

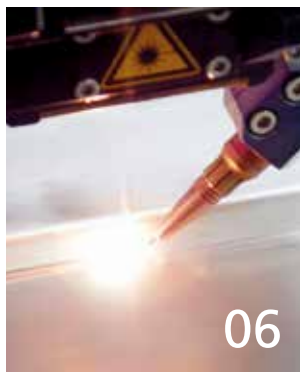
# motion

02.2018

THE MAGAZINE WITH DRIVE



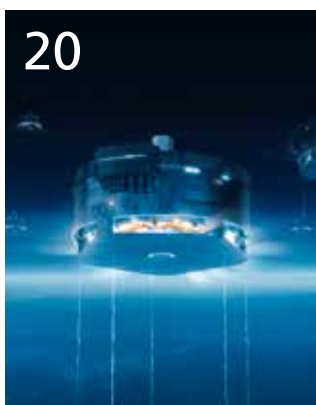
POWER  
IN NEW  
DIMENSIONS



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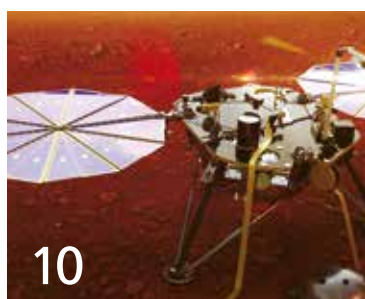
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### Dear readers,

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In boundless outer space or the smallest installation space: drives from FAULHABER have proven themselves many times over. For example, they move the CIMON robot assistant of the current ISS commander Alexander Gerst freely and safely through the International Space Station. And in November, six of our motors will land on Mars – as part of SEIS, the most sensitive seismometer ever deployed on an interplanetary mission and the first designed and built in Europe for this purpose.

At almost the same time, we welcome you to the launch of our new, innovative BXT series, which can be succinctly described with: power in new dimensions. Its ratio of torque to installation space exceeds all previous representatives of its motor class, making it the ideal solution where high-performance drives with very flat construction are required.

Likewise in a very restricted space, with up to 60,000 revolutions per minute and Formula 1 technology from Straub Medical, drives from FAULHABER open clogged arteries and, in the form of the "PROJECT ANTHOZOA" sculpture, open our eyes to the smoothly floating movements of mysterious deep-sea creatures.

Learn more in this issue of FAULHABER motion – the magazine with drive.

I hope you enjoy reading this issue!

Sincerely

Gert Frech-Walter  
Managing Director

Issue 02.2018

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**Layout:**

Werbeagentur Regelmann  
Pforzheim · Germany  
[www.regelmann.de](http://www.regelmann.de)

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**Publication frequency & subscription:**

FAULHABER motion is published twice a year and is delivered to customers, interested parties and employees of FAULHABER free of charge.

FAULHABER motion is also available as an app.



[www.faulhaber.com/motion](http://www.faulhaber.com/motion)

## TOP 100 – FAULHABER IS ONE OF THE LEADING INNOVATORS OF 2018



TOP 100 award ceremony

For the 25th time, TOP 100 has selected the most innovative of Germany's small and medium-sized enterprises. This year, these leading innovators include Dr. Fritz Faulhaber GmbH & Co. KG. On 29 June 2018 in Ludwigsburg, mentor of TOP 100, Ranga Yogeshwar, together with Prof. Dr. Nikolaus Franke and compamedia honoured the company

from Schönaich at the award ceremony as part of the 5th German summit for small and medium-sized enterprises. FAULHABER has made it into the ranks of this innovation elite for the third time. In this independent selection procedure, the company with 646 employees impressed the competition jury particularly in the category "Innovation success".

### FURTHER INFORMATION

FAULHABER  
[www.faulhaber.com/news](http://www.faulhaber.com/news)

### NEW

## MINIATURISATION PAR EXCELLENCE

With the new IEH3-4096 L encoder series, FAULHABER again takes miniaturisation to the extreme. The existing products – IEH2-4096 with 2 channels and IEH3-4096 with another index channel – are already extremely compact. Integrated in the precious-metal commutated DC-micromotors of the SR series, they lengthen the motor by just 1.4 mm. In the same installation space, the IEH3-4096 L now adds another function to the quadrature signals A and B and index channel (each as complementary square wave signals): a line driver for noise-resistant transmission. With respect to its compactness, it is now the new leader in its class.



### FURTHER INFORMATION

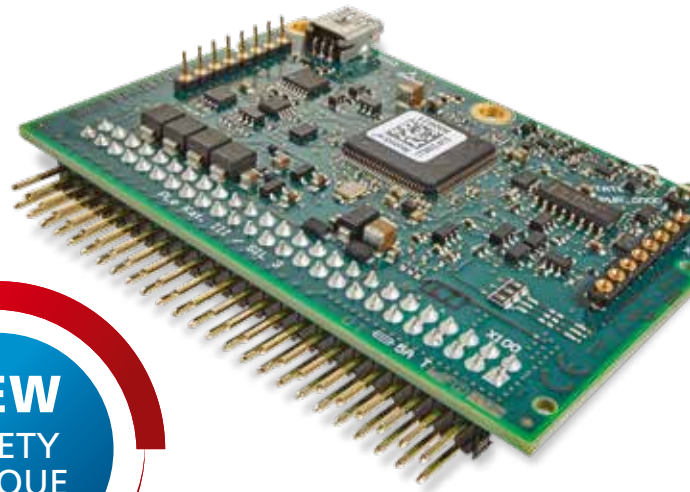
FAULHABER  
[www.faulhaber.com/news](http://www.faulhaber.com/news)



NEW

## SAFETY FOR HUMAN-MACHINE COLLABORATION

Optimised for the FAULHABER drive program, our new Motion Controller MC 5004 series gets the maximum out of every motor. With redundant shutdown based on the STO principle in line with IEC 61800-5-2 (SIL 3) and EN ISO 13849-1 (PL e), the new MC 5004 P STO series ensures certified safety during cooperation between man and machine, also in an Industry 4.0 environment. At the same time, the devices meet the requirements of highly interconnected processes with their communication capabilities. They are available with USB, RS232, CANopen and EtherCAT interfaces. As a result, they are able to communicate in real-time with the higher-level process control technology and offer great flexibility in usage applications.



