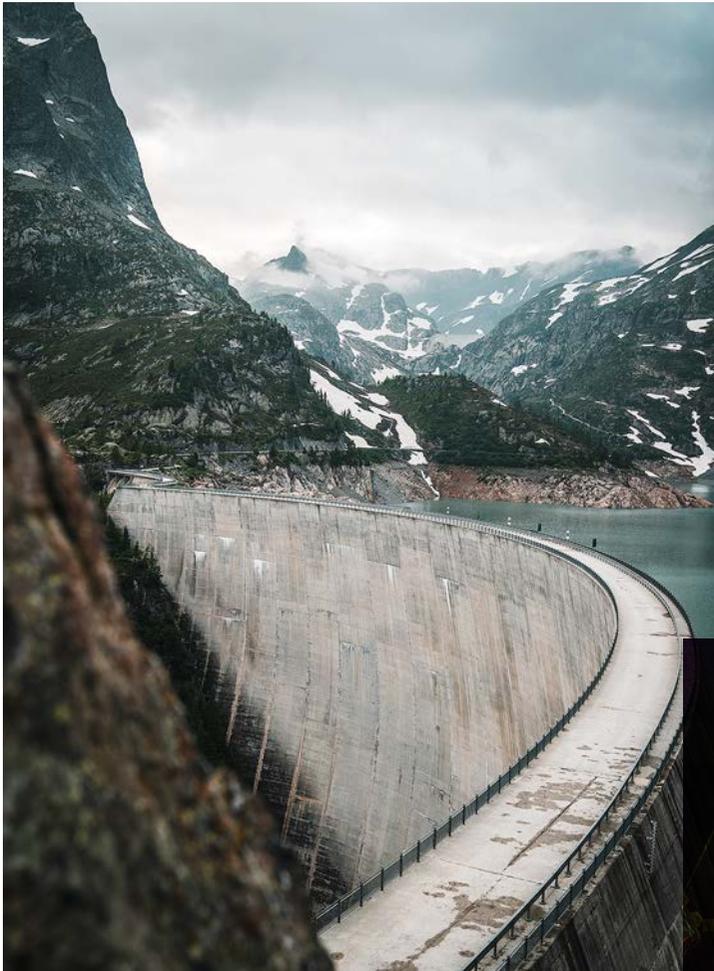
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4 Drones instead of climbing ropes: This is how the structure of bridges will be inspected in future.

