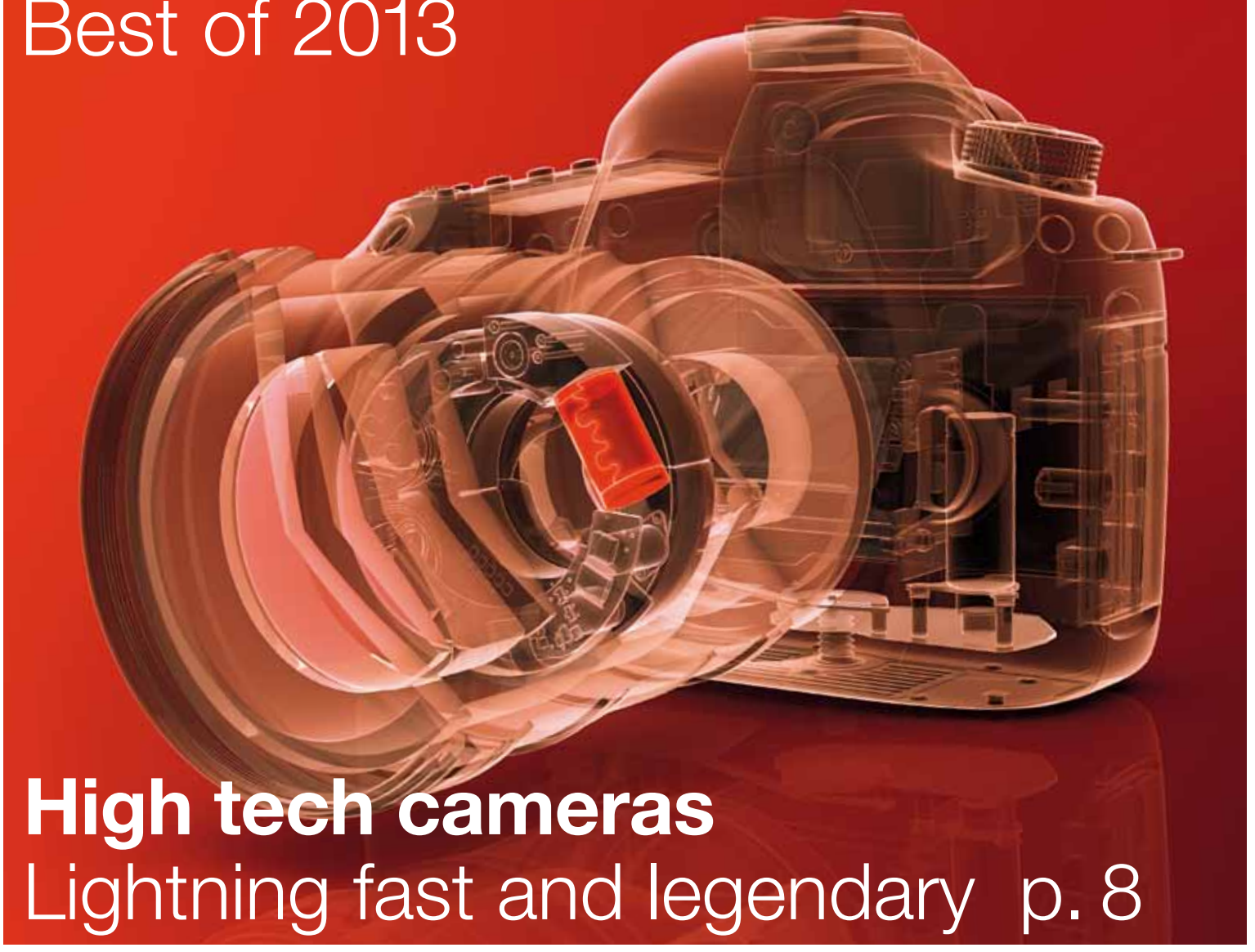
The maxon motor **magazine**

driven

Best of 2013



High tech cameras
Lightning fast and legendary p. 8

Comfortable seats, better air
Aircraft technology today p. 20

To stand up and walk again
Modern prosthetics p. 38

XTRA DYNAMIC

From 0 to 9000 rpm in 4 ms.

11 READY IN DAYS

The configurable DC drives of maxon motor are very dynamic: The DCX motor with 35 mm diameter accelerates to 9000 rpm within 4 ms at nominal voltage. Configure a custom drive online to include gearhead and sensor. Your finished drive will ship from Switzerland in 11 working days.

dcx.maxonmotor.com

maxon motor

driven by precision

maxon drives in humanoid robots.

maxon EC-4pole
The power packet.

When it really matters.

Humanoid robots also rely on our drive systems. They are used, for instance, in hand, arm, hip and leg joints, where they enable service robots to move precisely in the real world, not only in the movies.

Androids like Hubo 2 engineered at Kaist (Korea Advanced Institute of Science and Technology) are becoming more agile. They are able to gesture, shake hands, walk and even run. Therefore androids have to rely on energy efficient and dynamic DC drives such as the brushless maxon EC-4pole.

The maxon product range is built on an extensive modular system, encompassing: brushless and brushed DC motors with the ironless maxon winding, iron-cored flat motors, planetary, spur and special gearheads, feedback devices and control electronics.

maxon motor is the world's leading supplier of high-precision drives and systems of up to 500 watts power output. maxon motor stands for customer specific solutions, highest quality, innovation and a worldwide distribution network. See what we can do for you: **www.maxonmotor.com**

maxon motor

driven by precision

Editorial

In focus: robots, high-tech cameras, and little green men.

Eugen Elmiger, CEO maxon motor ag

maxon drive systems are used in countless applications; for example in medical technology, aerospace, or the communication sector. These were the focus topics in the three tablet editions of "driven – the maxon motor magazine" in 2013. We compiled the best stories, interviews, and technical reports in a "best of" magazine. Read the interview with robot expert Rob Knight, learn how high-tech cameras shoot high-resolution pictures quick as a flash, be amazed at how, thanks to state of the art prostheses, people learn to walk again, and discover what it would be like to live like a little green man on Mars.

Happy reading!

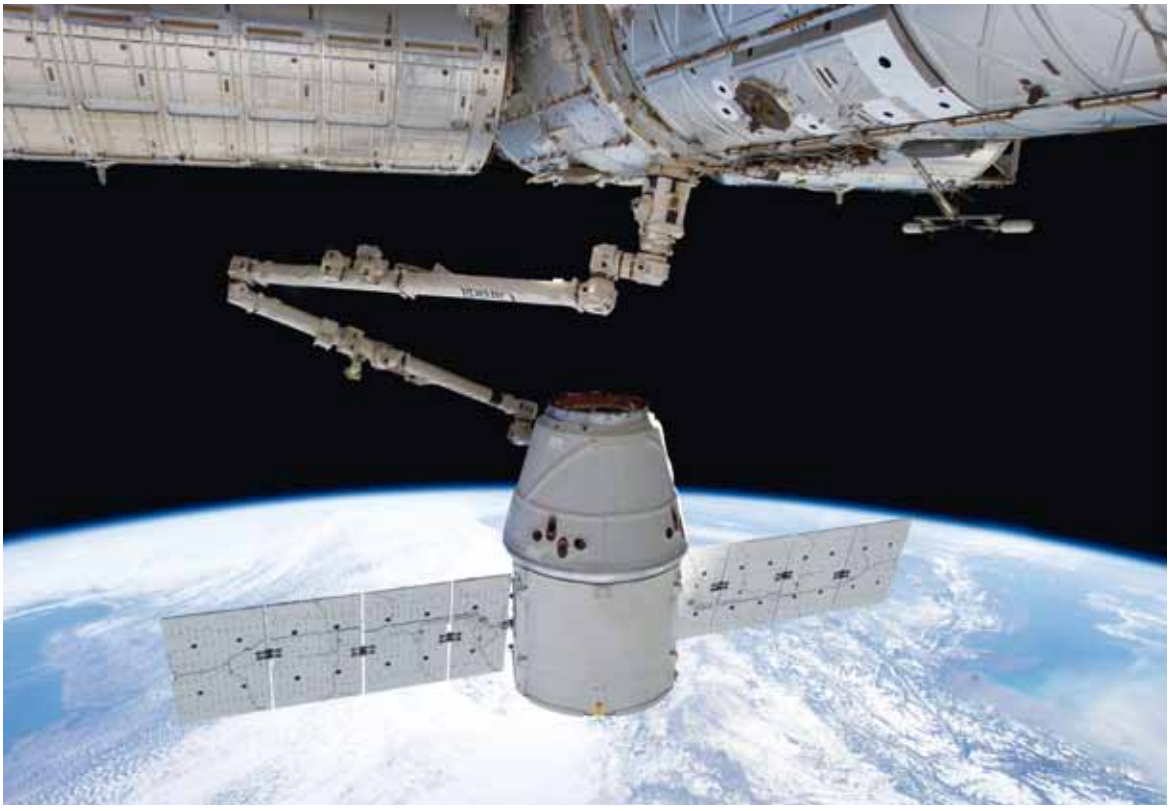
The current tablet edition with interactive and multimedia features can be found in the Apple App Store and on Google Play.

UAC-mounted cameras offer new insights p. 14

Leading the field thanks to prosthetics p. 37

Martian for a while p. 30

2013



Space

March 3, 2013
On March 3, 2013, the Space X Dragon capsule docked at the International Space Station (ISS). Aside from food for the ISS crew, the capsule also carried supplies and equipment for scientific experiments, such as the stem cells of mice, protein crystals, and plant seeds. Brushless maxon motors were used for positioning the two solar panels, for opening the instrument bay hatch, and for locking in place the fixture that allows Dragon to be grappled by the space station's. robotic arm.

Paris

June 17, 2013
The Boeing 787 Dreamliner was the center of attention at the Paris Air Show. A special feature is the plane's air conditioning, which makes long trips more comfortable for the passengers. 48 brushless maxon DC motors, spur gearheads and resolver combinations ensure a pleasant climate high up in the sky.

Photos: maxon motor ag, NASA

Zurich

March 9, 2013
The international robotics trade show Robots on Tour drew large crowds. Among the many robots on display was "Roboy", one of the most advanced tendon-controlled robots. More than 50 brushless maxon drives are responsible for the android's precise movements.

Successful partnership

maxon motor awarded mission patch by SpaceX

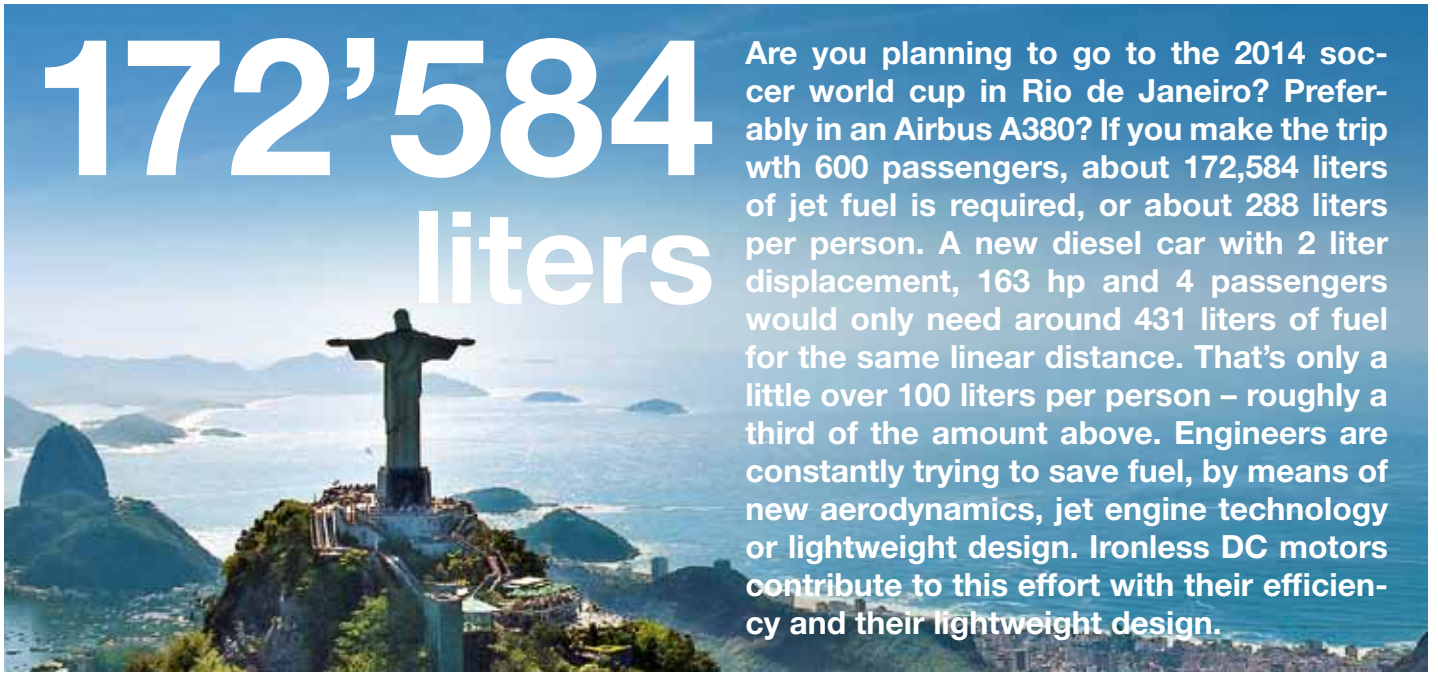
SpaceX honors maxon motor with a mission patch (Flown in Space). This certificate, signed by SpaceX CEO Elon Musk, confirms that maxon motor successfully participated in the first commercial SpaceX mission to the ISS in May 2012. The maxon motors continued to function reliably in follow-up missions. On the voyage to the ISS, brushless EC maxon motors were used to rotate the solar arrays to keep them aligned with the sun as Dragon orbited the earth, to open the instrument bay door which contains navigation equipment, and to lock in place the fixture that allows Dragon to be grappled by the space station's robotic arm.

Enhanced service offering

New production site in Korea

Since early this year, type EC-i 40 brushless DC motors are being produced in Sejong City. The EC-i 40 has a diameter of 40 millimeters and is designed to deliver up to 70 W of power. It stands out through its very high torque.

"The maxon motor Group already has production sites in Switzerland, Germany, and Hungary. This fourth production site marks the Group's expansion into Asia. This expansion is part of our long-term growth strategy in the region," says Eugen Elmiger, CEO of the maxon motor Group. Howard Sul, President of maxon motor manufacturing Co. Ltd., adds: "The development and production of maxon motors is a valuable addition to our existing business in Korea. In Sejong, we will stay abreast of the latest advances in technology and contribute to their development to ensure that products conform to the highest quality standards." The new site will also strengthen our service portfolio for the entire region of East Asia. Sul: "We are pleased at the opportunity to offer our customers in Korea and neighboring countries high quality service on short notice."