FURTHER INFORMATION

FAULHABER  
[www.faulhaber.com/news](http://www.faulhaber.com/news)

## FAULHABER ACQUIRES STEPPER MOTOR MANUFACTURER DIMATECH



Management FAULHABER & Dimatech

Schönaich/La Chaux-de-Fonds – Effective 19 July 2018, FAULHABER Drive Systems acquires Dimatech SA, a Swiss manufacturer of high-performance stepper motors using disc magnet technology. With the integration, FAULHABER expands its portfolio in the area of stepper motors in the upper performance range, thereby establishing improved access to other application fields in the textile industry, medical technology, robotics and automation. Dimatech,

with headquarters in Les Bois in the Swiss Jura, will, in the future, be integrated in and managed as an additional location of FAULHABER PRECistep SA, which is located just a few kilometres away. FAULHABER PRECistep SA from La Chaux-de-Fonds just recently celebrated its company anniversary and is ideally positioned to bring along its 30 years of experience in the marketing of this drive technology.

FURTHER INFORMATION

FAULHABER  
[www.faulhaber.com/news](http://www.faulhaber.com/news)

## A STRONG

# PARTNERSHIP

Laser beams can melt and even vaporise metals highly efficiently and very precisely. For this reason, they are increasingly used as a tool for joining components, namely for welding and soldering e.g. in the automotive industry. Normally, laser devices – like conventional welding torches – have a single focal point or "spot". Laserline has now developed multispot optics for laser soldering and welding which also allow particularly difficult materials to be processed. Motors from FAULHABER help to ensure that the spot energy is distributed correctly.



Zinc protects steel against rust. Vehicle manufacturers therefore mainly use zinc-plated sheet metal for vehicle bodies. Previously, the protective metallic coating was applied by means of electroplating. However, hot-dip galvanisation is now becoming the method of choice. It provides even better corrosion protection. When such hot-dip galvanised metal sheets were first used in production, an unexpected problem arose during soldering.

### Soldering or welding?

Compared to welding, soldering offers a series of advantages for series production in the automotive industry. In the case of welding, the metal sheets are heated to melting temperature along the welding seam itself and the two sheets are then directly joined together. This requires a high degree of precision and it is not possible to achieve visible seam quality. Welded seams are rough and the vaporisation of

zinc makes them porous. With soldering, however, a seam made of a different material is inserted as a filler material between the metal sheets. This copper-silicon solder – liquefies during soldering and then solidifies again – not only joins the parts together, but also fills the gap between them. As a result, soldering permits a greater dimensional tolerance and requires less effort with regard to clamping the workpieces. Above all, soldering allows gap-free joints to be made in visible quality, which means that the soldered components can then be painted without first having to undergo further processing.

In the case of hot-dip galvanised metal sheets, however, the solder does not behave in the usual way. "On the surfaces next to the seam there was increased spatter from liquid solder. Microspatter in particular occurred which is hard to see initially, but then becomes clearly visible after painting", reports Dr. Axel Luft, Automotive Sales Manager at Laserline. "There was also a deterioration in the quality of the



actual seam. It was rougher and often formed so-called wavelets, in other words points at which the solder crosses the planned seam boundary."

### **Soldering solution for hot-dip galvanised metal sheets**

It was obvious that these problems had something to do with the zinc layer on the steel sheet. As a result of the hot-dip galvanisation, this layer had become thicker and less regular. Furthermore, it exhibited a different reflection behaviour, which also had a negative effect on the soldering process. Thorge Hammer, who as an engineer in the technology planning and development department at Volkswagen in Wolfsburg is responsible for this soldering process, had an idea how to solve this problem: The zinc should be removed from the edges of the seam before soldering takes place. However, this would require the usual circular laser spot to be rectangular and would also have to

have an opening through which the solder can be fed. The "front" corners of the spot would then be responsible for removing the zinc, while the larger part of the rectangle performs the actual soldering.

"From a technical viewpoint, this solution was not possible, but we were on the right track", recalls Dr. Markus Baumann, chief development engineer at Laserline. "Instead of forming a spot with a complex – and therefore optically very difficult – shape, we finally added two smaller spots to the main spot.

During soldering, these smaller spots are always directed at the edges of the seam in front of the main spot which measures a few square millimetres." Their energy is enough to vaporise the zinc layer in this area, to start to melt the steel and to generate slight oxidation. This produces a so-called passive layer that prevents sloshing of the solder liquefied by the main spot.

As a result, the soldered parts do not require subsequent work to remove solder spatter before painting. There is another reason why the rectangular main



spot proved to be a good solution: It distributes heat over the solder more evenly than its circular counterpart, which also contributes to a calmer solder bath. "With this technology, we were finally able to solve all of the problems that we encountered with hot-dip galvanised metal sheets," says a delighted Dr. Luft. "It is now used in series production at VW. And it allows us to achieve a soldering speed of up to 4.5 metres per minute. Other manufacturers will follow soon."

### Beam splitting with optics module

An optics module is responsible for ensuring precise alignment of the spots. It contains various optical elements that selectively modify the laser beam. The collimation lens aligns the divergent laser beams leaving the fibre-optic cable, so that they run parallel to each other. A so-called homogenisation array generates a square-shaped main spot, while other optical elements split the beam and generate additional spots. In the case of soldering, two leading spots are generated to the front and side of the main spot. To obtain the desired clean seam at the end of the process, the power distribution between the main and leading spots as well as between the leading spots must be precisely set. How the laser power is distributed to these spots depends on the position of the optical elements. By moving these elements in the x and y-axis, it is possible to achieve the precise distribution of laser power required for the task in question.

To deep-weld aluminium, for example, a small, intensive spot can be positioned inside the weaker large spot. To weld together metal sheets of different thicknesses, two spots can be adapted to the respective material. This can be done during the running process because the elements in the Laserline optics module are moved by motors.

The edge length of this square-shaped module is 12 centimetres, with a depth of 5 centimetres. The optical elements and a sophisticated mechanical system are housed in this small space. There isn't much room left for the motors. The primary requirement placed on the drives is therefore compactness.

"We opted for brushless DC-servomotors of the 1226 B FAULHABER series with 12 millimetre diameter, with lead screws bonded directly to the motor shaft and without shaft coupling", explains Dr. Baumann. "This provides us a very compact drive which nevertheless reliably delivers the required power and speed. Easy integration of the motor controller in the system was another important consideration." The Motion Controller from FAULHABER was housed outside of the module and communicates by means of an RS232 serial interface. If the Laserline customer so desires, the motor/controller combination can also be







# LASER BEAMS EFFICIENT AND PRECISE

actuated via a CAN bus system without needing to make any changes to the mechanics or housing. The RS232 controller can easily be replaced with a version with CANopen interface.