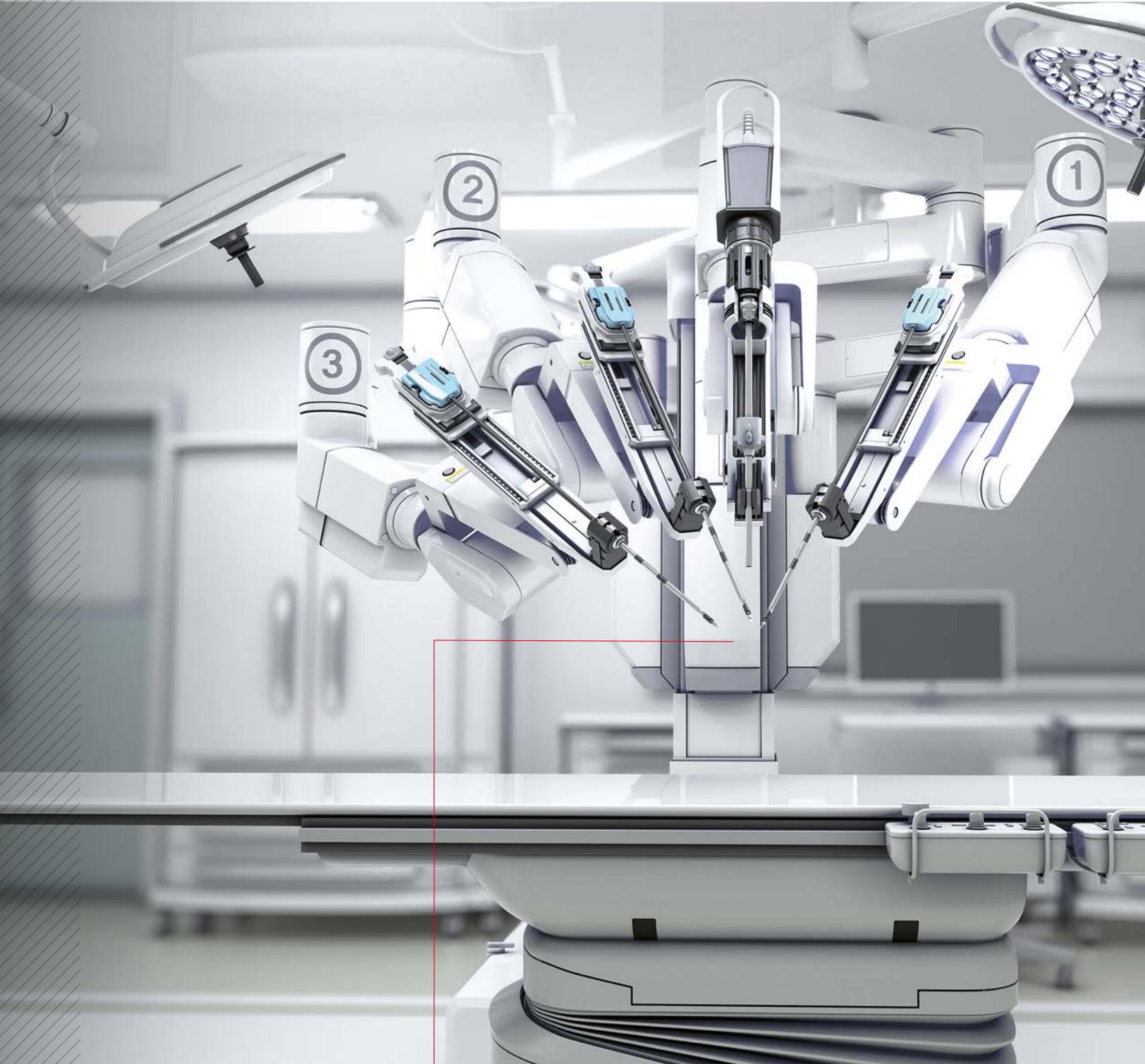
5 A look inside inaccessible areas of refineries.

6 Dams regularly have to be inspected for cracks.

7 Drones could also be increasingly used on ships in the near future for the inspection of storage rooms or fuel tanks.



7



A surgical robot is a typical example of an application with multi-axis systems

EPOS4 Truly micro!

Robotic, analysis, and handling systems demand compact integration of a large number of energy-efficient compact drives, combined with highly dynamic controllers and a networked bus system. maxon is up to the challenge.