Photos: maxon motor ag, sfmthd – Fotolia.com

NEW PRODUCTS

New motor/gearhead variations

maxon DCX 10S/ DCX 22L and maxon GPX 22C/ GPX 22LN

maxon motor has expanded its configurable DCX product family. The DCX 10L is now complemented by a shorter version, the DCX 10S. Like all DCX motors, this brushed DC motor excels through high power density and low vibration.
The DCX 22L is the new big brother of the short DCX 22S. At 22 mm diameter, this brushed DC motor tops even the RE 25 (20 Watt). The GPX 22C is a performance-optimized version of the GPX 22. Ceramic axles provide better operating characteristics and a longer life span. Another new member in the GPX family is the low-noise version of the GPX 22. The GPX 22LN has special plastic planet gears in the input stage that reduce operating noise by about 5 dBA.

maxon DCX 10S

maxon DCX 22L

maxon GPX 22C/ GPX 22LN

maxon ESCON Module 50/5

Easy commissioning – highest performance

maxon ESCON Module 50/5

The miniaturized OEM plug-in module belongs to the new ESCON servo controller family. The powerful 4-quadrant PWM service controller is designed for efficient control of permanent magnet-activated brushed DC motors or brushless DC motors (BLDC motors) with Hall sensors, up to approximately 250 W. The OEM plug-in module has excellent control properties and a very fast digital current controller with an enormous bandwidth for optimal motor current/ torque control. The drift-free, dynamic speed characteristics enable a speed range from 0 to 150,000 rpm.
A motherboard for initial commissioning of the module is available. With the «ESCON Studio» graphical user interface, the servo controller can be adapted easily. The large range for the input voltage and the operating temperature allows flexible use in almost all drive applications – in automation technology, in small machine manufacturing and equipment engineering, and in robotics.

spindle drive GP 8 S

Low-wear and economical

GP 8 S spindle drive (ceramic version)

Spindle drives convert rotary motion into linear motion. The two most common designs are the ball screw and the lead screw. Smaller drives can also be designed as metric spindles. This is the case with maxon's new GP 8 S spindle drive. The standard version of the drive can be combined with two different motor types (RE8/0.5 W and RE8/0.5 W with encoder).
The benefits of metric spindles include backdrivability and cost-effectiveness. Ceramic spindles have the advantage of minimizing nut wear thanks to their ceramic glide surface. The spindles are used in applications such as drives, measuring equipment, medical and optical technology, and vacuum and laboratory applications.

Model: Leica S2
Shutter speed: 1/750 sec

Model: Leica S2
Shutter speed: 1/1500 sec

Photos: Jonas Bendiksen / Leica Fotografie International, Leica Camera AG, maxon motor ag

Lightning-fast images

Digital high-end reflex cameras can deliver extremely sharp photos. This is a challenge not just for the photographer's skill. The technology inside the camera also plays a role.

The central shutter generates no vibration and is very fast. The gear motor is used for tensioning three springs that store the energy for the central shutter.

The Leica S system combines the image quality of a medium-sized camera with the handling, speed, flexibility of a compact camera. The objectives used in the Leica S have a built-in dedicated processor for controlling the auto focus. These lenses are also available with a central shutter, for maximum flexibility when using flash.

Besides the focal-plane shutter, which is integrated in the camera, the central shutter is one of two common designs. A central shutter is typically located at the center of the objective, between the lenses. It consists of several blades arranged around the optical axis in a concentric pattern. When the shutter release is depressed, the blades snap back from this axis synchronously and let the light fall on the sensor.

Because all settings are made with an open shutter, the first thing the central shutter of a reflex camera does after release is to close. The mirror swings up, then the central shutter opens for the duration of the exposure before closing again. Finally the mirror swings back into the path of light, and the shutter opens. Even though it employs the classic solution of mechanical springs for the efficient storage of potential energy, the central shutter is a piece of cutting-edge technology. The tensioned-spring principle contributes significantly to the extremely compact dimensions.

Small motor for tensioning

The springs are tensioned by a specially developed maxon motor with a high-precision overrunning clutch and release their stored energy to activate the shutter blades when the shutter release is depressed. A specially constructed solution prevents the blades from rebounding when the shutter is opened or closed. A microprocessor-controlled pawl and ratchet mechanism controls the shutter cycle via two electromagnetically activated plungers.

The gear motor is used for tensioning three springs that store the energy for the central shutter. A maxon A-max 12 is used as the base motor. The gearhead is an all-new development by maxon motor, specially adapted to fit in the limited available space. The development of a compact, enclosed and sealed custom version with perpendicular power transmission to the shutter through a crown gear – all with a life span of more than 100.000 releases – was a special challenge.

maxon A-max 12
Ø 12 mm,
precious metal brushes,
0.75 W

Small but strong
The gear motor in the Leica S lens is used for tensioning three springs that store the energy for the central shutter. An A-max 12 is used as the base motor. The gearhead is an all-new development adapted to the available space. The maxon A-max portfolio offers high-quality DC motors with an optimal price/performance ratio.

The whole is more than the sum of its parts: Leica sets a new standard with its S lens system.

Moments **for eternity**

Ever since technology has made it possible, people have wanted to preserve special moments like historical events or challenging physical feats in photographs. Leica is a pioneer of camera design.

Article: Anja Schütz

The first Leica camera.

Photos: Leica Camera AG, Jonas Bendiksen / Leica Fotografie International

Mountaineer Hilde Bjørgaas on the way up and in the focus of a Leica S2. She is climbing in the Lofoten, a Norwegian archipelago of about 80 islands.

1968

Impressions of the Olympic Games in Mexico City, photographed by René Burri.

The rocks in the Lofoten, an archipelago off the Norwegian coast, are a challenge to any climber. There are 800 meters of altitude to overcome. Every crack in the rocks is checked for stability before the next anchor is set. Without a safety line, the risk of falling would be far too great. Finally reaching the top is what mountaineers live for, and it is a moment worth preserving for posterity.

Leica and other pioneers of camera design have made this possible. The history of the company goes back to 1849, when the optician Carl Kellner founded an optical institute in Wetzlar, Germany. The first Leica, known among connoisseurs as the "Ur-Leica", was designed by Oskar Barnack in 1914. Many more camera models were to follow.

In 1961, serial production passed the one million milestone. In 1986, Leica GmbH was founded to consolidate the activities in the photography market. Twelve years later the first digital Leica compact camera is introduced.

Leica continues its growth and has won the hearts and minds of many photographers, for example with its digital reflex cameras. The company maintains close ties with the famous image agency Magnum Photos. Being accepted as a member is like a knighthood for photographers. This year, Leica honored the photo reporter and Magnum photographer René Burri with the "Leica Hall of Fame Award" for his life's work. The now 80-year old photographer captured many important events of the past century and achieved worldwide fame. They include, for example, the iconic portrait of Cuban revolutionary leader Ernesto "Che" Guevara with a cigar. The Swiss photographer also recorded historical events in Germany before and after the Berlin Wall was built, as well as the fall of the Wall.

A legend: René Burri in front of his life's work, for which he received the Leica Hall of Fame Award.

Photos: Keystone/Sandro Campardo, René Burri/Magnum Photos

1979

Impressive: Transport of the legendary Space Shuttle through California, photographed by René Burri.

1989

René Burri documented the fall of the Berlin Wall in 1989 in numerous pictures.

The Torresol concentrated solar thermal power plant in southern Spain, photographed from a UAC equipped with technology by Photo Higher.

The world from above

The camera gimbals are driven by maxon EC 32 flat brushless DC servo motors. This customized drive system is flat and compact while still fulfilling the demanding speed and torque requirements. The key factor however is the backlash-free output, which makes these drives an ideal choice for camera gimbals. The motors are controlled by a custom maxon servo controller.

Aerial images offer many benefits to a wide range of industries and companies. Often things are revealed from above that are hidden to the observer on the ground.

Mining companies survey mines from the air, oil and gas suppliers monitor their drilling rigs, and energy utilities their overland lines. All these application have one challenge in common: In a frequently rough operating environment, the camera needs to be protected against wind, turbulence and the vibration of the carrier aircraft while being kept in a stable position. This is the job of high-precision camera gimbals. The suspension offers a stable and level platform that allows users to shoot high-quality aerial photographs. The company Photo Higher, based in Wellington, New Zealand, has specialized in the design, development, and manufacture of high-precision camera gimbals for vertical-ascent rotary-wing UACs. Gimbals by Photo Higher are lightweight, easy to operate, and very stable. The device's core is the drive unit for the stabilizing platform, for which the company required small brushless DC motors. The original requirement was for a backlash-free gear motor with 40 rpm and an output torque of 2 Nm. The overall weight of motor and gearhead was not to exceed 100 g, and the maximum length was 50 mm.

Power consumption is an important issue in most UAC applications. Thanks to their higher power density and better efficiency, brushless DC servo motors by maxon offer lower energy consumption than other motors, allowing the UAC to remain airborne for longer periods of time.

After numerous trials with a variety of drive units, including the use of an angular gearhead that turned out to be too heavy, an ideal solution

The Halo 2000 by Photo Higher is a three-axis camera stabilizer system made from 100 per cent carbon fiber. The stabilization is provided by maxon motors and servo controllers.

maxon EC 32 flat
Ø 32 mm, brushless, 15 W

maxon ESCON servo controller

was found: a flat brushless DC servo motor to drive the gimbals directly. This customized drive system is flat and compact while still fulfilling the speed and torque requirements. The key factor however is the backlash-free output, which makes these drives a perfect solution for camera gimbals. Independent of camera brand and or model, the end user can always adjust the gimbals to match the center of gravity of the entire system. In a well balanced system, the DC servos offer strong acceleration and fast response at very low energy consumption.

To control the brushless DC servos for various camera gimbals, Photo Higher uses a custom servo controller, also made by maxon. Some of the characteristics, like the shape of the circuit board, amplification, and connectors, have been adapted specifically to suit the requirements of this application.

The camera gimbals of the AV and Halo series by Photo Higher were designed for demanding applications. The system is stable enough for film recording, allowing the UAC to be used to obtain high-resolution aerials and geodata quickly. In addition to UACs, the gimbals are also suitable for helicopters, airships, cranes, or boats – a wide range of applications. Aerial images in particular continue to fascinate due to the perspective and offer surprising insights, revealing connections that were the subject of conjecture before. A common use today is to simplify the search for subterranean archaeological sites.

Photos: Dedicam GmbH, Photo Higher

Can we make **artificial stars?**

Humanity still has a long way to go before we can make artificial stars. For scientific applications however, there already is such a technology. The Optical Tube Assemblies of the Netherlands Organisation for Applied Scientific Research light up the sky.

Article: Anja Schütz

The flagship of European astronomy is the Very Large Telescope (VLT) on mount Paranal in Chile. The location offers optimal conditions for observations in the infrared and visible light range.

A high-precision drive system by maxon motor controls the tip and tilt motion of the Field Selector Mechanism.

The European Southern Observatory (ESO) is the most successful scientific observatory in the world. Since it was founded in 1962, the ESO has been providing astronomers and astrophysicists with state-of-the-art research facilities. The flagship of European astronomy is the Very Large Telescope (VLT), located on mount Paranal in Chile, which offers optimal conditions for observations in the infrared and visible light spectrum. Only recently, the oldest known solar twin was discovered using the VLT. This star, very similar to our sun, is roughly 8.2 billion years old, compared with our sun's 4.6 billion years.

The VLT consists of four main telescopes, with mirror diameters of 8.2 meters, and four auxiliary telescopes. The Netherlands Organisation for Applied Scientific Research has developed a projection system for the VLT. The so-called "Optical Tube Assemblies" (OTAs) are complex projection systems for generating artificial stars. Aided by these systems, four powerful 20-Watt lasers send light beams up into the atmosphere to create "artificial stars". Their purpose is to correct distortions in the VLT's images that are caused by turbulence in the air.

Normally, telescopes collect incident light from the sky and focus it in an instrument. The new technology reverses this process: The telescopes are used to project laser beams into the sky and thus create points of light. The laser beams excite a layer of sodium atoms at an altitude of 90 km, making them glow. This happens with an accuracy of 45 mm – at 90 km distance. These glowing spots function as artificial guiding stars and make astronomical observations easier.

maxon drive systems in the Field Selector Mechanism

The design of the OTA consists of a 20x laser beam expander and an active tip-and-tilt mirror, the Field Selector Mechanism (FSM). This mechanism is bonded to a membrane spring-and-strut combination that allows only tip and tilt movements. The mirror of the FSM has a diameter of 100 mm. It can be rotated around two orthogonal axes in a plane parallel to the mirror surface. The rotation of the mirror results in an asymmetrically reduced response in the on-sky angle of the laser beam. The mirror is elastically hinged and is aligned by means of self-locking actuators with high stiffness. The required absolute accuracy is achieved with sensors that directly measure the mirror's orientation with respect to the base.

A high-precision drive system using brushless maxon flat motors, a planetary gearhead with a spindle, and an encoder is responsible for the accurate tip-and-tilt movements of the mirror in the FSM and thus for precise alignment of the laser in the sky. In a telescope, two maxon motors are used per FSM unit. For the design of the actuators, the dynamic range requirements were decisive. Very few commercially available actuators are equipped with a self-locking function that fulfills these requirements. Therefore, TNO developed a high-precision spring transmission based on a standard maxon spindle drive with planetary gearhead and integrated ball-screw spindle. As the available space in the FSM units puts limits on the height of the components, brushless flat motors are especially suitable for this application. In 2015, the first telescope in the Paranal Observatory in Chile will be equipped with the new laser technology. Furthermore, the ESO plans to implement the technology in other telescopes. Regardless of whether we will create artificial stars in the future or not: We will definitely see the stars much more clearly.

With the Optical Tube Assemblies, laser beams are shot high into the atmosphere to generate artificial stars.

The first prototype of the Field Selector Mechanism (FSM). Two maxon motors are used per FSM unit.

Photos: ESO / C. Malin, TNO

The mysterious dark energy

A clear sky full of stars impresses everyone who has the opportunity to witness a truly dark night. Dark matter and dark energy are two important components in our understanding of the universe's expansion.

by Bruno Leibundgut

Glittering starlight tells us of faraway worlds. And in this case, faraway really means far away: Voyager 1, the first probe ever created by humanity, has just left our solar system after 35 years of travel, during which it has covered a distance of 18.8 billion kilometers. A light beam or a radio command takes a little over 17 minutes to get from Earth to Voyager 1. In other words, the handlers of Voyager 1 can go for a coffee after sending a command, as the confirmation will not arrive until more than half an hour later.