## Motor with position guarantee

The laser optics are mounted to a robot arm during soldering and welding; this robot arm moves the laser optics to the required position. The optics must withstand considerable dynamic loads which act on the motors and which can trigger unwanted changes in position. "This is no problem for the FAULHABER motor because it detects its current position using the integrated Hall sensor and if necessary readjusts – at the latest when the laser is positioned on the seam", emphasises Dr. Luft. "This gives us the certainty that any incorrect positioning is ruled out. Thanks to the high quality of the drives, we can rely on consistently reproducible results. This is crucial because our customers expect trouble-free operation over a period of at least seven years!"

For Dr. Baumann it was clear that he would find the right motor at FAULHABER – just as he did eight

years ago when looking for the right motor for a new zoom optics system. Back then, stepper motors were generally used for this type of device. However, as the development engineer reports, these stepper motors had problems with the acceleration of masses in the robot arm: "The dynamic load can cause a stepper motor to miss out individual steps. To prevent this from happening, an encoder can additionally be used for position determination and readjustment. This is not only complicated but in this combination it is also expensive. When I was younger, I needed a compact motor for a model ship and I found it at FAULHABER. I remembered this when developing the zoom optics system, contacted FAULHABER and once again found the optimum drive. This has helped us create an extremely cost-effective solution that has since proven very successful." The new multispot module too carries out its work in series production flawlessly. Furthermore, this optical system has already gained widespread recognition among experts: The technical solution and the economic efficiency achieved in industrial applications over just a short period of time convinced the international jury of the "Innovation Award Laser Technology". This year, it awarded the developer team first prize.

### BRUSHLESS DC-SERVOMOTORS

Series 1226 ... B  
Ø 12 mm, length 26 mm  
Output torque 2.6 mNm



### FURTHER INFORMATION

Laserline GmbH  
[www.laserline.com](http://www.laserline.com)

FAULHABER  
[www.faulhaber.com](http://www.faulhaber.com)

# Is there

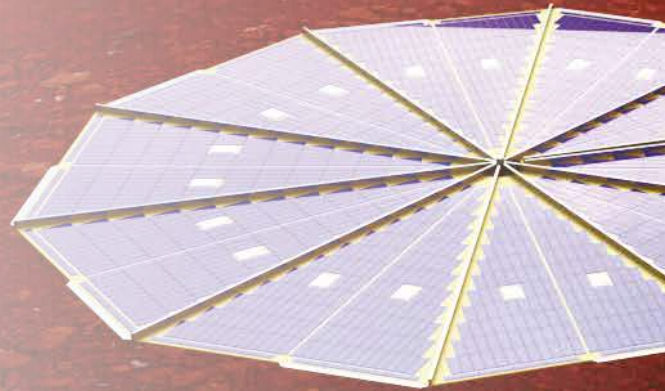
## SEISMIC ACTIVITY ON

# THE RED PLANET?

When SEIS reaches its destination at the end of November, the most sensitive seismometer that has ever been built will begin its work on Mars. Six FAULHABER stepper motors with planetary gearheads are currently on their way through space and, after the instrument has landed, will have two tasks: firstly to precisely balance the measuring mechanics and secondly to compensate for the tension forces that occur as a result of severe seasonal temperature fluctuations.



Quakes are a sure sign of the movement of masses below a planet's surface. This realisation is actually quite recent in the world of natural sciences. Around 100 years ago, the German geoscientist Alfred Wegener proposed the theory of plate tectonics – a theory which was initially ridiculed by colleagues. Today, our understanding of continental plates, which float and shift on the Earth's molten mantle, is routinely taught in schools. Deep rift valleys and high ridges: the movement of continental plates alters geological formations. This is known to happen on Earth. But what about on our planetary neighbour Mars?







© Sodern ArianeGroup 2018

## More sensitive than any other device

The Upper Rhine Plain in Germany stretches over a length of around 400 kilometres. The Valles Marineris on Mars is ten times as long and at some points is seven kilometres deep. Was the canyon on our neighbouring planet also formed as a result of plates shifting on the planet's crust? And: did this process end long ago, or is it still continuing today? These questions can be answered by measuring seismic waves. Is there seismic activity on Mars? NASA's "InSight" mission, which was launched on 5th May 2018, should provide an answer to this and other questions. The lander will touch down on Mars at the end of November and, using its robot arm, will place a seismometer on the planet's surface. The measuring instrument called SEIS is so sensitive that it can detect subsurface displacement corresponding to the diameter of a single hydrogen atom. NASA refers to this instrument as "the most sensitive seismometer that was ever built."

## Compensating for material expansion

The sensitivity and measuring accuracy are, among other things, the result of the thermal balancing of a spring mechanism. This balancing is necessary because the different seasons on the Red Planet cause great fluctuations in temperature. And what applies on Earth equally applies on Mars: different temperatures cause materials to contract and expand and also have an effect on their strength – an aspect that is particularly noticeable in spring mechanisms. Three type AM 0820 stepper motors from FAULHABER are installed inside the vacuum chamber of SEIS in order to offset these changes in temperature. The motors with a diameter of just eight millimetres are combined with 08/1 series planetary gearheads from FAULHABER. With their stainless steel housing the gearheads are equipped with a special shaft and a specially coated ball bearing for their use on Mars.

The seismometer was built primarily by Sodern – a subsidiary of the French Ariane group. When evaluating the drive technology, Sodern sought the best technical equipment. "This required painstaking research," recalls press spokesman Rémy Lambertin. After all, his company was about to "build one of the smallest instruments that we have ever sent to Mars." And the smaller an instrument is, the more fragile it will be. Consequently, the bar was set extremely high with respect to aspects such as robustness, durability and operational reliability.