Jürgen Wagenbach,
Head of Customer
Support, Motion Control
at maxon

SUMMARY

_The EPOS4 Micro module is the size of a postage stamp

_It provides EtherCAT for even the most confined spaces

_IIOT data with a 1 ms cycle

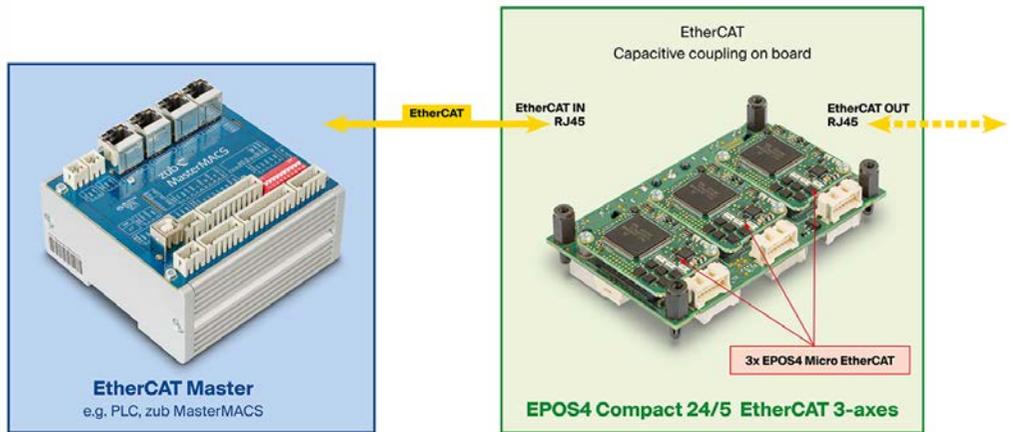
_EPOS4 = FOC, Observer, Dual Loop, and more

Requirements: Compact multi-axis system concepts

Products such as surgical robots, analytical instruments for medical devices and laboratory technology, as well as multileaf collimators for radiation technology need miniaturized drive systems that can be tightly packed into an installation space. An ideal drive package includes not only electric motors, but also compact, networking-capable motor controllers that can be integrated directly into the device, close to the motor and sensors.

Focus: Miniaturized motor controllers

The key properties of the motor controllers are high energy efficiency and high power density to allow >



Coupling via external RJ45.
Internal capacitive coupling on 3-axis board.

➤ space-saving integration of all components. Connectors for various sensors and actuators, as well as a fast bus interface, are equally important. The EPOS4 Micro modules offer a large standardized function range, leading-edge control algorithms, a compact power stage, as well as a CANopen or EtherCAT interface – and yet are no larger than a postage stamp (from 32 × 22 × 736 mm). Device manufacturers can integrate the plugin modules into their own electronics for the required number of axes. This makes it possible to produce a cost-optimized multi-axis system with ultra-compact dimensions.

Bus interface as spinal cord of the entire system

Via the bus interface, each drive unit exchanges command and access data with the master controller (e.g. PLC or maxon MasterMACS) in a fast cycle. Common fieldbus systems used for this are CANopen and EtherCAT. EtherCAT's very high transmission rates offer advantages for complex multi-axis applications in particular, but it has the disadvantage of requiring additional hardware and the large, standardized RJ45 connector for coupling individual axes. The size of the controller and bus connector can sometimes be the deal breaker for the use of EtherCAT in handheld devices and robotics.

Micro, even with EtherCAT

EtherCAT makes use of inductive transducers to shield DC signal components based on potential differences, suppress interference, and ensure signal integrity. However, these components and the RJ45 connectors need a lot of space on the printed circuit board and increase costs if they have to be integrated separately for each drive controller. When several EPOS4 Micro

units are integrated into the same electronics board, it is alternatively possible to internally connect the EtherCAT ports using a capacitive coupling. This is a highly compact and cost-saving solution. RJ45 connectors are then only needed for the external EtherCAT connection. Based on this principle, maxon offers an extremely compact multi-axis controller with an installation size of 90 × 56 mm (the size of a business card), equipped with three EPOS4 Micro 24/5 EtherCAT modules.