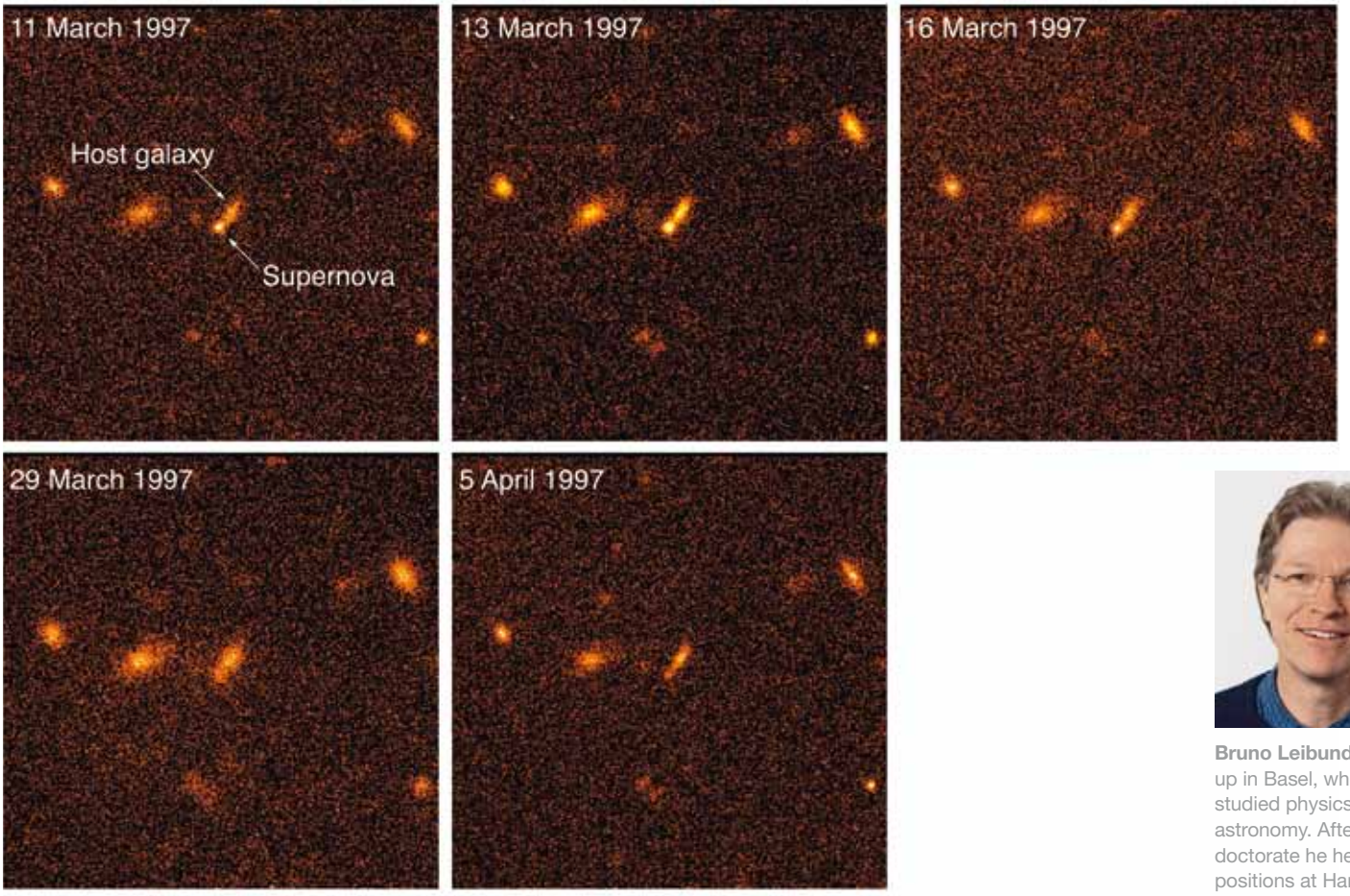
However, in comparison with the size of the cosmos, Voyager is basically still sitting in our lap. The sun's closest neighboring star is already 4.6 light years away. Were we to send a friendly hello, we would have to wait nine years for an answer! And most of the stars we can see at night are hundreds or even thousands of light years away from us. Communication in such a system would quickly become a test of patience beyond the scope of a human life.

It all started with the Big Bang

There is another feature of the night sky that is often overlooked: It's dark! Even in a dense field of stars, most of the sky is black. This trivial-seeming fact is fundamental to our understanding of the universe. In an infinitely old and infinitely large, static universe, the night sky would not be dark, but as bright as the surface of the stars. The first people who thought of this were Edmund Halley and Jean-Philippe Loys de Chéseaux in the 18th century, and the problem was described by Heinrich Wilhelm Matthäus Olbers in the early 19th century. Today it is generally known as Olbers' paradox. Think about it like this: In an infinitely large forest, your glance would inevitably fall on a tree trunk eventually, no matter in which direction you looked. In a similar way, in an infinite universe the glance would inevitably fall on the surface of a star – and therefore the entire sky would be as bright as the surface of the sun, far too bright for the naked eye to look at!

In a finite forest however, it might be possible to catch a glimpse of, for example, a lake beyond the forest's edge. This indicates that our universe must be dynamic, and probably also finite. The Big Bang marks the beginning of our universe in time. This was 13.5 billion years in the past. Because the universe keeps expanding, the light from the Big Bang shifts ever longer wavelengths. This radiation can be observed as the cosmic background radiation. However, it is invisible to the human eye.

The dynamic universe is defined by its contents. The key element is the effect of gravita-



Observation of a distant supernova. The brightness change is clearly visible.
It was brightest around March 13, then it faded over the course of a month. This supernova exploded about 5 billion light years from the sun.

Bruno Leibundgut grew up in Basel, where he studied physics and astronomy. After his doctorate he held science positions at Harvard and at the University of California in Berkeley. Two decades ago he joined the European Southern Observatory (ESO) in Munich. Today he is its scientific director. He was part of one of the teams that discovered the accelerated expansion of the universe.

tion, and thus matter, in the cosmos. Gravitation should have slowed the expansion since the Big Bang. However, the amount of observable matter is insufficient to explain this effect. Astronomers therefore had to postulate two additional components, dark matter and dark energy. Dark matter exerts a gravitational pull while dark energy, which is possibly an accelerating feature of space itself, drives the universe apart. Dark matter is necessary to explain why galaxies remain coherent. Dark energy was discovered when explosions of distant stars – so-called supernovae – were observed. A supernova can be observed for a few weeks and used to measure distances in the universe.

Mysterious dark energy

Two groups of researchers observed distant supernovae in order to measure the effect of dark matter on the expansion of the universe. They independently discovered that the farthest supernovae are farther away than should be expected in a hypothetical matter-less, empty universe. The only way to explain this is by introducing an additional force. For this discovery, Saul Perlmutter, Adam Riess, and Brian Schmidt received the Nobel Prize in Physics in 2011.

It is not quite clear yet what dark matter and dark energy really are. Dark matter has to consist of particles outside our everyday experience of reality. Its interaction with our world is so subtle that it can be measured only at the scale of galaxies and has not been shown in the laboratory yet. Dark energy is even more mysterious. It could be connected to a term that Albert Einstein once introduced into physics out of sheer exasperation. However, there are other possible explanations. However, it is going to take a few more years until we will be able to understand these two important components of space.

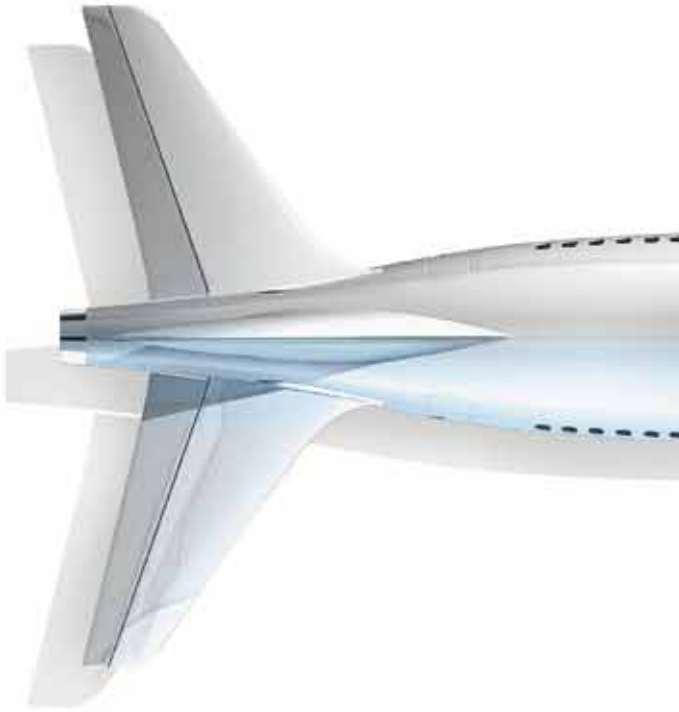
Photos: ESO

Autopilot and pedal adjustment

maxon EC 22
Ø 22 mm, brushless,
40 W

maxon GP 22 C
Ø 22 mm, 0.5–2.0 Nm

Brushed and brushless DC motors by maxon motor are also used in the cockpits of aircraft. For example in the altitude control equipment and in the control devices for the control surfaces, in the automatic thrust control or in force feedback joysticks of the fly-by-wire flight control. The pedal adjustment in the cockpit is also controlled by maxon motors. Pilots can adjust the rudder pedals to match the length of their legs. A maxon unit drives a linear spindle that adjusts the pedal. To this end, a drive system consisting of a brushless EC 22 and a planetary gearhead (GP 22 C) is used.



Satellite communication

In the near future, many flights are likely to offer Internet and cellular phone connections – thanks to maxon products, among others. Some airlines are already running pilot projects with such systems. maxon drive units are responsible for the tip-and-tilt movements of the antenna, to constantly keep it aligned to the current satellite position. The satellite sends and receives the data from an earth station. Brushless EC-45 flat motors, EC-32 motors, the GS 45 spur gearhead and encoders are used.

maxon GS 45
Ø 45 mm, 0.5–2.0 Nm

maxon EC 32
Ø 32 mm, brushless,
80 W

Shades and displays

Aircraft cabins contain numerous automatic systems, like window shades, displays or seats. Here again the light and efficient maxon drives can be found. EC-max 16 motors combined with a planetary gearhead (GP 16) are used for adjusting the shades in a modern aircraft. maxon EC-max is a cost-optimized EC product range. Thanks to the brushless design, the drives are well suited for long periods of operation.

EC-max 16
Ø 16 mm, brushless,
5 W

Comfortable seats, better air

Modern passenger aircraft are getting more and more comfortable. maxon motors make a decisive contribution. A challenge in lofty heights.

In modern passenger aircraft, pneumatic cushions in the seats for example make long flights much more pleasant. The customary plastic foam in the seat cushions is replaced with air-filled chambers. Flat motors made by maxon take care of filling the cushions with air. Other maxon motors ensure quiet electronic adjustment of the seat backs and thus further contribute to the passengers' comfort. Window shades and the displays of the on-board entertainment system are operated automatically – depending on the aircraft type – and are moved by motors.

A total of 48 maxon motors are installed in the environmental control system of a Boeing 787. This includes drives for the cabin ventilation, for cooling the electronics, and for closing and opening the air inlet on the outside of the aircraft. The aircraft's environmental control system – more than 5 m long and 700 kg heavy – would suffice to cool or warm 25 households. The cabin ventilation system consists of 36 shut-off valves that are driven by brushless maxon EC 45 flat motors. These light motors have been designed to fit into even the smallest

spaces, thanks to their tiny dimensions. EC flat motors achieve speeds of up to 20,000 rpm and, thanks to their open design, offer excellent heat dissipation and high torques.

maxon motors for the cockpit and for the lavatory

Let us take a look into the cockpit. This is another area where maxon motor's brushless and brushed DC motors are used, for example in the attitude control system, in the actuators for the mechanical flight control surfaces, in the automatic thrust control, or in the force feedback joysticks of the fly-by-wire flight control.

An aircraft also has numerous valves for various tasks. For example, the water supply and water disposal in the lavatories are controlled by means of valves that are opened and closed by maxon drives.

Highest loads across long life spans

Motors for aerospace applications differ greatly from standard motors. They have to cope with great temperature fluctuations (–55 to +85 °C), withstand constant vibration and repeated impacts, have a long life span, and emit as little electromagnetic interference as possible. Furthermore the weight, quiet running and absolute reliability of the drive system play an important role.

Pneumatic seat system

Fore more Information on the seat system by Lantal see the interview on p. 23.

In modern passenger aircraft, pneumatic cushions in the seats make long flights much more pleasant. This system replaces the customary cushion foam in the seat cushions with air-filled chambers. Brushless maxon flat motors take care of filling the chambers with air. The system allows various degrees of filling; this allows the passenger to steplessly choose between a hard or soft setting. The air cushion system also makes the seats lighter, thereby reducing the aircraft's fuel use and, ultimately, its operating costs.

The motors are a central component of the air cushion system. Each aircraft seat with integrated pneumatic air cushion system is equipped with a maxon motor. A single brushless EC 45 flat motor per seat drives the vane pump of the air cushion. The flat motors have an output power of more than 30 W, but weigh only 75 g apiece – a particularly important criterion for use in aircraft.

maxon EC 45 flat
Ø 42.9 mm,
brushless, 30 W

Environmental control system for passenger aircraft

Modern pressure cabins and environmental control systems ensure a pleasant atmosphere in commercial aircraft. Brushless maxon DC motors help to maintain the correct pressure in the cabin, provide adequate oxygen and ensure that the temperature is just right. The cabin ventilation system consists of 36 butterfly valves that are operated with EC 45 flat motors. The linear drives for the air inlets consist of adapted brushless EC 32 motors with low-temperature Hall sensors, a flame barrier at the output shaft and special vibration-resistant threads for fastening. The maxon EC 45 flat is used as valve actuator in the aircraft. It is characterized by a simple, reliable design with high torque resistance in a short design. The brushless motor functions in the standard temperature range encountered in civil aviation, from –55 to +85 °C. A total of 48 drive systems by maxon motor are installed in the Boeing 787. The EC 45 flat drives the valve flap via a spur gearhead.

maxon EC 45 flat
Ø 42.8 mm,
brushless, 50 W

Photos: Lantal, Shutterstock/Adisa, maxon motor ag, Lantal/T+T Fotografie

“It is important to think **laterally.**”

Globally, around 60 percent of all aircraft textiles are produces by Lantal, a Swiss company. With the development of a pneumatic seat system, Lantal has discovered another market niche for itself.

Interview: Anja Schütz

Dr. Urs Rickenbacher completed his doctorate in business education and educational management (Dr. oec. HSG) at the University of St. Gallen. After his studies, he worked in executive positions at Gebr. Sulzer AG, Kuoni Reisen AG, Jelmoli AG and the USM Group before he became the CEO and delegate of the board of directors at Lantal Textiles Group in Langenthal (Switzerland) in 2003.

What in particular fascinates you about your job as CEO at Lantal? What are the largest challenges?