The stepper motor drive solution designed jointly with the French FAULHABER subsidiary is expected to perform at least 160 correction cycles over a period of two years. The endurance tests carried out on

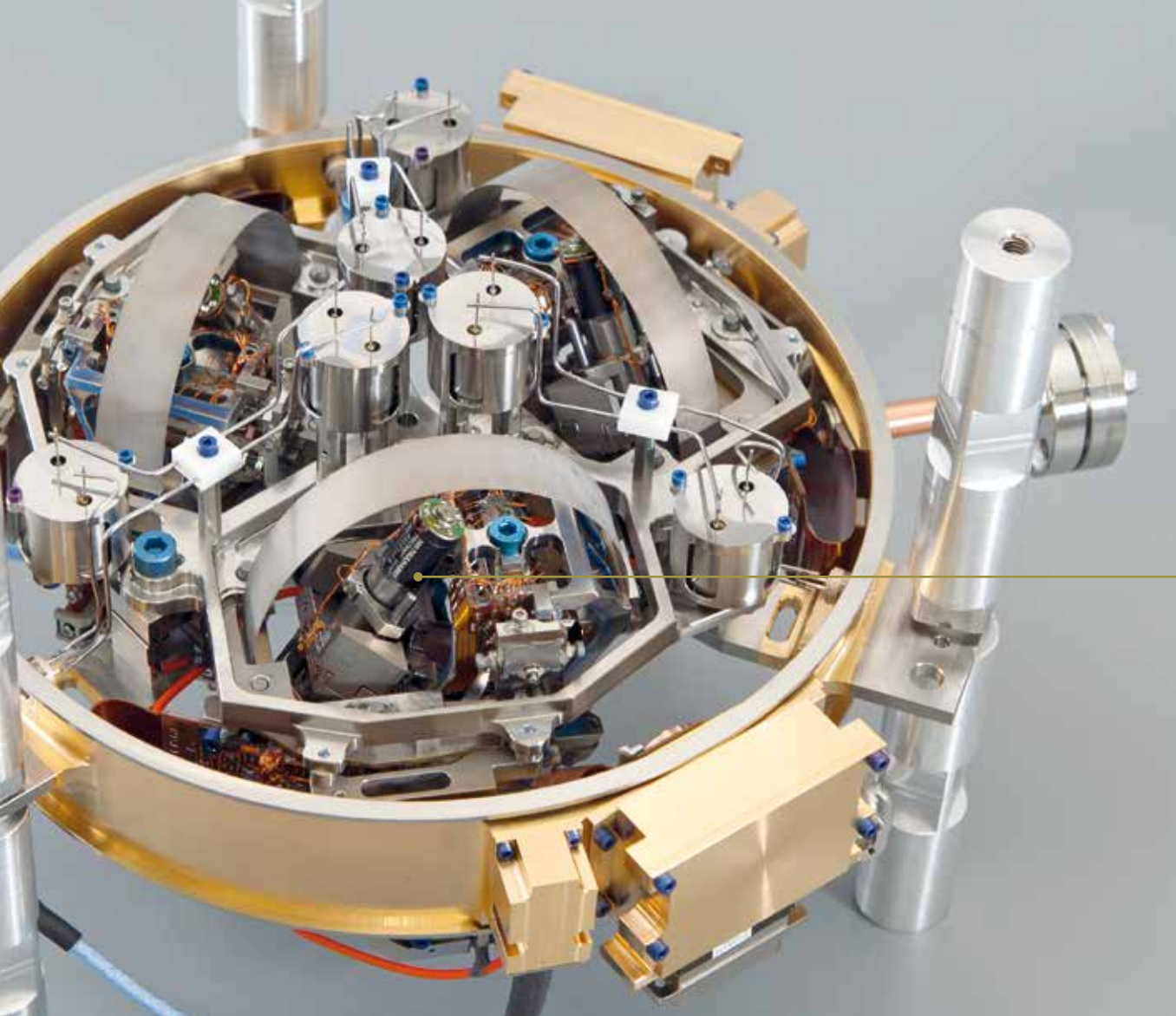
Earth were, however, designed to simulate six years – and this in a thermal operating range of -120 to +70 degrees Celsius. FAULHABER stepper motors have already been used successfully under such demanding ambient conditions on other NASA and ESA Mars missions.

## Well lubricated – a real challenge

According to Rémy Lambertin, one of the greatest challenges associated with use of the seismometer was ensuring that the drive technology was lubricated effectively. A special lubricant is necessary because the average pressure on the surface of Mars is only 6.36 hPa. On Earth, this roughly corresponds to the air pressure at an altitude of 35 kilometres. Reliable lubrication of the motors' ball bearings as well as the gearheads' sliding parts is provided by Dicronite and is one of the crucial factors enabling SEIS to be adjusted with zero backlash and exceptional durability on the Martian surface.

SEIS – Seismic Experiment for Interior Structure – essentially consists of two triaxial seismological sensors that detect ground motion of different intensity and frequency. One sensor measures frequencies of 0.01 to 10 hertz, and the other frequencies of 0.1 to 50 hertz. SEIS is supported by instruments that measure wind strength, air pressure, temperature and magnetic field. The objective of these measurements is to find out whether vibrations really are of seismic origin or simply the result of disruptive factors on the surface of Mars. In all, the instrument is able to detect vibrations that shift the ground of the Red Planet by less than the thickness of a hydrogen atom. This degree of precision is only possible because the positioning system driven electrically using FAULHABER stepper motors performs an elaborate levelling process. Incidentally, the system was developed in Germany at the Max Planck Institute for Solar System Research in Göttingen.





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## Backlash-free microdrives

After the landing in November, the drive axes will work with a positioning accuracy that has a tolerance of less than 0.1 degrees. The zero backlash of the six FAULHABER drive axes ensures the consistently high repeatability of travel – and this with a net mass of less than 20 grams. This huge technological effort is necessary because SEIS is alone on Mars. In contrast, seismometers on Earth are usually part of a network – which ultimately improves measuring precision. With this in mind, the highly sensitive seismometer on the Red Planet is housed in a thermally insulated vacuum box which is intended to protect against disruptive environmental factors.

### STEPPER MOTORS – PRECistep® TECHNOLOGY

AM0820 series  
 Ø 8 mm, length 13.8 mm  
 Output torque 0.65 mNm



### FURTHER INFORMATION

SODERN  
[www.sodern.com](http://www.sodern.com)

FAULHABER  
[www.faulhaber.com](http://www.faulhaber.com)

# HIGH-TECH **INSTEAD OF** **SIDE EFFECTS**

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© Straub Medical

The blockage is as thick as a finger and is now extending from the knee up to the thigh. It consists of coagulated blood and is stuck in the artery. The head of the catheter, on the other hand, is just a bit larger than the tip of a match. The head of the catheter is inserted into the artery by the surgeon through a small puncture and guided to the vascular occlusion under X-ray monitoring, where it then begins to rotate and suction at the push of a button. The thrombus is completely removed seconds later, leaving the vascular walls unharmed. The instrument used for the near miraculous removal of the threatening obstruction was a Rotarex®S catheter from Straub. It is powered by a FAULHABER motor.



We observe the atherectomy and/or thrombectomy described here (practitioners use different terminology for its removal, depending on the character of the clot) through a transparent plastic tube, which represents the artery. This is a very realistic demonstration and simulation of the treatment for peripheral arterial disease (PAD). According to projections, in Germany alone about two million mostly older people are affected by a PAD. This is caused by the narrowing of a femoral artery, which is followed by slowing of the blood flow and the subsequent formation of a blood clot.