Micro, and easy to integrate

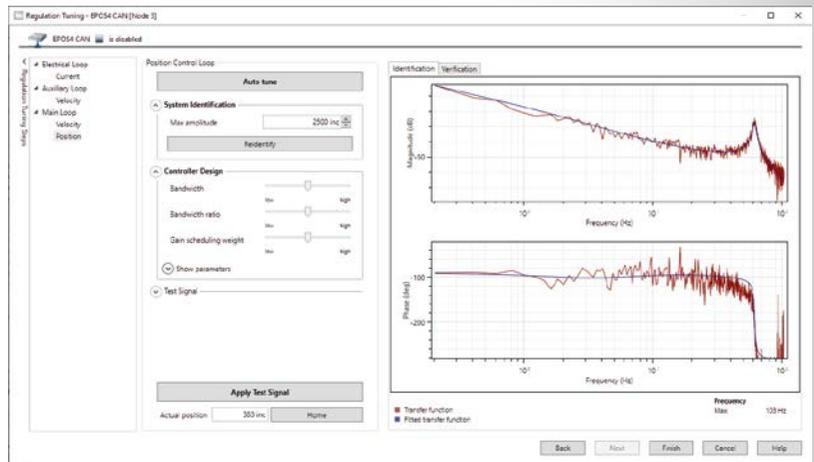
The data exchange and command functions of the EPOS4 Micro via CANopen or EtherCAT make use of the CiA® 402 protocol (Device Profile for Drives and Motion Control). The following standardized operating modes are supported: “PPM – Profile Position Mode,” “PVM – Profile Velocity Mode,” “HM – Homing Mode,” “CSP – Cyclic Synchronous Position,” “CSV – Cyclic Synchronous Velocity,” and “CST – Cyclic Synchronous Torque.” As a standardized motion control slave, the EPOS4 Micro (like all EPOS4 versions) can be integrated into the system manager tools and motion libraries of various PLC manufacturers. Applications that are commanded by a PC or Raspberry Pi via maxon's EPOS Command Library are also possible.

Micro, and ready for IIoT

The EPOS4 is the bottommost information supplier in the IIoT (Industrial Internet of Things) environment of a machine or of the drive train. Via the EPOS4 bus interface, it is possible to access motor currents and torques, position values, error statuses, temperature and load values of the controller and motor, as well as external sensor and actuator statuses, or data can be cyclically transmitted.



Size comparison: EPOS4 Micro and USB stick.



EPOS Studio: Dual loop control tuning.

Micro, yet multifunctional

With a 25 kHz current controller cycle and 2.5 kHz speed/position control cycle, the cycle rates of the EPOS4 Micro are identical to those of all other versions of the EPOS4 product line. State-of-the-art controller concepts such as Field Oriented Control (FOC), Feed Forward and Observer Control, as well as Dual Loop Control enable the EPOS4 Micro to provide maximum motor performance and precision of movement. The dual loop control with an incremental encoder on the motor shaft and an SSI encoder on the output shaft enables precise positioning of the load, even on drive systems with backlash, or elastic drive systems.

Micro, but versatile

EPOS4 Micro supports brushed and brushless DC motors with Hall sensors, digital incremental encoders, and SSI absolute encoders. A total of 5 digital inputs, 3 digital outputs, 2 analog inputs (+/-10 V), and 1 analog output (+/-4 V) make connection and evaluation of additional actuators and sensors possible.

Micro, but powerful

The EPOS Micro offers a power density of more than 50 W peak power per cm² installation size without additional cooling in ambient temperature conditions of -30°C to 45°C. In practice, this means a continuous output power of 120 W and peak power of 360 W for 10 seconds, with the controller and power stage requiring an installation area of just 32 × 22 mm (“EPOS 24/5 Micro CAN”) and a thickness of 7 mm.

Micro, also during commissioning

The intuitive EPOS Studio commissioning software includes the Startup Wizard, which guides the user

through the basic configuration and provides automatic tuning of all controller parameters, even for complex dual loop controller structures.

More than just products: maxon as system partner

With its support portal <http://support.maxongroup.com> and various services, maxon offers a lot more than just catalog products. For the integration of the EPOS4 Micro in customer-specific electronics boards, maxon is also available as development and production partner. In such cases, maxon is not only the product supplier, but also takes responsibility for the entire system as competent engineering partner in the field of drive technology. Early information exchange and idea finding in cooperation with maxon is the first step toward a solution that is optimal from both a technical and a commercial point of view. ■



In a nutshell:

Competent and goal-oriented – the EPOS4 Micro and maxon services power success.