It is fascinating to work with people from different cultures every day and to experience the beauty and diversity of the textile industry. The challenges are in particular the internationality of the business, as well as our aim to provide best performance in the face of strong competition, with high cost and margin pressure and a high degree of volatility.

Where did Lantal get the idea to develop a pneumatic seat cushion system (PCS)? Was marketing the idea to customers a rocky road?

Urs Baumann, the then owner and CEO of Lantal, saw a patented, small air-filled seat bench at the “prospective concepts” invention company. He made the right mental connections and recognized an opportunity for using the technology in Lantal’s core business with seat covers. It took four years until the first commercial seat cushion had been certified and installed at an airline. Another four years were needed to get business and first class seats equipped with a fully adaptive seat cushion system. Certifications in the aerospace industry are – rightly so – very complex and time-consuming.

> “It is fascinating to work with people from different cultures.”

The air cushion technology has now established itself in the business and first class. With which airline should I fly if I want to enjoy the benefits of the comfort system?

The first airline that offered a fully pneumatic comfort system in the business and first class seats of their long-distance aircraft was Swiss International Airlines. Today more than 3000 seats, mainly in the business class, have been equipped with this system. In addition to SWISS, these seats can be found at Lufthansa, Brussels Airlines, Austrian Airlines and at British Midland International under the label of British Airways. Orders have been received from Air Canada, for the Boeing B777, as well as from two north American airlines and an airline company from the Middle East.

How much does Lantal invest in research and innovation?

This question cannot be answered with a simple number. In the international market, innovations are crucial for survival. We constantly watch topics and trends in the aerospace, bus and railway industries, as well as related fields such as architecture, fashion, furniture design and mobility, to detect trends and ideas and implement them towards sustainable corporate development. It is important to think laterally, to get new input from other industries and to integrate these ideas with our strategic objectives. Innovation is of central importance for a highly specialized company. it is not limited to new design versions and targeted process optimization, but rather also includes new products that succeed in generating more or new benefits for the customer.

Download the tablet edition 2//2013 of driven to read the complete interview. magazine.maxonmotor.com

Rocket motors for extreme speeds: After the first thrust, the booster stage separates from the passenger capsule. The plane lands like a conventional passenger aircraft.

In **90** minutes from Paris to Sidney

Today, a flight passenger needs around 24 hours to travel a distance of 16,800 km. Hypersonic aircraft with rocket engines will reduce this time to a fraction.

Article: Anja Schütz

The SpaceLiner hypersonic aircraft does not need a long runway; it launches vertically into the sky over Paris. After a flight phase of around eight minutes, it switches to horizontal flight and glides to its destination at a height of 80,000 m. During some stages of the journey, the 50 passengers are traveling at 20 times the speed of sound, or about 20,000 km/h. 80 minutes later, the SpaceLiner touches down on a normal runway in Sydney. This might sound simple, but in reality it is quite complex.

"Due to the friction with the earth's atmosphere, the nose and wings need active cooling."

Within the scope of the Fast20XX study (Future High-Altitude High-Speed Transport), scientists from Germany, Austria, Spain, Switzerland, Italy, Belgium, the Netherlands, France and Sweden got together to concretize the vision of the SpaceLiner. The concept is based on a two-stage, reusable system: One passenger capsule and a booster stage that separates from the passenger capsule after the first thrust.

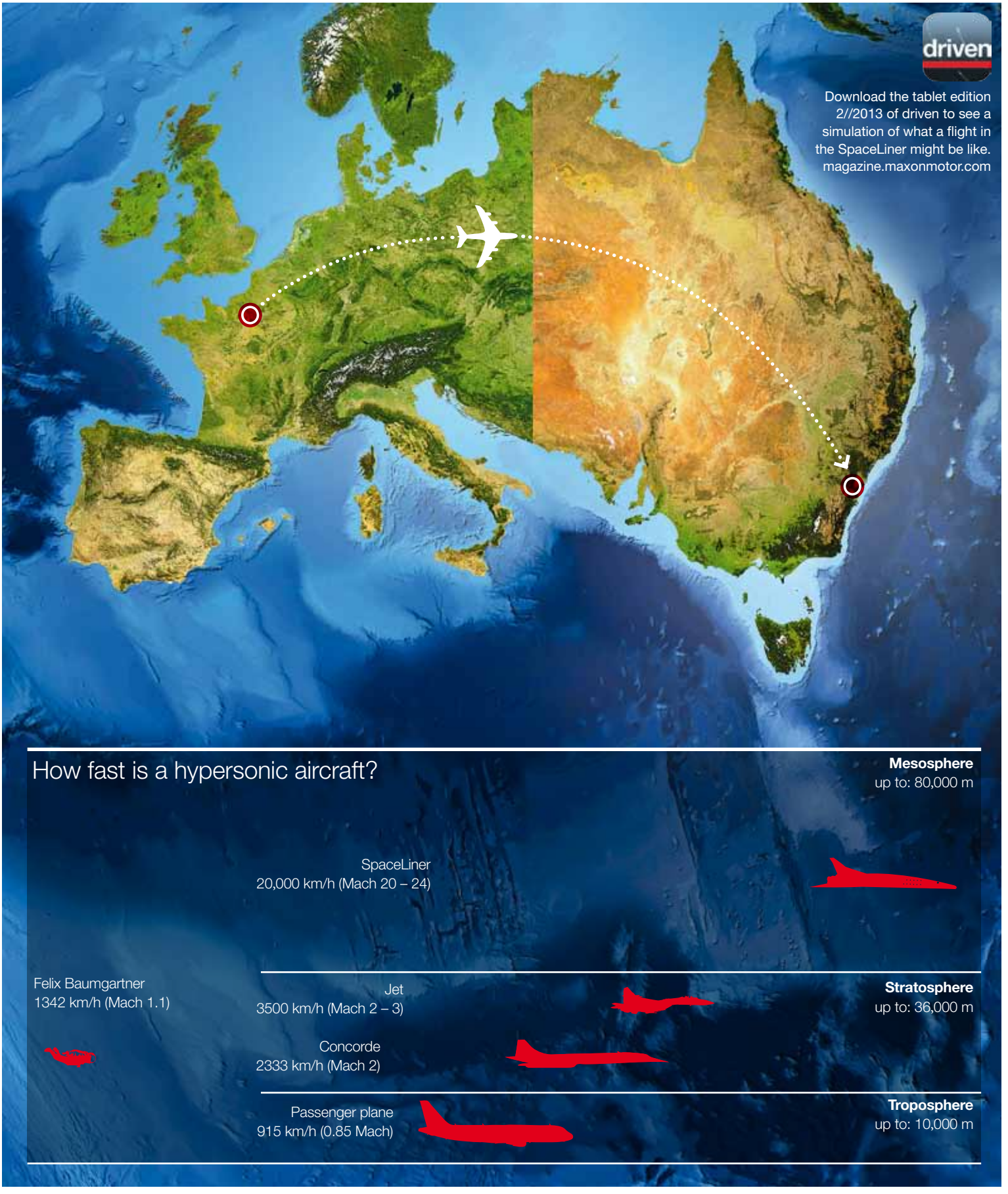
Rocket drives provide thrust

In principle, a hypersonic flight works just like any other flight, but at speeds of at least 1.7 km/s, i.e. over 6000 km/h. For short distances, the SpaceLiner can even achieve 20,000 km/h. This requires a powerful propulsion system. "On the SpaceLiner, we cleverly solve that problem by using rocket engines," says Martin Sippel, project manager at the German Aerospace Center (DLR) in Bremen. The rocket engine burns liquid hydrogen and oxygen; as a result, water vapor forms. Unlike for example the supersonic aircraft Concorde, which burnt 25,000 liters of fuel per hour, the drive of the SpaceLiner has been designed to be environmentally friendly right from the start.

Active cooling required

Another challenge for the scientists is the heat that develops during the flight. Due to the enormous friction with the earth's atmosphere, temperatures of up to 1800 °C are generated at the outer surface of the SpaceLiner. "In addition to a lightweight and very reliable passive thermal protection on the large surfaces, the SpaceLiner therefore needs active cooling on its nose and on the front sides of the wings," explains Sippel.

The project is currently in an early phase of development. According to the DLR, the first hypersonic aircraft with passengers could take off in 2050. However, it will take a little longer until the technology takes hold in the price-conscious mass tourism sector. Martin Sippel estimates that, in the beginning, a SpaceLiner ticket will cost roughly the same as the space tourism flights offered by Virgin Galactic. We are talking about around 200,000 dollars – an expensive, but extremely speedy way of traveling. Until hypersonic flight becomes a matter of habit for the general population, various technical developments will ensure that the passengers travel in comfort. And maxon motors installed in numerous aircraft components contribute to this, performing their duties out of sight.



Photos: DLR, Avenue Images / Oleksiy Maksimenko

Thirty by

ten by ten centimeters:

The UKube-1 miniature satellite.

Nanosatellites heading for space

Photos: Clyde Space

"maxon's participation was decisive for the development of the reaction wheel."
Craig Clark, CEO Clyde Space

Clyde Space, a Scottish company, researches new application options for nanosatellites. To this end, it counts on brushless DC motors by maxon motor.

Article: Anja Schütz

UKube-1 is the first British CubeSat mission – and the first Scottish satellite ever. In September 2013, it will be launched into space from the Kosmodrom in Baikonur (Kazakhstan), with the Russian Sojus-2 rocket. On board the UKube-1 satellite there is a GPS device for measuring the weather in the plasmasphere, as well as a camera to take photos of Earth.

The aim is to record the effects of radiation on technical devices by means of an innovative new image sensor and to find out whether the reliability of communication satellites can be improved by using cosmic radiation. UKube-1 also contains various instruments that enable British students to interact with the space vehicle.

Nanosatellites or CubeSats are miniaturized satellites used in space research. They are only 10 x 10 x 10 cm in size and weigh less than 1 kg. These cost-effective and practical satellites were developed for research purposes. To improve the inclination control for the small CubeSats, Clyde Space cooperates with maxon motor. This opens up new areas of application for nanosatellites, for example observing the Earth with high-resolution cameras, transmitting data with high bandwidth, applications in the fields of space science and astronomy, or precision inspection of new technology in orbit.

Innovative inclination control developed

Clyde Space and maxon motor have jointly developed a tri-axial inclination control system. It is based on torque positioning by means of a reaction wheel. The wheel is driven by a brushless maxon DC motor. When the speed of the reaction wheel changes, the resulting torque rotates the CubeSat. The satellite is stabilized by means of rotation at constant speed. To achieve complete inclination control on all three axes, several reaction wheels are used. Clyde Space was looking for a cost-effective solution and decided on a brushless standard maxon motor with a diameter of 20 mm. maxon motor modified this product to suit the application environment, delivered and installed the reaction wheel and ensured proper dynamic calibration of the entire subassembly.

"maxon's participation in the project was decisive for the development of the reaction wheel. We are now able to provide our customers with complete tri-axial inclination control based on series-produced components," explains Craig Clark, CEO of Clyde Space. When he chose the components, high resilience was important: "We specifically chose maxon motor to ensure that the brushless DC motors can handle the strong vibrations and impacts during the rocket start and the high cyclical thermal load and radiation in orbit."

maxon motors drive the reaction wheels that control the inclination of the satellite.

On the rim of the Valles Marineris

Robin Phillips, Aerospace Project Manager at maxon motor ag in Sachseln (Switzerland), comments on three controversial theses concerning the subject of hypersonic flight, as well as manned trips to Mars and to the Moon.

Robin Phillips studied mathematics at Bristol University (UK) and astrophysics at the University of Kent (UK) before working as an instrument support scientist at the James Clerk Maxwell Telescope on Mauna Kea in Hawaii. Then he moved to the University of Lethbridge in Alberta (CA) where he worked as a project manager in an instrumentation group, designing and deploying specific measuring instruments for telescopes. This work ultimately led him to his current position at maxon motor.

Photos: maxon motor AG, DLR, Reuters / NASA, Reuters / Jim Urquhart

The German Aerospace Center (DLR) plans to fly from Europe to Australia in just 90 minutes with a special hypersonic passenger plane in 2030. This isn't a realistic goal.

I am sure this will become a reality, but I doubt 2030 is realistic. Since the 1960s, there have been many attempts to develop high-speed supersonic (or hypersonic) aircraft, but they have always failed, not because the technology is impossible, but because the market for them just isn't there. People prefer cheap tickets to fast travel! This could clearly been seen in the case of Concorde vs the Boeing 747, both of which were developed in the late 1960s. Despite massive government subsidy, no airline chose to buy Concorde over the Boeing 747.

The situation is no different today. Even Boeing's Sonic Cruiser concept of a few years ago, which was designed to travel near the speed of sound, couldn't be made to work commercially, and the Boeing 787 was developed instead, with an emphasis on economy of travel. Before hypersonic travel becomes a reality for commercial airlines, there needs to be a step change in technology, both in terms of the propulsion systems and in terms of airframe cooling. This probably means a fuel system that doesn't rely on fossil fuels, since as these become scarcer, the argument for economy instead of speed just becomes stronger.

I'm sure we will eventually develop such an aircraft, and maybe my grandchildren will get to fly in it in their old age. I think that is the kind of timescale we are talking about.

Manned space research in the future might lead to Mars or back to the Moon.

The Moon or Mars are not really very distant objects; they are in fact amongst the closest objects we can consider visiting. This statement shows how far we really are from a Star-Trek-like ability to travel around the galaxy. The unmanned spacecraft Voyager 1, which flew past Jupiter and Saturn in the early 1980s, is only now reaching the edge of our solar system, and it has been travelling for 35 years to get there!

I actually think it is more likely that we will have a permanent presence on Mars before we have regular hypersonic travel from Europe to Australia! There are a number of very rich people investing large amounts of money in reducing the cost of access to space. I think in a decade or two, it will be within these people's (and their companies') reach to put people on Mars. For human travel to Mars, new propulsion technology is not really needed. The problems that need solving have more to do with how to land when you get there and how to protect those fragile human bodies from heat, cold and radiation on the way!

"We took a giant step forward in solving the landing problem with the sky crane system used to land the Curiosity rover. This was specifically selected as one of the very few systems that is capable of landing a heavy system (as any manned spacecraft would be) on a planet with an atmosphere that is too thin for parachutes to slow a spacecraft down sufficiently for a soft landing."

There are ambitious projects that are planning a Mars colony, although it has not yet been established whether a person can survive on Mars.

I think there is a good chance that humans will be living on Mars within the next 50 years. The technology for doing this has been around for some time. Over the last 10 years, unmanned spacecraft have discovered that Mars still has frozen water present. This makes the technical aspects of building a colony on Mars much simpler. If a suitable power source is available, all the other basics for sustaining life can be made on Mars. In theory, it should be possible to build domes, develop agriculture for food and separate the air we need to breathe. However, it is just too expensive for governments to fund if there are no exceptional circumstances. The Moon landings in 1969–72 undoubtedly count as an extraordinary achievement, but they were a product of special political circumstances in the 1960s and were not part of a long-term plan.