### Compelled to window shop

The blockage often starts with vessel scarring or calcification. At a narrowed point called a stenosis, the flow of blood is significantly reduced. At some point, due to the constant movement in the knee, for example, and the pressure of the calcification, the inner layer of the artery ruptures, which starts the clotting process at exactly this location. The resulting thrombus (the blood clot) completely blocks the artery. Due to the bottleneck, this thrombus continues to form upwards until it blocks the entire vessel, which frequently stretches over 25-30 centimetres. Other small vessels then attempt to supply the leg with blood, but their attempt is futile as the volume of blood does not suffice. The muscles get less oxygen, which in essence is the equivalent of an engine running without petrol. Walking becomes painful after just a few steps. The patient is forced to rest repeatedly. This is where the colloquial name of PAD comes from: "shop-window disease". To hide the ailment from others, patients prefer to take a break in front of shop windows.

There are various methods for eliminating thrombi and the underlying narrowing. Thrombolysis is used frequently. In this process, substances that dissolve the thrombus are passed through a catheter directly to the thrombus. Such thrombolytics are not without a large number of side effects, however, one of which being haemorrhage. Moreover, patients must

be monitored in intensive care for up to two days. In addition to that, thrombolysis is only effective for new occurrences of thrombus and has no impact on other occlusive materials such as calcifications or scar tissue. The initial narrowing also remains when this method is used. If the thrombus is already older than two weeks, thrombolysis is no longer effective.

Purely surgical removal using a catheter (Fogarty method) takes place by means of a balloon. Once the vascular surgeon has surgically exposed the artery, usually the inguinal artery, this balloon is completely emptied and guided inside the vessel through the clot. On the other side of the blockage, the balloon is pumped up to the diameter of the vessel by injecting a saline solution. The filled balloon is then pulled back out by the surgeon, the idea being, that the blood clot is removed from the vessel at the same time. However, this process often has to be repeated multiple times. And even then it is not certain that the entire clot has been dislodged. Any thrombus residue can become the nucleus of a new blood clot. Furthermore, this method of using an inflated balloon over the entire length of the vessel also results in massive damage to the vascular wall, which often results in abrupt reclosure of the vessel.

### Fragmentation and removal

Straub Medical's method, on the other hand, is elegant and efficient: A motor outside the human body is connected to the catheter via a contactless magnetic coupling. The rotation generated by the motor is transferred inside the body to the head by means of a high-strength steel spiral (also called helix) inside the catheter tube. Similar to a chisel, the catheter head is bevelled at the front on two sides. As soon as the head begins to rotate, these surface areas dislodge the solidified material from the inside and cause the fragments to move in a strong vortex, which then clears the entire cross section of the blood vessel. The catheter head also has two small side openings where the helix is exposed. Pursuant to

the Archimedean principle of the screw, the rotation of the helix results in suction. This suction removes the fragments of the blocking material into a hose. The fragments are further crushed by interior blades when they enter the openings, so that the removed debris can pass smoothly through the passage to the collection bag outside the body.

"The occlusive material is not only thoroughly shattered, but also completely removed," explains Dirk Dreyer, Director of Sales and Marketing at Straub Medical. "The side effects known from thrombolysis and other procedures are thus avoided. In most cases, the occlusive material can be removed with a high degree of reliability in one to two passes. On average, the problem is solved in three minutes." Thrombolysis with its many side effects is also no longer required for dissolving and removing fresh thrombi that have not yet solidified into massive clots. For these, there is the Aspirex®S variant, whose suction head manages without the rotating chisel of the Rotarex®S. The suction effect of the rotating spiral suffices to extract the blood clot into the windows of the head and then transport it out of the body, similar to the Rotarex®S. Straub catheters can also be used for blockages in veins, bypasses, stents or dialysis ports.

## From Formula 1 to the operating room

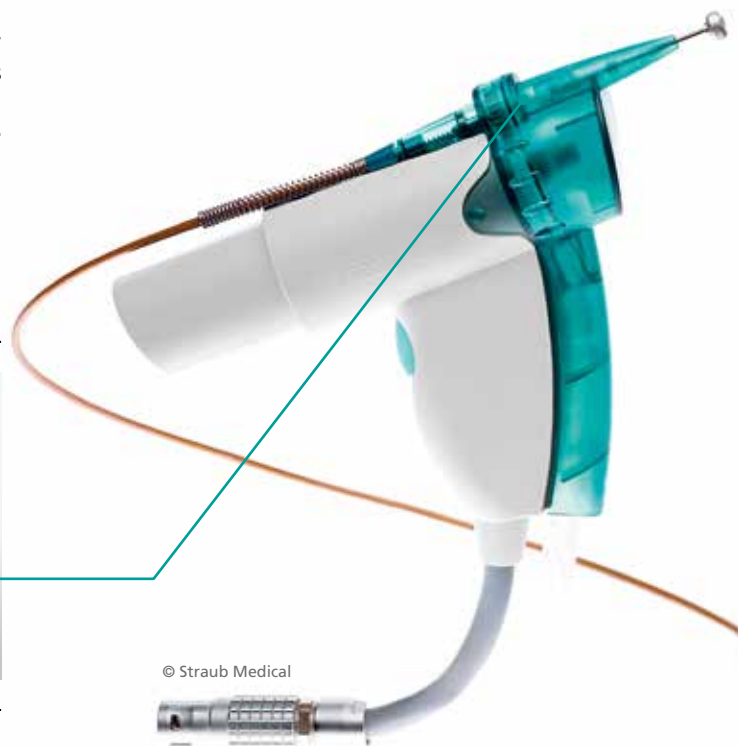
The evolutionary history of the Rotarex®S method is typical for the medium-sized medical technology industry in Switzerland: a high-tech engineer hears about an unsolved medical problem (often by chance) and comes up with a solution. The founder of the company, Immanuel Straub, who died in 2012, had been developing novel high-performance springs since the 1950s, which were installed in the valves of

Formula 1 engines, among other things. At the end of the 1980s, a friend and doctor drew his attention to the difficulty of removing vascular occlusions. The engineer then came up with the idea of combining the catheter, which was already widely used in vascular medicine, with a high-performance spring, which is basically what the internal wire spiral is, and the rotating chisel designed by him. As a result, Straub developed a completely new treatment method that has stood the test of time in clinical use since 2000.