“Trexo gives us so much hope, because as a parent you are constantly being told all the things your child will probably never do.”

Mother of an affected child



The proudest moment

Canadian company Trexo Robotics has developed a walking robot that enables children with cerebral palsy to stand on their own legs again. It is the work of founders Manmeet Maggu (CEO) and Rahul Udasi (CTO), driven by their love of Iron Man and a personal twist of fate.



Getting going!
The robot gently moves
the child's legs.
youtu.be/711VCRKVq_w



The Trexo walking robot is configured and controlled with a tablet.

Text: Anja Wieder

Trexo's story begins in 2011, when Manmeet learned that his nephew Praneit had been diagnosed with cerebral palsy. This disease is a posture and movement disorder caused by a disruption of brain function that occurs during or immediately after birth. In North America alone, 500 thousand children are affected. Praneit's diagnosis meant he would never be able to walk. Young robotics engineer Manmeet Maggu couldn't stop thinking about it. He looked for solutions to assist his nephew in walking, only to find to his dismay that there was nothing suitable on the market. There were "exoskeletons" available, but they were designed only for adults. So he decided to develop his own walking robot, working together with the affected children, parents, and physical therapists. Manmeet Maggu founded Trexo Robotics with his colleague Rahul Udasi, who studied robotics with him at the University of Waterloo. "Our goal is to create technologies that physical therapists trust, parents can afford, and children love," Manmeet said. After many months of development, endless testing, and sleepless nights, Praneit finally got his own Trexo. "It was the proudest moment of my life, when my nephew took his first steps with the Trexo."

Trexo helps with walking exercise

Children with impaired mobility spend a lot of time sitting, which can lead to negative health outcomes.

Active movement is very important. Trexo's robotic legs gently move the legs of the child. The speed and the level of assistance can be individually adapted to the needs of the wearer. That also includes the settings for the knee angle and adjustment of the hip angle.

The battery-powered Trexo walking robot is controlled via a tablet computer, as are the settings, such as the gait pattern and the walking speed. Each knee and hip joint in the Trexo robotic legs has been designed to move within the range of natural human movement. In this way, Trexo strengthens the child's legs, builds up stamina, and brings considerable improvement in motor skills. Best of all, Trexo grows along with the child.

Powerful motors for powerful legs

The precise and even movements require the support of powerful drive systems. According to the founders of Trexo Robotics, their walking robots have a very dynamic range of requirements. Consequently, they use two actuators at the hip joints and two additional drives at the knee joints. The motors and gearheads used need to have both high speed and high torque, while at the same time being able to handle rapidly changing torques. When it comes to robotic joints, space and weight are paramount, so it was very important for the developers to find a compact drive system. The brushless flat motors from maxon meet all these

criteria. In total, four maxon EC 45 flat motors (70 W) are used in the robotic legs, in combination with the GP 42 C planetary gearhead (ceramic) with MILE encoder. Manmeet said, “We found that the motors from the maxon EC Flat series were the best for size and power density. The planetary gearheads with ceramic gears also provide exceptionally high torque, and can withstand varying output torques.”

Trexo gives people hope

Worldwide, there are now about 100 children using the Trexo walking robots. With every new child who uses the Trexo, the walking robot undergoes further improvement. This is achieved above all through close collaboration with the parents. Luz’s mother Caro said, “Trexo gives us so much hope, because as a parent you are constantly being told all the things your child will probably never do. Trexo has changed that.”

For the two robotics specialists, it is incredible to see the children laughing loudly as they learn to walk, and get stronger and stronger. Manmeet said, “The joy we see in the eyes of the children and parents and the positive feedback we get gives us fresh motivation every day to keep going and further develop our walking robot. For us, every one of these kids is a little Iron Man.”



www.trexorobotics.com
www.maxongroup.com
www.drive.tech



GP 42 C planetary gearhead

This planetary gearhead is extremely wear-resistant and equipped with ceramic components. As a result, it provides superior torque capacity and durability.