In the last decade, we have started to see reasons being found to justify sending humans beyond low Earth orbit and into a long-term presence on the Moon or Mars. This means there has to be a reason for people to live and work there and ultimately, in the long term, for these places to develop their own economies. This sort of process takes a long time. For comparison, it took 128 years between Columbus discovering North America and the first permanent European settlement (Plymouth, MA) being founded. A fully self-sustaining colony is of course a very long way off. Mining is not the only possible reason for going there, tourism may be another example where people are willing to pay sufficient money to make it a profitable venture. I for one would love to have the opportunity to stand on the rim of the Valles Marineris and admire the view!

Martian for a while

Volker Maiwald is 31 years old and studied aerospace technology at RWTH Aachen. Since 2010, he has been working for the German Aerospace Center (DLR) at the Institute of Space Systems in Bremen. Volker Maiwald was acting commander and habitat engineer of the Crew 125 in the Mars Desert Research Station from February 23 to March 9, 2013.

The Mars base in the desert of Utah is small: The two-story station has a diameter of just ten meters. Here the six “astronauts” live for two weeks.

During the “EVA missions”, the crew collects rock samples that are later examined in the laboratory of the Mars Desert Research Station (MDRS).

In ancient times, Mars was seen as the embodiment of the god of war due to its red color. It has carried the name ever since. In 1965, the Mariner 4 space probe took the first close-up photos of Mars and quickly destroyed earlier assumptions of artificially created "channels" or even civilizations on Mars. The planet nevertheless remains very interesting for many scientists. Currently its surface is not suitable for human habitation, but it is less hostile to life than Venus. Mars has a rich supply of resources, including water ice, and it is comparatively easy to reach.

Mars gets its red color from hematite, which contains iron.

Currently a number of probes and rovers (e.g. Europa Mars Express, or the US rovers Curiosity and Opportunity) are exploring Mars. ESA and NASA, but also several private companies, plan to bring people to Mars and build colonies there – a dream that will not be realized within the next 30 years.

Such an endeavor – similar to the historical exploration trips, but hopefully more peaceful – needs planning and training, for example in the Mars Desert Research Station (MDRS) in Utah, where I had the opportunity to test "Life on Mars" for two weeks. In addition to geological and biological research, the objective behind the desert station of the Mars Society is to test the restrictions that apply during a mission to Mars, and to gain valuable experience before attempting a real trip to Mars. But why would one want to go there?

Mars could provide many answers regarding the origin and development of the solar system and the Earth and could provide a habitat to live in – with the aid of technology. In the weeks before my trip to Utah, two asteroids came close to Earth; one crashed down in Russia. It is maybe not such a bad idea to consider establishing settlements on another planet.

Cramped quarters within an endless expanse

A manned mission to Mars would of course entail restrictions. In Utah, our crew of six had a daily water supply of 120 liter – back home, that is the water consumption of a single person. Showers were taken every third day, for two minutes. We ate dried food: Small tomato, broccoli or beef cubes that became edible when water was added. But the isolation from the outside world in particular was a very dramatic experience: You cannot exit the Mars station whenever you want. Even during time outside, you are isolated from the outside world in your (simulated) space suit. The feeling of being cramped in becomes noticeable within the first few days. And it was a very intense time: On average, we worked approx. 18 hours per day, on experiments and reports, on keeping contact to ground control and on maintenance tasks.

The crew's quarters: A folding table and a bed in a space of 3 square meters.

Each gram that is taken to Mars costs a lot of money. So you have to make do with as little as possible. In the ideal case, everything can be recycled. The MDRS is round, has a diameter of 8 meters and two floors. The lower floor contains the workshop, laboratory and airlocks, while the upper floor contains the computer workstations, kitchen, dining table and the "quarters", which is only 1.5 x 2 meters for each person – not very spacious!

But after two weeks of "life on Mars", six strangers from five nations have become good friends – and perhaps that is the biggest achievement of a Mars mission: Getting closer together, to continue in the spirit of the flights to the moon: We come in peace, for all mankind.

Crew 125 of the MDRS: Csilla Orgel, Ayako Ono, Volker Maiwald (rear, left to right), Melissa Battler, Hans van 't Woud, Matt Cross (front, left to right).

Photos: Volker Maiwald, Reuters / Jim Urquhart, Keystone / Science Photo Library / Detlev Van Ravenswaay

Strong replacements

Modern prostheses are high tech systems that save lives and significantly improve the quality of life of their wearers. Researchers hope for further advances through a better interface with the nervous system.

Article: Anja Schütz

The computer specialist Curtis Grimsley of New York was focused on his work when the earth suddenly started to shake. He was sitting in his office on the 70th floor of the World Trade Center on the fateful date of September 11, 2001. A day that had begun as a normal workday turned into a nightmare in a matter of seconds: Photos fell off walls, paper flew through the air, and people ran for their lives. In a panic, they raced to the staircase. Curtis was one of those lucky enough to quickly reach the stairs. He hurried down the seventy stories to the floor, reached the entrance, and made it out of the building. Only later would he find out exactly what happened that morning, the number of colleagues who lost their lives in the World Trade Center, and how lucky he really was. Curtis was able to escape – despite wearing a prosthetic leg. The former basketball player and track athlete had lost his left leg in a car accident years earlier. For sev-

Photos: Ottobock Healthcare GmbH, Schlossmuseum Jagsthausen

eral years, Curtis Grimsley lived with a standard prosthesis, until he heard of a new German innovation: The C-Leg, the world's first prosthetic leg to be completely controlled by a microprocessor. In the C-Leg (short for "computerized leg"), integrated sensors continuously analyze the walking situation, and the hydraulics in the prosthesis adjust themselves automatically. With a standard prosthesis, Curtis probably wouldn't have made it out of the building.

Prostheses didn't always have a "mind of their own." The history of prosthetics can be traced back to the ancient Egyptians, who used simple prosthetics as early as 2000 B.C. In the Middle Ages, wood and iron were the favored materials for artificial limbs. One of the most famous prostheses in the 16th century was the "iron hand" of Götz von Berlichingen: It was made of more than 200 parts, and its mobility made it a wonder of its time. The fingers were movable and could be fixed in various positions by gears.

Curtis Grimsley's C-Leg helped him successfully escape from the World Trade Center.

Arm muscles coordinate the motion of the hand

Today, hand and arm prosthetics are a bit more complex. The human hand is a singular work of nature – a multitude of nerves, tendons, muscles and bones are all interconnected to form a precision instrument. Recreating the natural form and numerous functions in a prosthesis is one of the greatest challenges in medical engineering. The Michelangelo prosthetic hand made by Ottobock Health Care GmbH comes remarkably close to nature's original. It can perform seven different gripping movements. A maxon motor moves the thumb joint; a second motor moves the main joints of the other fingers. The artificial wrist can lock into various positions, but has attenuated mobility otherwise. Its attenuation makes the motion of the prosthesis seem very natural, for instance when shaking hands.

The interface with the human body is essential for functional prosthetic arms or hands because the motion of the prosthesis is controlled by body signals from the arm muscles that have remained intact. In many cases, the motion of the prosthesis is coordinated by two arm muscles, with one muscle responsible for opening the hand and the other for closing it. The contraction of the muscle generates an electric pulse on the skin. This pulse is received by implanted electrodes and transmitted to a microprocessor in the prosthesis. The more the muscle tenses, the faster and more forceful the gripping motion of the prosthesis. A force sensor integrated in the artificial thumb supports the motion by measuring the level and direction of the gripping force. For instance, if an object is about to slide out of the hand, the equipment automatically adjusts and prevents the object from falling.

From external prostheses to endoprostheses

As opposed to external prostheses – artificial body parts outside of the human body – endoprostheses are implanted inside the body, for instance as pacemakers, hearing implants, or medication pumps. The technology for implantable medication delivery systems is very advanced. These devices are often critical for the survival of the patient, which means they have to be absolutely reliable. Implantable pump systems are used for treating a range of illnesses –

The human hand is a precision instrument, a unique work of nature. Recreating it is not easy.

The Alfapump fluid pump

The Alfapump implant is placed between the subcutaneous fat layer and the peritoneum. The implant is made of PEEK (polyether ether ketone), a biocompatible plastic. The unique ambient conditions within the human body require special motors and appropriately adapted electronics, as no hermetically sealed encapsulation is possible when plastics are used. Due to the presence of moisture, the implant is sealed completely; the electronics are protected with an additional coating.

maxon EC 13
Ø 13 mm, brushless, 6 W

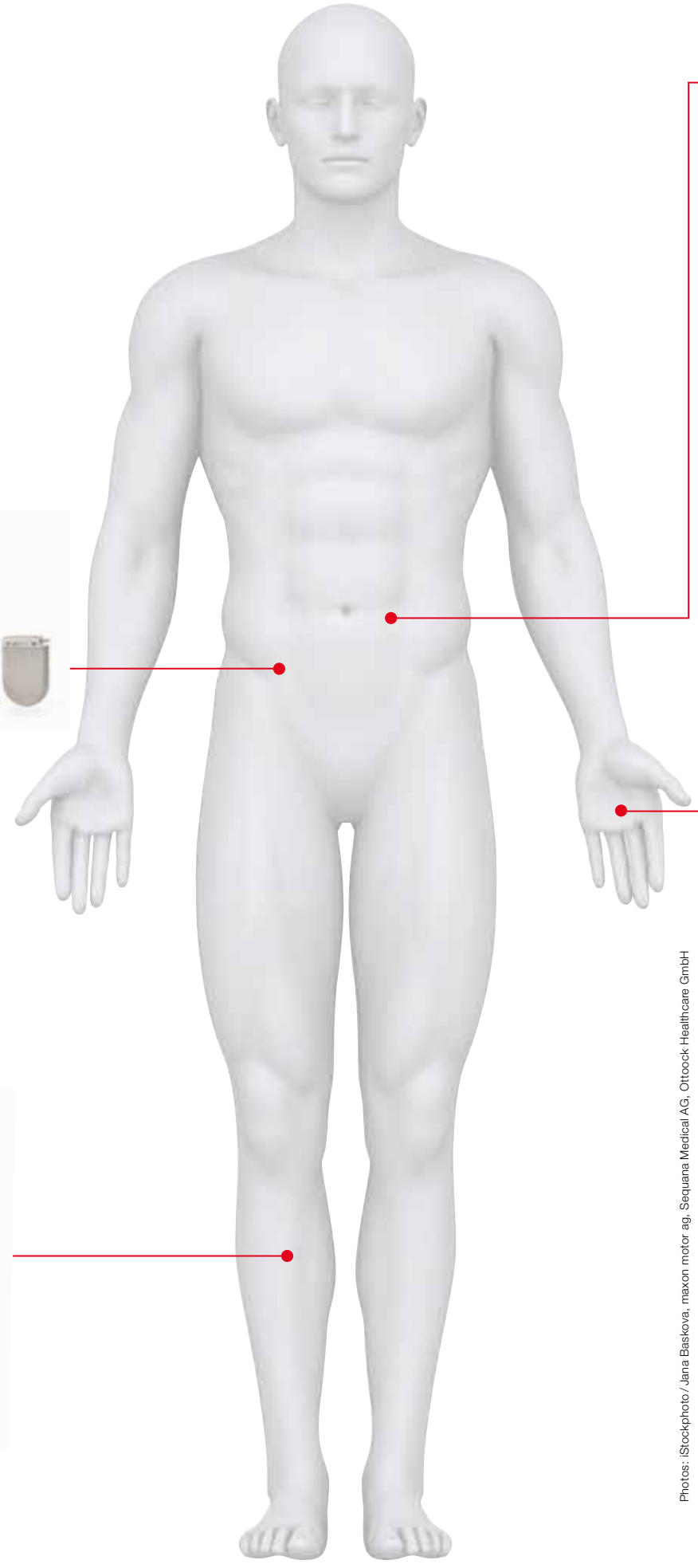
The EC 13 motor drives the pump gears of the Alfapump. The motor is equipped with Hall sensors that provide important position feedback. The motor controller uses these Hall sensors to achieve reliable and stable operation, in particular at low speeds and high load torques.

The C-Leg prosthesis

A microprocessor in the knee joint of the C-Leg recognizes the wearer's phase of gait and reacts in real time – both for the swing phase and the standing phase. The active prosthesis independently makes adjustments for different terrain and walking speeds. Around 50 times per second, it measures the load on the knee joint and the knee's angle. The electronics calculate the required suspension in the hydraulic knee joint and ensure that the servo-controlled valves bend and stretch the knee at the right moment. Two valves adapt the characteristics of the hydraulics. These valves are controlled by RE 10 DC motors by maxon.

maxon RE 10
Ø 10 mm, precious metal brushes, 0.75 W

Each C-Leg contains two RE 10 motors by maxon motor. One strength of the motor is its small size. With a 10 millimeter diameter, it is the third smallest DC motor made by maxon. The RE 10 features ironless windings and neodymium magnets that allow top performance with minimal size. Precious-metal brushes are used for the commutation of the motors. This ensures detent-free running of the maxon motors, even at low speeds.



Photos: iStockphoto / Jana Baskova, maxon motor ag, Sequana Medical AG, Ottoock Healthcare GmbH

Implantable medication delivery systems

The active implant is placed in the lower abdomen and delivers a dose of medication at a given time of day, according to parameters set by the physician. The implant has a wireless data interface to a patient interface, making it possible to adapt the dosage at any time. The internal medication reservoir can be refilled by a specialist. The service life of the implant spans several years and is limited only by the life of the battery. The centerpiece of the device is a reciprocating piston pump by maxon medical. This generates a linear movement that pumps the liquid. The individual parts of the pump have very narrow tolerances and allow the pump volume to be adjusted with a precision of less than a microliter per piston stroke.

Reciprocating piston pump by maxon medical

The Michelangelo active hand prosthesis

Features of the Michelangelo prosthesis made by Ottobock include seven different gripping movements, a realistic appearance, and a low weight of just 420 grams. Michelangelo is a myoelectric prosthesis. At each contraction of the muscle, electric voltage is generated on the skin of the user; this voltage controls the prosthesis. The main drive provides the gripping movement and gripping force of the prosthesis. The actively driven elements are the thumb, index finger, and middle finger. The ring finger and little finger move passively. With the thumb's special drive, it is also possible to form a flat, open hand.

maxon EC 10 (base)
Ø 10 mm, brushless, 8 W, with Hall sensors

There are two EC 10 motors in the "Michelangelo" prosthesis. The motor was modified with high-precision worm gearing. The electronically commutated brushless DC motors feature excellent torque characteristics, high power, an extremely high speed range, and a long life span. Their outstanding control qualities make it possible to realize precision positioning drives.

including diabetes and ascites. Ascites is a condition in which fluid collects in the abdominal cavity. The cause is often a severe illness such as cancer. Sequana Medical has developed an active implant for controlling the collected fluid in the abdomen. When necessary, the Alfapump, driven by a maxonmotor, pumps the fluid from the abdominal cavity into the patient's bladder. The pump was commercially implanted for the first time in October 2011, in Vienna, Austria. According to Prof. Dr. Markus Peck-Radosavljevic of the Gastroenterology and Hepatology Department at Vienna General Hospital (AKH Wien), the two short operations went without complications. "The Alfapump System represents a real breakthrough in the treatment of refractory ascites. By using the Alfapump, the patient no longer has to return to the hospital on a frequent basis to undergo drainage procedures," says Peck-Radosavljevic.