For the Rotarex®S head to dissolve the clot and to have sufficient suction, this requires relatively high and consistent speed. As a guide value, 40,000 and even 60,000 rpm are used, depending on the catheter size and model. This range must be adhered to as closely as possible for technical reasons. The force transmission from the motor housing to the catheter takes place via a magnetic coupling. It is critical to keep the speed within a very narrow range during use, no matter whether the hardened blockage is broken up or whether the last few particles are transported away.

### BRUSHLESS DC-SERVOMOTORS

Series 2444 ... B  
Ø 24 mm, length 44 mm  
Torque 18 mNm







The rotating head dislodges the solidified occlusive material and shatters it, so that the resulting fragments can be transported out through the catheter by the helix into a collection bag outside the body. © Straub Medical

### Precision balancing for the drive

The control thus reacts very quickly to any load change and the motor must be able to convert its signals with corresponding precision. "There aren't many motors that meet our quality standards," explains Dirk Dreyer. "FAULHABER provided support already during the development phase of the first prototypes and provided important know-how. One of the issues we had to deal with for using a motor in a medical device was medical products approval. FAULHABER has the necessary certifications, which gives us an additional advantage in terms of proof and traceability of the parts of the device."

The motor is fitted in the handpiece of the device and must thus be as small and light as possible. It also had to be as quiet and vibration-free as possible during use. The brushless drive of the 2444 ... B series is therefore already balanced during manufacture. Material is removed milligram by milligram from the rotating magnet until the concentricity is optimised at a high rate of speed. The motors for Straub Medical then undergo additional precision balancing, in the course of which the bell of the magnetic coupling is also processed. The latter serves to contactlessly transmit the force between the drive and helix without a fixed mechanical connection. The minimal gap between the coupling elements makes it possible to separate the sterile system components inserted inside the body from those that work non-sterile outside the body. For this purpose, the handpiece and the motor are wrapped with a sterile foil that is running through this gap, and the sterile catheter is then coupled to the handpiece via the foil. But the magnetic coupling also provides torque protection: When the helix or Rotarex head is blocked during operation, the coupling element on the motor continues to rotate without adding additional force.

This prevents damage from occurring on the motor or device, and even more importantly the blood vessel is protected against wall damage and destruction.

Rotarex®S and Aspirex®S catheters are available with diameters between 2 and 3.3 millimetres. Blood vessels must have a diameter of at least 3 millimetres in order to be accessible by the devices from Straub Medical. Such diameters include, for example, the vessels of the legs, which are particularly frequently affected by occlusive diseases, and also those of the abdomen. However, veins in the brain and coronary vessels are too narrow or too curvy for the catheters that are currently available. This method is as of yet not suitable for stroke and heart attack victims. "Our developers are working on even smaller catheters, so that these patients can also benefit from our method," reports Dirk Dreyer. "This is a unique medical/technological challenge that we aim to overcome with the support of FAULHABER."

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#### FURTHER INFORMATION

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Straub Medical AG  
[www.straubmedical.com](http://www.straubmedical.com)

FAULHABER  
[www.faulhaber.com](http://www.faulhaber.com)

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## LITTLE HELPER IN SPACE



The aerospace division of Airbus has developed the first artificial assistant for astronauts named CIMON. It has been supporting the crew of the International Space Station ISS in several experiments since June. The little helper's suitability for more significant tasks in the future is also tested and further developed. Motors from FAULHABER enable it to move freely about the station.



Airbus initially examined the flight assistant concept as part of a self-financed study. Then came the order from the aeronautics division of the German Aerospace Centre (DLR) in August 2016 to go ahead with the project. This was subsequently implemented by a team of around fifty people from Airbus and DLR and the Ludwig Maximilian University in Munich (LMU) in the record-breaking time of less than two years. Also participating were experts from computer manufacturer IBM, upon whose Watson technology the artificial intelligence (AI) of the CIMON project is

based. Thanks to this technology, the little helper is able to orientate himself, move, acquire knowledge and recognise his human counterpart.

CIMON journeyed to the ISS as part of the Horizons mission. Its work there will initially be limited to three experiments, which it will conduct together with the German crew member and temporary commander Alexander Gerst. Together, they undertake to sort the colours of the Rubik magic cube and carry out an experiment with crystals, as well as a medical experiment. The helper assists with learning

© Airbus-Space



processes, gives step-by-step instructions, checks the completion with the help of his built-in camera and intervenes if necessary – of course only verbally – and corrects where needed.

### With propeller drive in space

On board the ISS, the spherical robot, the size and shape of a medicine ball, floats weightlessly in space despite its weight of five kilos. To make sure it does not crash into anything and for precise movement, CIMON is equipped with seven tubular air nozzles, each of which has two small propellers. They also allow it to interact using body language.

"Four tubes are provided along the x-axis, which are responsible for forward and backward movement, for which we need the highest speed," explains Philipp Schulien, Science Engineer at Airbus in Friedrichshafen. When the individual propellers are properly controlled, they also give mission companion CIMON the ability to nod or shake his head. Two tubes are provided for lateral movement, one for up and one for down. This arrangement – instead of one larger propeller per axis – was chosen among other things because of the strict noise regulations of the ISS.

When the helper works with a crew member, he must remain in a "box" – an imaginary cuboid within the station. CIMON must do quite a bit of work to stay put, as this box moves circularly with the permanent rotation of the ISS. Moreover, the air on board is constantly circulated. The airflow and rotation would easily push him against the nearest wall if it was not for his resistance.

#### BRUSHLESS DC-SERVOMOTORS

Series 0824 ... B  
Ø 8 mm, length 24.1 mm  
Output torque 1.1 mNm



ESA astronaut Alexander Gerst and the CIMON assistance system  
© Airbus-Space

### Automatic thrust pulses

This is why the propellers in its air nozzles regularly push out small thrusts to correct the position. The various movements of the mission companion are controlled by switching the individual propellers on and off as well as by controlling the speed of the individual motors. The latter are brushless servomotors from the 0824 ... B series. The SC1801 Speed Controller translates the commands of the navigation software into the proper speed.

"FAULHABER motors have proven themselves in space travel," explains Philipp Schulien. "Since every gram and every cubic centimetre matter when travelling in space, we always need as much driving power as possible with the lowest possible weight and volume. The selected combination is extremely compact. In addition, total reliability, a long service life and low maintenance are just as important. And lastly, the drives should also consume as little energy as possible and be very quiet so that the crew is not disturbed by additional noise." Other FAULHABER motors were also selected for the trip to the ISS for the very same reasons: they drive the peristaltic pumps for a bio-experiment, which is also carried out during the Horizons mission. The astronaut assistant is intended to remain on board after completion of the mission and continue his own training. His feedback will help the earth-bound developers to fine-tune the concept.