Praneit,
the nephew of founder
Manmeet Maggu,
is one of the reasons
Trexo Robotics
exists today.



**“We believe that
the ability to walk is
a human right.”**

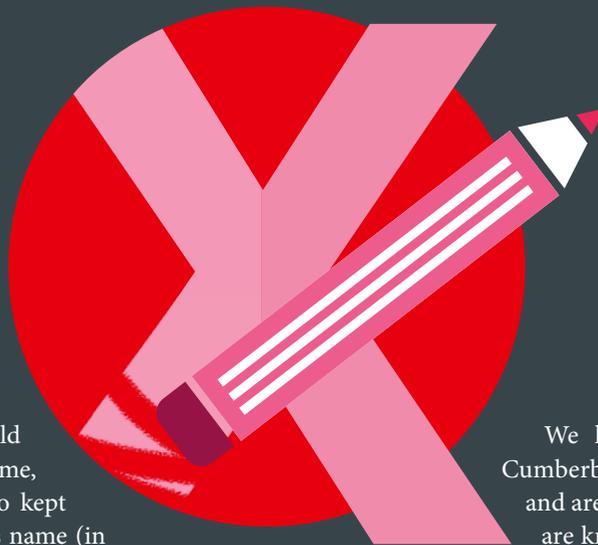
Manmeet Maggu,
CEO and co-founder of Trexo Robotics



The founding duo:
Manmeet Maggu
(left) and **Rahul**
Udasi (right).

maxxon motörs in space

Text: Stefan Roschi



Benedict Cumberbatch could have chosen an easy stage name, and a lot of journalists who kept forgetting or misspelling his name (in the past, at least) would have had an easier life. But if you have enough talent and deliver quality, you can still get to the top and into people's heads even with a complicated name. At maxon, Benedict Cumberbatch is the example that gives us hope. Admittedly, our company name is perhaps easier to remember than Cumberbatch. Nevertheless, representatives of the media struggle to write "maxon" correctly. For decades, we fought against the "s" that the writers kept trying to add to our name. "No, not max-on motors!" Even though parallels with names such as General Motors suggest otherwise. Finally, in the summer of 2019, we removed the "motor" part completely and now simply go by the name "maxon." That only helped somewhat. On the one hand, the "motor" part is still firmly ensconced in the minds of many people. On the other hand, the missing second word is now sometimes compensated for by adding additional letters. How many Xs would you like? "maxxon"? Or "maxxxxon"?

We have adopted Benedict Cumberbatch as our role model, and are convinced that once we are known all over the world, beyond our own industry, our name will also be written correctly. To tell the truth, that is the only reason why we decided to get into the Mars business back in the 1990s and to supply motors to NASA for moving the first rover on the Red Planet. Today, there are more than 100 of our drives on Mars and we are part of the current Mars2020 mission – on board both the Perseverance rover and the Ingenuity helicopter. We have high hopes for the helicopter in particular, since it is an attractive application that also piques the interest of the general public. The flying drone shall be the one that finally gives our name its big break. A name that was inspired by the father of the two company founders Erwin and Artur, Max Braun. Max and Son together make... that's right, maxon! It's not that hard, is it? And now, all together: m! a! x! o! n! ■

Contest



Contest

In which country did maxon open an innovation and production center in January 2021?

All participants with the correct answer will be entered into a draw to win a Garmin GPS smartwatch. Good luck!

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

The deadline for submissions is July 31, 2021
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

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 share their knowledge. Get excited, learn new things, and discuss with our bloggers.



Check out this article about a startup in the USA that develops affordable arm prostheses for children.

Story

Affordable prosthetics empower amputees



Precious core

Electrical drives are merely functional, right? Not at all!
The elegance of this copper stator of a brushless
EC 90 flat motor proves the opposite. Wound to perfection.
Ready to move the world.
#drivenbymaxon