Endoprostheses are implants placed inside the human body.

Neural interface as a vision for the future

Despite all the advances in medical engineering, we still have a long way to go before prostheses and implants will measure up to the functional and aesthetic quality of nature's designs. The dream of many prosthesis developers is an even more internalized connection between the body and technology. The key lies in neural interfaces – it is hoped that electrodes, placed in the brain, could make it possible to achieve even more complex movements with prostheses. There is also much unbroken ground in the field of haptics. Various research projects are currently focused on giving artificial hands the sense of touch. In the EU research project "SmartHand," a team of scientists from Italy and Sweden has developed an artificial hand equipped with 40 sensors and miniature motors. These sensors and motors allow it to emulate the sensory faculties of human skin. Robin af Ekenstam, a Swedish national who lost his right hand due to cancer, was one of the first patients to test the scientists' prototype: "When I grip something, I can feel it with my fingertips, which is strange, since I don't have them anymore."

driven

Download the tablet edition 1//2013 of driven to see how the Michelangelo prosthesis is controlled by the wearer's muscles. magazine.maxonmotor.com

"The wearer should **forget** the **prosthesis** is there."

With the C-Leg, Ottobock HealthCare GmbH has created a unique prosthetic leg that increases the wearer's safety and improves their quality of life.

Interview: Anja Schütz

Dr. Pfuhl, you have been working at the Ottobock Group for 17 years. How did your career begin, and what is your role as Managing Director of Prosthetics?
I started as assistant to Prof. Hans Georg Näder, the company's owner. My job was to develop the strategic corporate planning. On the one hand, the challenge was to communicate the company's growth targets, and on the other hand, to work with teams to draw up strategic options for achieving those targets. After the next eight years as CMO of Ottobock HealthCare, I was made Managing Director of the prosthetics business unit in 2012. We adopted an organizational structure based on business units to make the company faster and more dynamic. However, the main benefit of this step is that it enables us to define targets and strategies for the different business areas and to optimally network the profitable areas vital to our success. And that pretty much describes my current role.

"The safety of the amputee is the most important consideration."

Ottobock is a very successful company today – the number of employees has tripled, and the revenue has even quadrupled. What was it like experiencing this incredibly fast growth first hand?
Just as you said: incredibly fast! The company is constantly recreating itself. This means employees constantly face new challenges. They have to be flexible, but most important is a willingness to learn and expand the company's knowledge base. It is fascinating to see how products emerge from this very knowledge base, frequently in cooperation with external experts.

The C-Leg prosthesis is a marvel of prosthetic engineering. The hydraulic characteristics are modulated by two valves that are controlled by RE 10 DC motors. How important to the prosthesis is this functional design?
First of all, the day-to-day safety of the amputee is the most important consideration when designing a prosthetic leg. You also need to consider ease of motion, which directly leads to higher mobility and improved quality of life. The adjustable hydraulics are the centerpiece of the C-Leg prosthetic knee system. They make it possible for the prosthesis to adapt to a range of situations. The feedback from numerous sensors allows the prosthesis to recognize situations such as walking in uneven terrain in the woods, walking downhill on a slope, or suddenly stumbling. A microprocessor analyzes this information and then sends the information and positioning signals to the minimotors. The motors then adjust the hydraulics accordingly. It's important that the size, weight, power consumption, and noise emissions are kept to a minimum. Our goal is for the wearer to forget the prosthesis is there, and feel completely secure at work and in daily life. It's not enough for the prosthesis to be as lightweight and inconspicuous as possible. The amputee also has to trust the system, and be able to rely on it at any moment. To make sure this is the case over the entire service life of the prosthesis, we only use components that meet the highest quality standards.

Dr. Helmut Pfuhl was born on April 22, 1961. During and after his studies, he was employed by the University of Göttingen and Mercedes Benz. He has been the CMO of Ottobock HealthCare GmbH since 2002. He also headed the international marketing business unit until 2011. In 2012, he became managing director of the prosthetics business unit.

driven

Download the tablet edition 1//2013 of driven to see what daily life is like with a C-leg. magazine.maxonmotor.com

Kelly Cartwright was born on April 22, 1989 in Melbourne, Australia. In 2008, she was discovered by the Australian Paralympics Committee and joined Australia's national team. Since then, she has enjoyed numerous victories, most recently at the 2012 Paralympics in London. Kelly Cartwright is one of the Ottobock Health Care GmbH Paralympic ambassadors.

"The only thing that really is off limits is wearing **high heels.**"

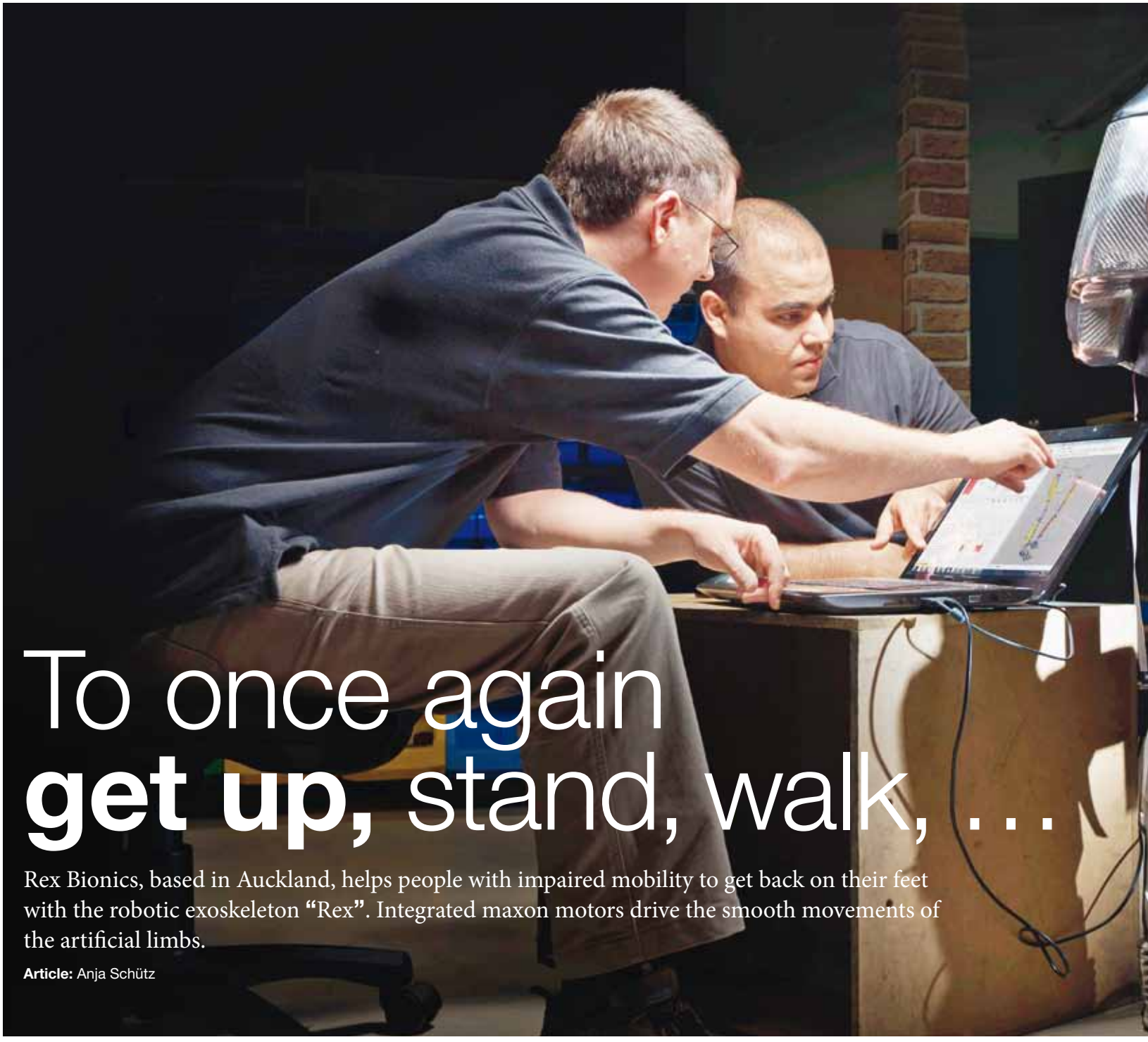
Kelly Cartwright lost her right leg to cancer as a teenager. At the Paralympics 2012, she set a new world record in the long jump, jumping 4.38 meters for gold.

What role do athletics play in your life?
Athletics have always been important for me, but more as a hobby. Since the amputation, athletics have become one of the most important things in my life. Right now, I can't imagine my life without athletics.

How important is the relationship between the athlete and the prosthetist?
It's important that there is complete trust in the relationship. You need someone who listens and takes you seriously. Every human is different and has different needs. A solution that works well for one athlete doesn't necessarily work for someone else.

Do you live according to a particular motto?
As far as I'm concerned, you can do anything you want, whether you have a disability or not. People often ask me what sort of things I'm not able to do because of my disability. The only thing that really is off limits is wearing high heels. There are some things I do in a different way because of my disability, but my disability doesn't keep me from doing them.

Photos: Ottobock HealthCare GmbH



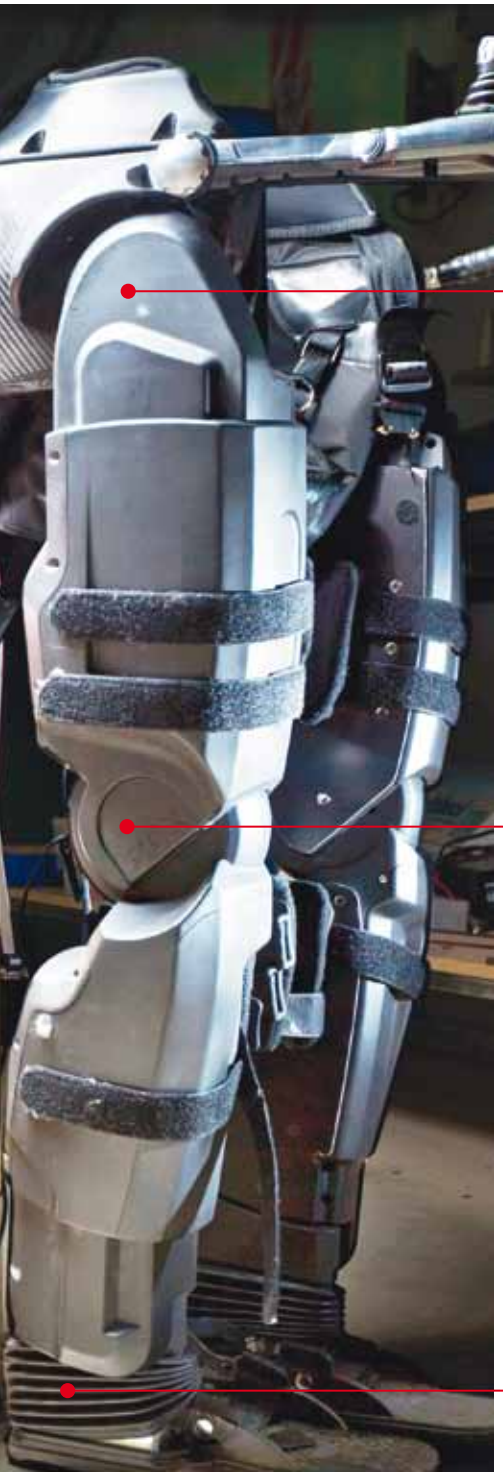
To once again **get up,** stand, walk, . . .

Rex Bionics, based in Auckland, helps people with impaired mobility to get back on their feet with the robotic exoskeleton "Rex". Integrated maxon motors drive the smooth movements of the artificial limbs.

Article: Anja Schütz

The exoskeleton weighs 84 pounds, but the user does not carry any of this weight. The exoskeleton is powered by an integrated, exchangeable battery that lasts for around two hours of continuous operation. Rex is controlled with a joystick and control pad. Other exoskeletons frequently use sensors. A major advantage of joystick operation is that no movement or nerve functions are required to use the exoskeleton. With a speed of approx. 3 m per minute, Rex is not very fast, but the user moves very safely. Whether switched on or off, the exoskeleton remains stable. This means the user can take part in a sports event or a concert without worrying

Photos: Rex Bionics Ltd., maxon motor ag



The wheelchair is empty. The exoskeleton returns temporary autonomy to the patient.

about being pushed over. In addition, Rex does not require supporting aids such as crutches, giving the user full use of his or her arms and hands.

Strong motors for a secure stance

Rex is a highly complex electromechanical device. Each exoskeleton has thousands of precision parts, including the limbs, which are controlled by a network of 29 microcontrollers. The special arrangement of microcontrollers allows for movements and reactions in a matter of seconds. The user experiences the motion as very smooth and fluid. Motors made by maxon ensure that no jerky movements occur. The motors control all movements of the limbs, which move in the same way as a human leg.

Rex is a highly sensitive medial product, and the saftey of the user is of utmost importance.

Ten type DC RE 40 maxon motors are integrated in each exoskeleton. The RE 40 delivers a powerful 150 W and has an efficiency of more than 90 percent. The mechanically commutated DC motors are characterized by good torque behavior, high dynamics, a very large speed range, and a long service life. Rex Bionics chose to use high-quality motors by maxon for a good reason: Rex is a highly sensitive medical product, and the safety of the user is of utmost importance.

maxon RE 40
Ø 40 mm,
graphite brushes,
150 W

High efficiency
Ten maxon DC RE 40 motors are used in each exoskeleton. The RE 40 delivers a powerful 150 W and has an efficiency of more than 90 percent. The mechanically commutated DC motors are characterized by good torque behavior, high dynamics, a very large speed range, and a long service life.

How little drives **do big things**

Camera systems, humanoid robots, or use in space: High-tech drives that pack a lot of power into a small form factor are needed everywhere. Here is a brief overview of the history of miniature drives – and a peek into the future.

Enhanced automation
In 1996, maxon motor introduced the A-max series – a modern, cost-effective version with an AlNiCo magnet. With the A-max series, maxon motor was able to continue to provide the same wide range of options while at the same time achieving a useful automation. Soon afterwards maxon motor built an even stronger version, the RE-max with an Nd-Fe magnet.