#### FURTHER INFORMATION

AIRBUS  
[www.airbus.com](http://www.airbus.com)

FAULHABER  
[www.faulhaber.com](http://www.faulhaber.com)









# Power IN NEW DIMENSIONS

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Today, you don't find visionary designs in Hollywood, but rather in the development departments of innovative companies. Requirements for drives are changing – particularly when high-torque drives are required that are as short as possible in the axial direction due to limited installation space, it is often difficult to find a suitable solution. With the visionary BXT motor series, FAULHABER extends the limits of what is possible for such requirements.



## New standards for "traditional" dimensions

More power in a very small space – from robotics to prosthetics and even in the medical and laboratory technology: this requirement arises frequently. In terms of making compact yet still extremely high-torque motors, the design of the motor winding and its production are critical. This is where FAULHABER comes in, who has developed the new FAULHABER BXT motor family on the basis of traditional external-rotor motors. Thanks to innovative winding technology and an optimised design, the brushless DC-servomotors offer torques of up to 134 mNm at diameters of 22 mm, 32 mm and 42 mm. This means the compact motors significantly exceed the previous output values in this drive class.

Particularly the ratio of torque to installation space and weight is much better than what is common on the market. As the motors are only 14 mm, 16 mm and 21 mm long in the axial direction, they are easy to accommodate in applications that offer little space.

The three sizes can solve many different drive challenges. For a forearm prosthesis, for example, the small motor can be used for the hand and the mid-sized one for the elbow. Other possible applications for the small compact drives are robot grippers, industrial automation, humanoid robots and even bio-robotics.

The motors also have other impressive characteristics such as good synchronisation properties, which is advantageous for dialysis machines and medical pumps, for example. Thanks to the high copper filling factor and the design of the pole shoes, the magnetic field is strong and the cogging torque very small. The efficiency of the motors significantly exceeds that of comparable motors of this size and design.

For example, the motors offer a continuous output of up to 100 W. Customised modifications on the electrical and mechanical interfaces of the motors are available. The motors feature standard single strands

### BRUSHLESS DC-SERVOMOTORS

BXT motor family  
 Ø 22, 32 and 42 mm  
 Lengths 14, 16 and 21 mm  
 Torque up to 134 mNm  
 Power up to 100 W





**The "heart"**  
of the high-torque  
motors: innovative  
winding and optimal  
design of the stator  
and rotor

and thus offer a flexible electrical interface for a wide range of applications. A plug concept for the connection of controls is also provided. The series is designed for speed ranges of up to 10,000 rpm and can be combined with a wide variety of gears, encoders, brakes and drive electronics from the FAULHABER product range. This modular system offers a perfectly matched drive system. The motors are equipped with digital Hall sensors from factory. Thanks to the high number of poles, the speed of the motors can be controlled very precisely with only the digital Hall sensors.

The motors are available with or without housing. The unoused BXT R models are particularly recommended for speed-controlled applications in which high powers are transformed, as the heat is optimally dissipated in the unoused versions. However, it must be ensured that the rotor can rotate freely during use. The housed version BXT H is particularly recommended for positioning applications, as it can be combined with a wide variety of optical and magnetic encoders. The housings of the BXT H serve as protection against touching as well as dirt, are diameter-compliant and thus just as compact as the unoused BXT R motors.

### A strong "heart"

The powerful heart of the visionary motors is the electromagnetic design of stator and rotor. With 14 powerful NdFeB single magnets on the rotor and 12 teeth on the stator, proven technologies are combined with an innovative winding technology. The copper fill factor in the active part of the winding is exceptionally high, while the space used was kept to a minimum through the way the wires are laid.

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#### FURTHER INFORMATION

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FAULHABER  
[www.faulhaber.com/m/bxt/en](http://www.faulhaber.com/m/bxt/en)

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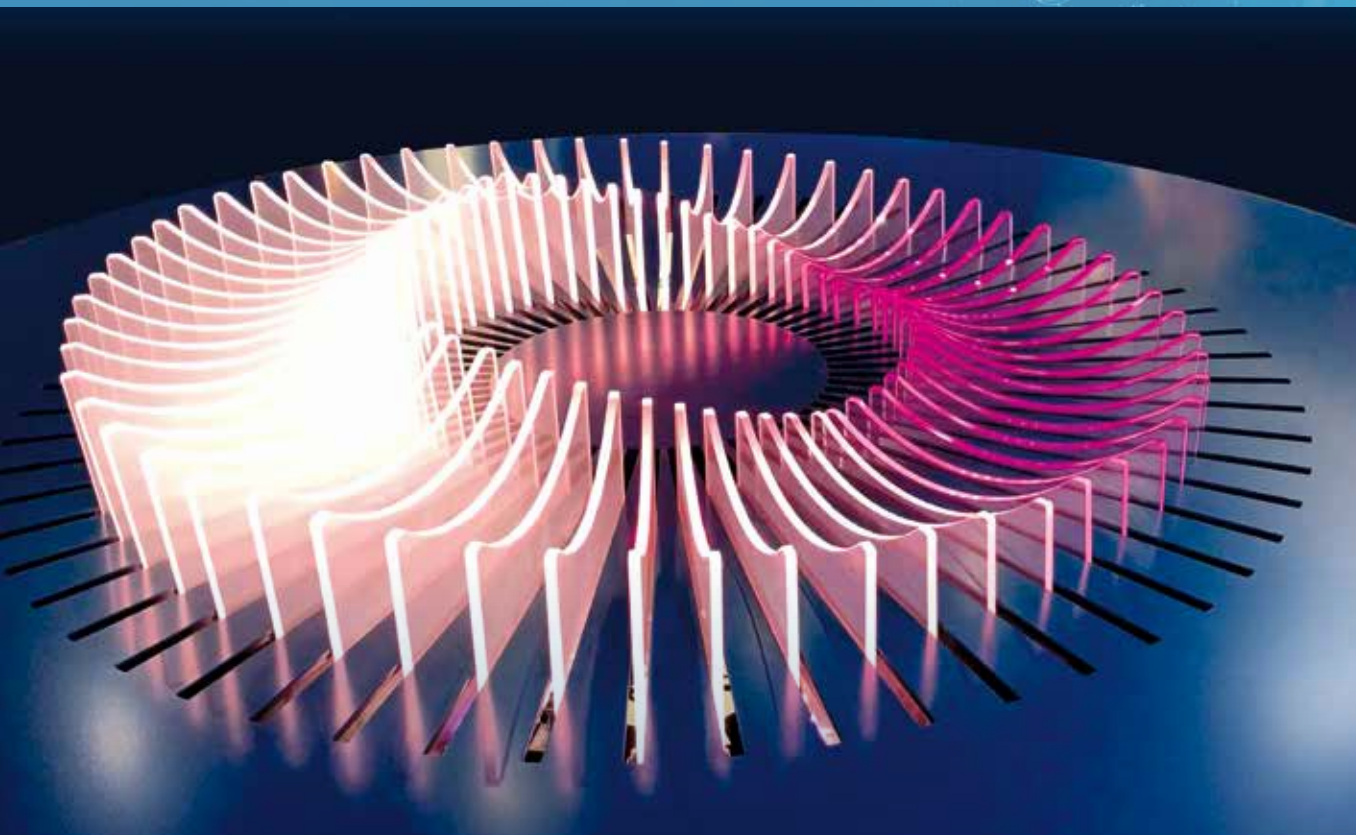
# PERFECT CHOREOGRAPHY IS ALWAYS A QUESTION OF PRECISION

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Flowing, living movement without cogging torques, a strictly linear force-current ratio, high dynamics, exact position control: thanks to these properties, the linear DC-servomotors from FAULHABER are ideal for micropositioning tasks – or for bringing a fascinating work of art to life. The kinetic sculpture "Project Anthozoa" – a collaboration between MKT AG, flying saucer GmbH and FAULHABER.

**MKTAG**  
Fine Exhibition Engineering

**flying saucer<sup>™</sup>**  
ATTRACTION DESIGN & ENGINEERING



With the passion to inspire and convey knowledge in a lively manner as well as the firm desire to transform even abstract and technical topics into an exciting experience, the designers at flying saucer (Berlin) and engineers at MKT AG (Olching) continue an age-old human aspiration: to artificially and artistically reproduce nature. From the first cave paintings to modern robotics, technology has always set limits here – and expanded them. As with the drives from FAULHABER, the continuous further development of which systematically pursues the goal of perfect motion: away from the clumsy imitation generally associated with "robots" towards a more flowing, natural movement without any discernible technical limitation.

### Fluid and lifelike

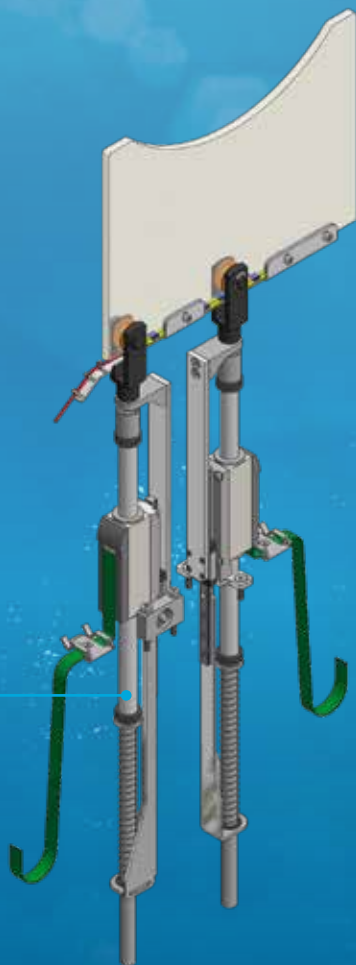
FAULHABER drives are ideal for this purpose: the linear DC-servomotors combine the speed and robustness of pneumatic systems with the flexibility and reliability of electromechanical linear motors. The innovative and compact construction with self-supporting three-phase coil in solid, non-magnetic stator housing

ensures extraordinary performance and dynamics with strictly linear force-current ratio – with a surprisingly small installation volume. The result is a fluid, life-like and highly dynamic movement without cogging torque; exact position control can easily be realised via the integrated Hall sensors.

### Balance and weightlessness

With all of these properties in the back of their minds, the industrial designers and engineers stumbled upon the "art forms" of naturalist and polymath Ernst Haeckel – particularly impressing them were the anthozoa, or sea anemones: the largest class of cnidarians served as the source of inspiration and namesake of the art-technology project. As invertebrates, with their physical characteristics and smooth and floating movement behaviour in the water, they pose unique demands. "That is precisely what the 'PROJECT ANTHOZOA' sculpture simulates. In perfect choreography with ethereal sounds, viewers are mesmerised by the merging of two movement concepts: subaqueous weightlessness and balance," says Axel Haschkamp from MKT.





## FAULHABER inside

A total of 120 linear DC-servomotor drives of the LM 2070 series with an equal number of EtherCAT controllers from FAULHABER are at work in this fascinating work of art to impressively demonstrate the perfect choreography of this movement. A flowing – even weightless – movement sets the highest standards on the control and on the bus system that is used. For this reason, a decentralised control structure was used for ANTHOZOA.



Here, Motion Controllers of the third generation control the drives independently of the bus runtime, i.e., the drives are actuated with the internal clock speed of 100  $\mu$ s to follow the target position, which is updated on the order of milliseconds. It is this combination that makes perfect synchronisation of the 120 drives possible.

## In use internationally

"PROJECT ANTHOZOA" has already thrilled trade fair visitors in Amsterdam, Hanover, Bern, Munich and Nuremberg this year. Exhibitions and trade fairs for 2019 have been published on the [www.project-anthozoa.com](http://www.project-anthozoa.com) website.

## FURTHER INFORMATION

Project Anthozoa  
[www.project-anthozoa.com](http://www.project-anthozoa.com)

### LINEAR DC-SERVOMOTORS

LM 2070 series  
 Length 74 mm  
 Force 9.2 N



### MOTION CONTROLLER

Series MC 5004 P ET  
 EtherCAT interface  
 50 V DC / 4 A





PREVIEW

# E-Motion

## ON THE

# BIKE



It goes without saying that the bicycle is a part of locomotion culture in Germany. 97 percent of people in Germany can ride a bike. They use bicycles not only for bike tours in their free time but also on a daily basis for shopping or commuting to work. Due to rising petrol costs and the constantly congested roads at peak times, residents of large cities in particular see the bicycle as a true alternative to the automobile. In the next issue of motion, learn in which components of a modern bicycle drive technology from FAULHABER is put to work.



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Further information:



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**FAULHABER motion is now also available as an app.**

You can get the free download with this QR code.



WE CREATE MOTION DTEXT