1996

Brushless DC motors
In 1988, the advent of electronically commuted motors heralded a new era. maxon motor introduced its first motors under the name "maxon BL motor EC040-070". The abbreviation BL stood for "brushless". The electronically commutated DC servo motors stand out with excellent torque characteristics, high power, an extremely wide speed range, and a very long service life.

1988

New magnet materials
In 1983, maxon motor introduced the Ferrit series (F motors), achieving for ironless motors a previously unheard-of performance for the cost. Ferrite magnets take up more space, but they are significantly less expensive. During this time maxon motor also launched the modular product program, which allows customers to configure their own drives with motors, gearheads, and digital tachometers.

1983

Customized development
This is one of the great strengths of maxon motor today. maxon motor has developed numerous new products for at times extreme application environments, such as on Mars.

1996

For extreme performance
With its Heavy Duty motors, maxon was the first manufacturer to launch a standard motor for extremely rough operating conditions, such as temperatures above 200 degrees Celsius. Developed to meet the demanding requirements of deep drilling, it opened up new possibilities in many fields of application.

2010

Photos: maxon motor ag, NASA / JPL

1961

Founding the company
In 1961, the company that is maxon motor ag today was founded by the brothers Erwin and Artur Braun as Interelectric AG, a production site for the Frankfurt-based electronics manufacturer Braun. Shearing foils for electric razors by Braun GmbH were the first product made at the Sachseln facility. Nobody was talking about miniature drives at the time.

1968–1970

Self-supporting copper winding
Between 1968 and 1970, the research and development department created an entire product family of DC motors with diameters between 12 and 32 millimeters in record time. At the same time, maxon motor patented the manufacturing process for ironless rotors with a self-supporting copper winding. Building the motor without iron increased the efficiency by a factor of almost two compared with traditional DC motors.

1967

Ironless coil
When the Braun GmbH was sold to Gilette in 1967, ideas for new products were in high demand. While developing a multi-function electric razor, the company created a first high-performance electrical micro motor with an ironless coil: The maxon DC motor was born.

The heart of maxon motors: a globally patented ironless winding.

maxon's first DC motor. It was designed to drive an electric razor.

2012

Configurable drives
Today, precision drives by maxon motor can be found in communications technology, industrial automation, robotics, safety engineering, or aerospace. They are used e.g. in underwater robots to clean ships, or in telescopes looking at new astronomical phenomena. A new motor program was launched in

2012. The powerful DCX motors with matching drives and encoders are configured online and will be ready for shipment in eleven working days or less.

2013

Smaller, more powerful, smarter, and more robust
Take computers, phones, or any other electronic application: Devices are becoming smaller and smaller. As a result the trend towards miniaturization in drive technology continues. More and more "intelligence" can be squeezed into smaller and smaller spaces. Stronger magnets also allow to concentrate more power in a compact frame. The currently smallest drive in the standard program, the maxon EC4, has a diameter of only 4 millimeters. Some extreme applications require motors that, for example, are able to withstand temperatures of up to 500 degrees Celsius. Some initial tests have already been conducted successfully.

The Diamond Light Source particle accelerator in Great Britain.

Electric motors in vacuum

Electric motors are also used in vacuum, for example in production equipment for the semi-conductor industry, in particle accelerators, or in near-Earth space.

Article: Kornelia Stubicar, project manager at maxon motor ag

The term 'vacuum' describes the state of a gas with a defined volume at a pressure that is significantly lower than the atmospheric pressure. This means a state in a space that is largely particle-free. Operating electric motors in a vacuum presents special challenges. First we need to determine the vacuum range in which the motor will operate. The categories are low vacuum, medium vacuum, fine vacuum, high vacuum and ultra-high vacuum.

Influence of the vacuum on the drive

In vacuum conditions, the motor components are subject to increased outgassing. The low pressure causes the emitted material to deposit on the surrounding walls and components. Therefore it is not possible to use the standard versions of motor components under vacuum conditions. The vacuum classification determines to which extent the individual motor components have to be adapted.

The higher the vacuum class, the more important the preceding outgassing process. This entails high requirements on the temperature resistance of the motor components, as outgassing always also places a thermal load on the motor: The electric motor is usually outgassed in an oven, and during operation in the vacuum itself, the motor is subjected to increased thermal load due to reduced heat dissipation. There is risk of overheating, as the motor cannot properly transfer the produced heat to the evacuated surroundings. Therefore, in vacuum, continuous load operation should be avoided wherever possible, for example by planning for a power reserve when selecting the drive.

In vacuum, lubricants in the bearings and gears of the drive are subject to faster outgassing, which can significantly reduce the drive's life span. The increased outgassing of plastics, for example cable insulation, leads to the plastics becoming brittle. This can be avoided by using Teflon instead of PVC.

Influence of the drive on the vacuum

If a standard motor is used in vacuum, there is risk of the evacuated environment (vacuum) being contaminated very quickly. In the high and ultra-high vacuum ranges in particular, this influence of the drive on the vacuum can be a problem.

Photos: Image courtesy of Diamond Light Source, maxon motor ag

Vacuum class	Pressure hPa (~mbar)	Application area	maxon motor types
Low vacuum	300 … 1	Vacuum cleaner	All types
Medium vacuum	1 … 10^{-3}	Vacuum packaging, filament bulb	All EC, DC motors with special graphite brushes
High vacuum (HV)	10^{-3} … 10^{-7}	Silicon wafer processing (semiconductor industry)	All EC, DC motors with precious metal brushes
Ultra high vacuum (UHV)	10^{-7} … 10^{-12}	Manufacture of cathode ray tubes near-Earth space (Moon)	Heavy Duty series, modified (BLDC) EC
Extremely high vacuum (EHV)	< 10^{-12}	Interplanetary space, mass spectrometers	Customer specific drive based on HD Series

The vacuum is contaminated by the outgassing of softeners in plastics, of adhesives and lubricants, as well as of surface coatings. However, the contamination can also stem from air pockets in constructions that have not been deaerated.

Replacing components during manufacturing

Such outgassing is particularly critical in semiconductor and optical applications. The outgassed material can for example condense on optical elements, heat radiators, or on solar cells. To prevent outgassing of electrical motor components under vacuum, targeted measures are taken during the manufacturing of the motors. For example, the gearhead lubrication is adapted by using vacuum-compliant lubricants. Adhesive joints are avoided as far as possible or replaced by welded joints. Whether plastics, insulation or adhesives – in general, materials with low outgassing rates are used.

Motors for use in a particle accelerator

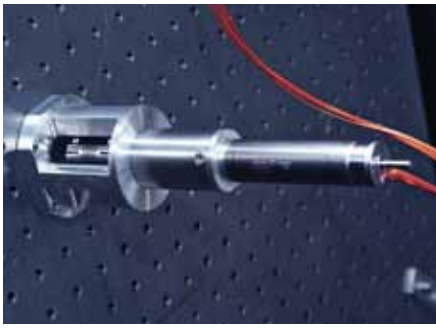
A good example for maxon motors used in ultra-high vacuum is a particle accelerator (synchrotron) in Oxfordshire (Great Britain). In the synchrotron, which measures 45,000 square meters, electrons are accelerated to 3 giga-electron volts (GeV), and light beams are generated that are up to ten billion times brighter than the sun. To prevent loss of electrons through collisions with air molecules, the entire process happens in a vacuum with only a billionth of the atmospheric pressure.

The challenge for maxon was to develop a high-power brushless motor without adhesives, without plastics and with an extremely high temperature resistance. The starting point for this customer-specific solution was maxon's heavy-duty brushless EC 22 HD motor (BLDC motor). Although it was initially developed for use in undersea oil drilling, the brushless 22 mm motor, with its laser-welded housing made of stainless steel and its high temperature range, turned out to fulfill many of the requirements for use in vacuum. As a brushless DC motor, it is by nature more efficient, quieter and more responsive than the stepper motor used previously.

In the course of modifying the EC 22 HD for use in the synchrotron, maxon motor had to consider numerous factors. The first was the thermal behavior. The BLDC motor used in the particle accelerator is temperature-resistant up to 200 °C. Another key requirement was a gearhead with high transmission ratio. To keep the outgassing in a high vacuum of 10^{-7} mbar and more as low as possible, each component of the motor was checked individually and improved if necessary. The PVC insulation normally used on the cables was replaced with a Kapton coating, for example. The customary adhesives and epoxides were eliminated, and the motor was largely assembled with welded joints.

Conclusion

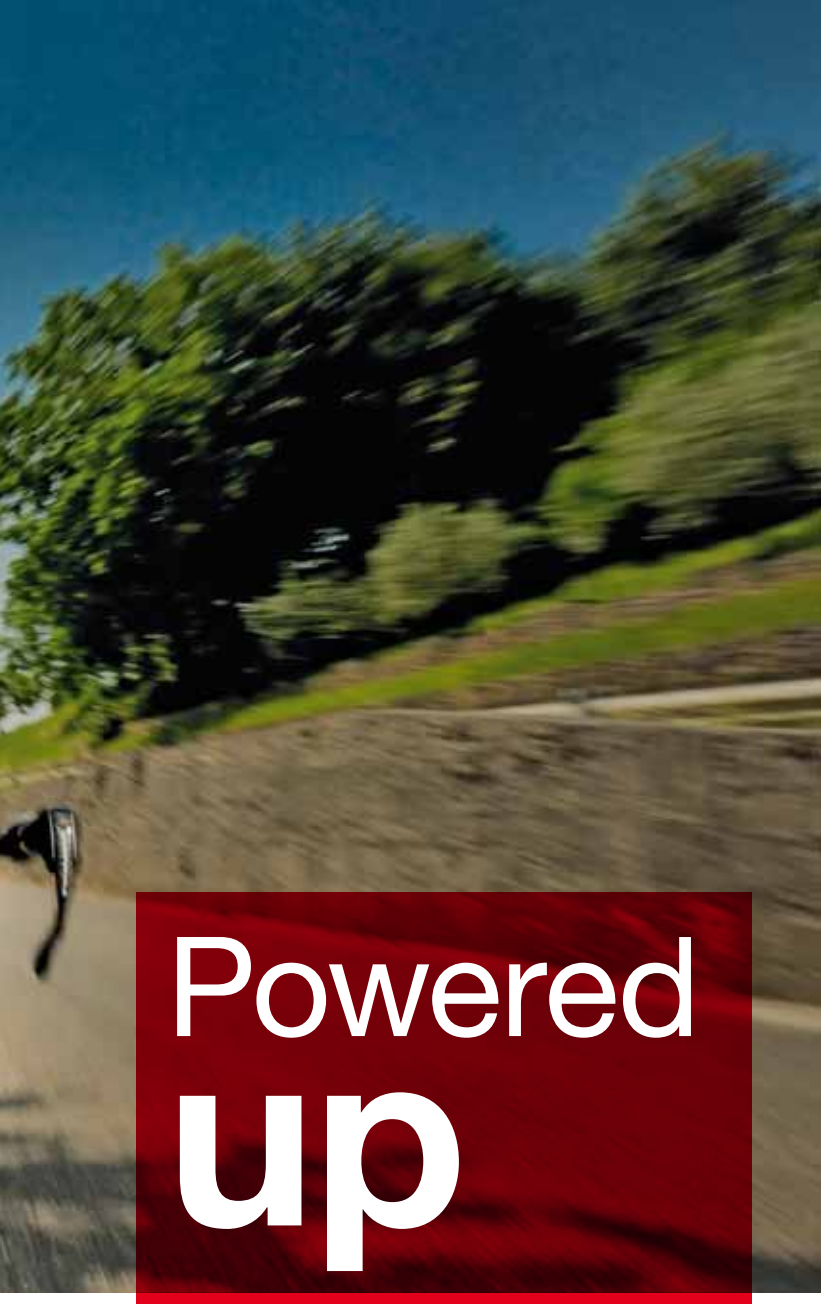
To use electric motors in vacuum conditions, numerous factors have to be considered. On one hand, precautions need to be taken to prevent contamination of the motor by outgassed materials. On the other, certain characteristics like high temperature resistance need to be ensured. The heavy duty motors and matching gearheads (EC 22 HD, EC 32 HD, GP 32 HD) provide a very good basis for vacuum applications. As brushless DC motors, the maxon drives are by nature more efficient, quieter and more responsive than the stepper motors that were previously used for vacuum applications. With the expertise of maxon motor, drives can be optimized to meet customer-specific needs.



The modified maxon motor EC 22 HD in the DLS particle accelerator.

The story of Campagnolo's electronic shifting system, now marketed under the name «Campagnolo EPS» (Electronic Power Shift), is a tour in six stages. Product development began in 1992. Two years later, maxon motor was brought in. The EPS shift system was launched on the market three years later and has seen continuous further development since then.

Photos: Campagnolo Srl, maxon motor ag



Powered up

In competitive cycling, every second before the finish line counts. The manufacturer Campagnolo has developed an electronic shifting system that uses maxon motors to execute shifting operations in tenths of a second.

Article: Anja Schütz

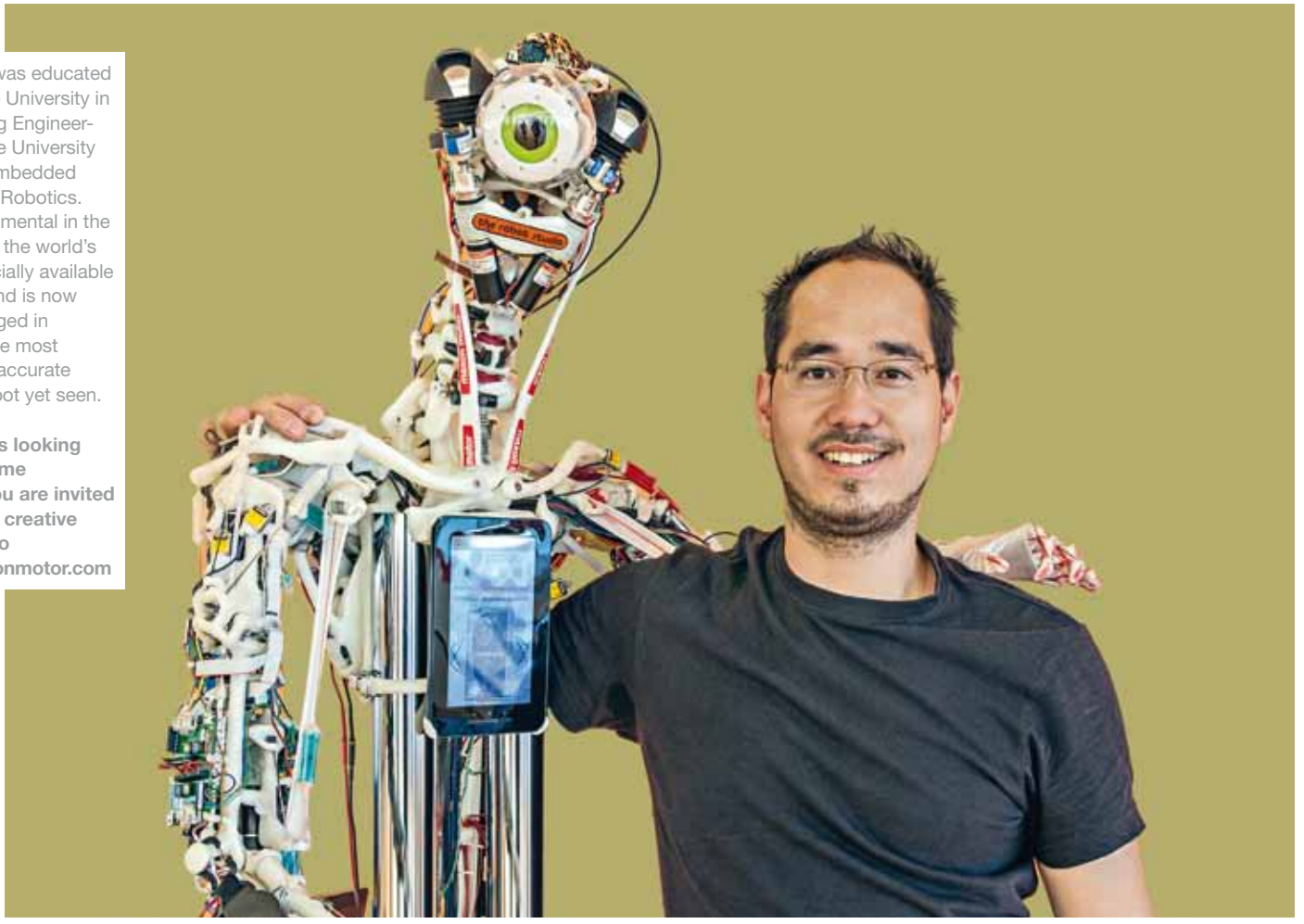
The newest EPS system, successfully launched in November 2011, consists of a battery, the electronics, a shift lever, the wiring, and the drive mechanism. maxon motors are located in the shift mechanism (at the rear) and in the derailleur (at the front).

The electronic shift system provides high shifting accuracy, a very fast response, and the required power. This allows for even faster shifting. The position of the derailleur can be adjusted more precisely than with a mechanical system.

The shift system changes from the smallest to the largest sprocket with a single click of the lever. The electronic mechanism shifts through eleven gears in only 1.5 seconds.

Almost 100%
The compact maxon RE 16 is well suited for applications where space is limited. A similar RE motor was used as the basis for the Campagnolo electronic switching system. RE-motors are high-quality DC motors, equipped with powerful permanent magnets. The centerpiece of the motor is the globally patented ironless rotor. This means cutting-edge technology for compact, powerful drives with low inertia. Thanks to the low inertia, the DC motors feature high acceleration.

maxon RE 16
Ø 16 mm, graphite and precious metal brushes, 2 to 4.5 W



Rob Knight was educated at Cambridge University in Manufacturing Engineering, and at the University of Essex in Embedded Systems and Robotics. He was instrumental in the production of the world's first commercially available robotic fish and is now actively engaged in developing the most anatomically accurate humanoid robot yet seen.

Rob Knight is looking for a new name for ECCE. You are invited to send your creative suggestion to driven@maxonmotor.com

A touch **more** human

Rob Knight of The Robot Studio has dedicated his life to robotics. His current main interest is the ECCE project, a generation of robots that very closely emulates human movement and may even take the dog for a walk in the future.

Interview: Anja Schütz

What is the difference between the old (EDS) and the new ECCERobot 3?

The main technical difference is in the level of the drive technology used. The EDS is built with motors and gearboxes taken from battery-powered screwdrivers aimed at the mass consumer marker. As such they have a good deal of grunt and are tough enough for the job, but are very noisy and inefficient. The ECCE3 was built with a mixture of maxon gearmotors and 3rd party control electronics, but as a complete system it never ran smoothly. The new DCX robot that we have most recently demonstrated however has a 100% maxon drive train interfaced to an open source ROS control system – and this is finally starting to show the potential of the anthropomimetic approach to robotics.

What is an anthropomimetic robot?

An anthropomimetic robot is a machine built to copy the precise anatomical design of the human body as closely as possible with the same bone and muscle layout as a person and most importantly including a series elastic element, i.e. a

Photos: maxon motor ag

spring, in the drivetrain of each muscle. We call this a compliant robot, and it has a much "softer" style of movement in the same way that adding suspension to a car allows it to drive on rough ground.

ECCE3 is now only a torso – what are the next steps in development?

We are committed to opening up the design of the robot to the open source community and to do this requires a new manufacturing approach. So far all the robots have been produced exclusively by hand moulding and assembly techniques which have proven difficult to pass on. To make this into a practical open source technology we plan to reverse engineer the latest DCX based design into CAD and optimise it for 3D printing.

We have already started publishing our implementation of the open source software that we use and hope to add a detailed open source hardware build guide in the near future. The aim is to produce a completely integrated open source platform that works all the way through from high-level software, to low-level microprocessors right down to the nuts and bolts of building the physical machine which brings it all together. This really is the essence of building robots, that the whole system must work together in unison – it's not like programming which can port from system to system, in robotics the integrity of the system is key.

"We are creating a head-to-toes copy of the human body."

We though only develop each section of the software as far as is necessary to produce a working system, and so all the individual parts can still be much improved. Our hope is that the open source community will be triggered by the availability of this complete set of plans into producing and improving robots of their own which they share back into the community.

As for us, yes, we are planning to finish the design of the robot and construct a robot copy of the human body – complete from head to toe.

You are using maxon DCX motors. What are the benefits of using this drive technology?

Smaller, lighter and smoother with tremendous torque for their size all improve the final performance of the robot. What's really nice with the DCX 22 is that it's allowed us to bring the overall size of the robot down whilst packing in 20% more powered degrees of freedom, making it the most realistic copy of the muscles of the human shoulder yet.

Robots being part of our daily lives seems less of a question of "if" than "when". In your imagination, what is a robot that shares people's everyday life going to be like?

I don't think we can be certain yet, but "robot age" is certainly a strong candidate for what will follow the "information age". If robots really do become ubiquitous, then you can imagine they would operate as a set of physical preferences. So you might interact by checking boxes on your smartphone – "ironing to be done at 10 am" – except instead of sending you a reminder, the robot would actually do the task. Walk the dog, receive home delivery of groceries, prepare food, vacuum clean house, etc., etc., etc.

"It could take the dog for a walk, prepare food, iron your clothes, or vacuum."

These tasks though are all still well beyond the capabilities of any robot, and it will take a great deal of effort to change that. Whether this happens in time is the crucial question, because there are deeply ingrained problems in the structure of our society that are already starting to make themselves known and will come to a head in less then twenty years. The slow recovery from the recent economic crisis in Europe is a reflection of a society that has tremendous quantities of debt and an unsustainably aging population. Robots as skill multipliers may be one technological solution, perhaps even to both these problems, but it is just one possible way to go and the clock is ticking.

Will future versions of ECCE3 do household chores or similar operations in the near future?

Certainly that is the aim. The next generation should be capable of simple tasks like tidying the kids toys away – large, brightly coloured objects that can be handled fairly roughly. More sophisticated tasks should follow, and what I really hope to see in the next few years is an acceleration as ever larger numbers of people get involved.

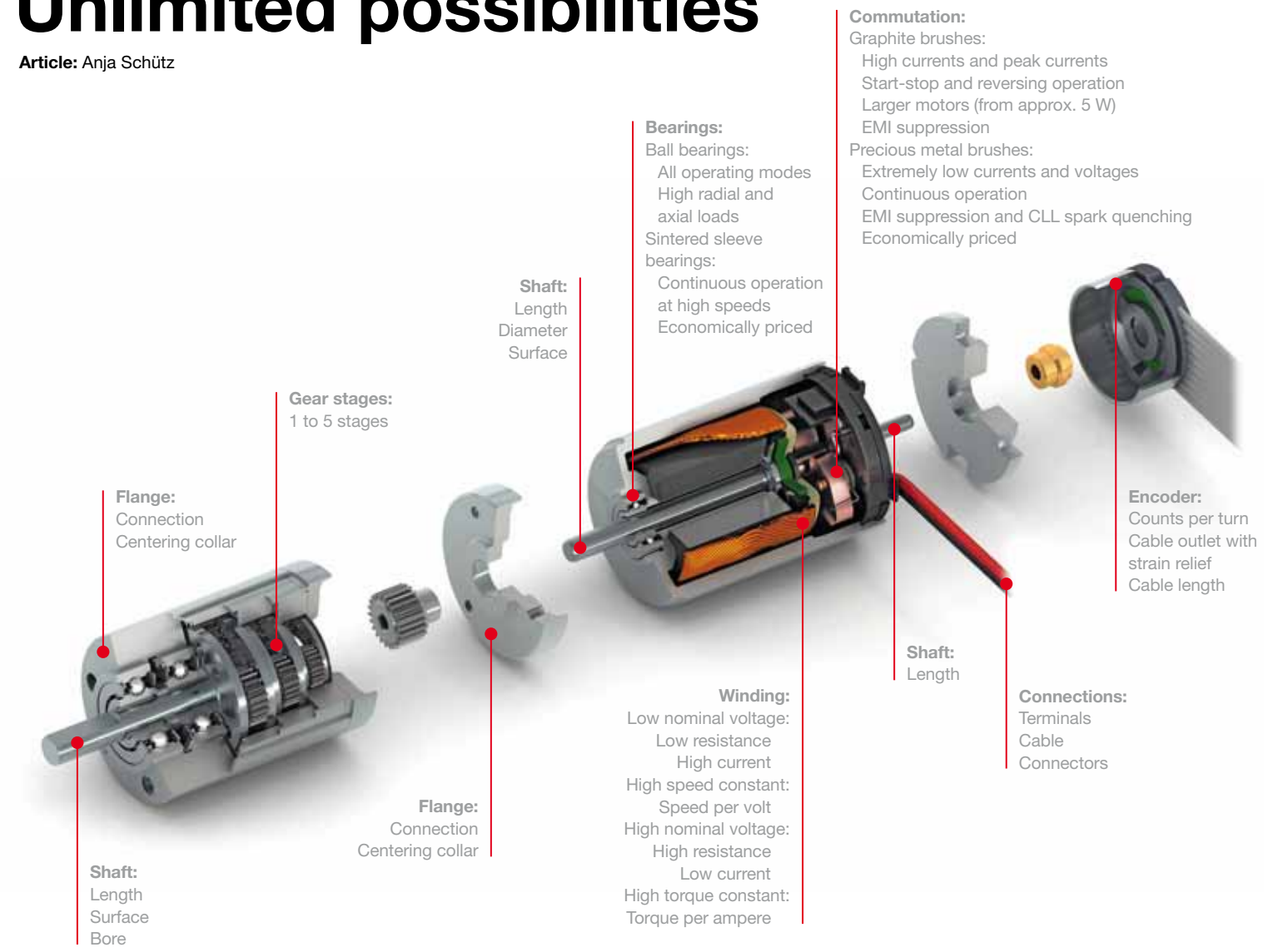
High power density
maxon DCX motors excel through their very high power density (torque per volume) and low vibration. Thanks to the robust design and the ironless maxon rotor, DCX motors provide a dynamic drive for almost any application – including ECCE, the robot. The matching GPX 22 planetary gearheads combine high power transmission with a very short design.

maxon DCX 22 S
Ø 22 mm, brushed, 5.5 Watt (precious metal brushes), 14 Watt (graphite brushes), configurable

maxon GPX 22
Ø 22 mm, planetary gearhead, configurable

maxon X drives
Unlimited possibilities

Article: Anja Schütz



The picture shows what can be configured online. dcx.maxonmotor.com

In late 2012, maxon motor launched a new dynamic drive series. The DCX motors feature a compact design, optimized power density, a high degree of customization, state-of-the-art manufacturing methods, and short delivery times. They are especially well suited for customers who have very specific requirements for motors and whose product is still in development. Their short lead time makes DCX motors ideal for minimi-

Photos: maxon motor ag

Luca Bongulielmi, Head of Strategic Business Development at maxon motor ag.

zing the time to market of new products. The X portfolio is rounded out by individually configurable gearheads and encoders.

Configurable from A to Z

One strength of the DCX motors is their high power density. The DCX 35L motor, with a diameter of 35 mm, has a speed/torque gradient (4 rpm/mNm) close to that of the RE 40 DC motor (40 mm diameter, 3.5 rpm/mNm). Its maximum efficiency is 90%, and its maximum output power is 120 W.

Their short lead time makes DCX motors ideal for minimizing the time to market of new products.

The range of possible combinations within the DCX drive series is virtually unlimited. For example, the DCX 22S features precious metal or graphite brushes, can be equipped with standard preloaded ball bearings or sintered bearings, and covers a wide range of voltages thanks to six different ironless windings. The newly developed casings and flanges make it possible to specify the mounting type of your choice. For narrow spaces, the DCX motor is available in a short, flangeless version. The length and diameter of the output shaft can also be selected. In addition, the motors can be delivered with or without a cable, and the cable length is also variable.

GPX gearheads offer high torque capacity in a compact design, run quietly, and feature low backlash. They are configurable as well and can have up to five gear stages. The ENX encoders, also configurable, have a sturdy design and high signal quality. The 2-channel encoders with differential signals guarantee interference-free function, even under the heaviest loads. The counts per turn, cable outlet, and cable length of the encoders are variable.

Their sturdy design, high power density, quiet running, and ironless maxon rotor make DCX motors a drive system suitable for a diverse range of applications. They are particularly well suited for applications with speeds under 20,000 rpm and for applications in start-stop operation. The target market sectors for the DCX drive series include medical technology, industrial automation, robotics, the aerospace industry, and mechatronic applications.

Configure and order online

The new product series of brushed DC drives is an important member of the maxon motor product family. According to Luca Bongulielmi, Head of Variants and Standards at maxon motor, not only the product and technology development posed a challenge. It was also a feat in itself to conceive and implement the lean processes for order processing. The design and processes have been optimized for the configuration of the products. The key tool for configuring these drives is maxon motor's online configurator, which provides customers with an entirely new way to configure and order maxon products. For instance, after completing a configuration, it is possible to download 2D and 3D dimensional drawings. A complete specifications document describes the configured drive system.

Almost everything is configurable on a DCX motor. Download the tablet edition 1//2013 of driven to watch our video tutorial. magazine.maxonmotor.com

The tablet edition of driven for iOS and Android can be downloaded for free.

More information:
magazine.maxonmotor.com

The digital **magazine experience**

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– Links to maxon product data

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