The ultimate in precision

EXCLUSIVE interview with Dr. Fritz Faulhaber

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Happy Birthday!
For the last ten years, the customer magazine has been published twice yearly, timed to coincide with the Hanover trade fair in spring and industry events like the SPS/IPC/Drives in autumn. Professionally researched reports on various applications, exciting projects with customers from a wide range of industry sectors and FAULHABER-specific news and features are presented in an informative and reader-friendly format.

A reflection of all the company stands for: quality from the drive engineering environment. FAULHABER info magazine is aimed at existing and prospective customers whose primary focus is on areas such production automation/robotics, mechanical engineering, instrument engineering or medicine/laboratory medicine. Over the years, global circulation has increased to 50,000+ copies. From the very beginning, FAULHABER info was published in German and English. It appeared in French from 2008, followed by Chinese in 2010. Our readership is increasingly global, the range of topics more and more international, and operating environments that were considered groundbreaking ten years ago have now become a matter of course.

An innovative approach. This too is one of FAULHABER’s guiding principles. The aim of our customer magazine has always been to bring fresh impetus. Consequently, the magazine as a medium has been evolving continuously for the last ten years. The design is updated at regular intervals to lend it a more contemporary look. We have taken modern trends on board but without indulging passing fads. For example, the magazine’s news section also includes information about social media activities such as FAULHABER’s new Facebook page.

Outstanding performance in a compact format. The company’s mantra can also be applied tongue in cheek to our customer magazine. Fascinating and technically sophisticated reports on product applications are packed with interesting details. Often, there will also be a large number of photographs to illustrate the particular challenges of the application described. So it is very easy for an article to exceed the confines of a two-page spread. On the other hand, the magazine also thrives on the variety and diversity of the various topics and areas of application it covers. It is therefore quite an achievement to be able to reduce the material to the most important subject matter and yet still find room for all the interesting stories accompanied by some very impressive photos.

Staying true to itself – The company’s successful customer magazine “FAULHABER info” is also a shining example of one of the FAULHABER Group’s defining principles at work.
Those in charge of similar projects will also be well aware that finding appealing subject matter is not always easy. After all, interesting articles have to be prepared and edited and suitable photographs provided to fill the magazine's 16 pages. In many cases, there are interesting topics from the most amazing sectors, exciting applications that are really cutting-edge, but unfortunately they are frequently subject to strict confidentiality rules and therefore cannot be published. Or there is a great subject that would make an excellent article, but there are no decent photographs to go with it. This is where the editorial team is called on to show great skill and occasionally demonstrate supreme patience and perseverance. And even where there is a reasonable lead time, there is still the constant pressure to meet that immutable deadline for going to print.

But where then do the topics actually come from? Our main source is our customer base – featuring specific products, applications and challenges. Our sales consultants submit suggestions for suitable stories along with contact details for the relevant people at the customer's company. The FAULHABER info editorial team then consults with the customer and researches the basic material required, so that the authors have a reasonable basis on which to compile the articles. After clarifying any outstanding questions, the content and layout are prepared, adapted and cleared for publication with the parties responsible.

At FAULHABER, we have a recurring fascination with the kinds of areas where our drive systems are used, and we love to tell you about them. But we like it even more when you, as readers, share our enthusiasm and give us your feedback. And of course there are some quite spectacular locations, applications and functions in which FAULHABER motors are used. Here is a brief review of some of them:

**Deep sea.** When filming the documentary “Oceans”, the camera had to be specially stabilized to guarantee shudder-free images from a permanently unstable surface.

**Outer space.** Small and light but strong and reliable over the long term: these were NASA’s requirements for its Magnetospheric Multiscale Mission.

**Micro-annular gear pumps.** Pure high-tech is what is required when it comes to the targeted dosing of very small amounts of liquid.

**Medicine and quality of life.** The world’s first microprocessor-controlled prosthetic leg is driven by a FAULHABER motor.

**Operating theatre table.** A miniature hexapod, fitted with tiny smoovy motors, provides high-precision guidance in spinal surgery.

**Arizona.** The most powerful stand-alone telescope in the world on Mount Graham in the U.S. state of Arizona.
A thank you to our customers.

Thank you very much, dear customers and others, for your interest in FAULHABER info; for your superb products, projects and applications which are a source of inspiration to us and provide the basis for our in-depth reports; for your support and flexibility in enabling us to publish them; and last but not least, for your feedback, your suggestions and your loyalty to our company.

We look forward to continuing to inform and entertain you with our FAULHABER info magazine.
Interview with Dr. Fritz Faulhaber, CEO

“Technology is what drives us”

With a history spanning more than 60 years, FAULHABER has outgrown its regional roots in south-western Germany to become a technology leader for microdrives in the range 0.01 to 200 mNm. Its catalog, in the meantime, is a hefty 470 pages long, there are plenty of new products in the pipeline for the coming years, and it will be interesting to see just what kind of innovations the market heavyweight from Germany’s deep south will come up with in future as it continues to make a name for itself in the industry.
Dr. Faulhaber, the success story of your company's drive systems began more than 60 years ago. What do the FAULHABER company and the FAULHABER brand represent today?

We are a technology-driven business. Even 60 years ago, the idea behind my father’s founding of the company, which grew out of his development of the ironless rotor coil, was wholly driven by technology. And today, too, it is this commitment to being one step ahead of the pack that motivates FAULHABER and opens up new possibilities for our customers and for the company itself. This is why the power of innovation has always been our most important corporate asset. For quite some time now, however, our innovations have no longer been limited to just product development. Nowadays, in fact, innovation straddles all areas of the company, particularly as it relates to production processes and manufacturing techniques. Ultimately, the key factors to success are the way we deploy our human resources and the quality and reliability of our work.

In such economically turbulent times as these, there is no doubt that stability is also an appropriate byword for the company and the FAULHABER brand. This means stability in a broad sense, be it management, quality standards, growth or financial strength. Why? Quite simply, because a traditional mid-sized, family-run company could not have survived within the market for 60 years without producing solid work. That might sound somewhat unadventurous and boring, but it has been a formula that has worked successfully for 60 years.

During these 60 years, FAULHABER has experienced a large number of milestones, not all of them technological. What events were of great significance to you personally?

Of course, from the very beginning there were a lot of technological highlights. We have worked with our customers to realize a large number of projects, each of which has been absolutely fantastic in its own right. From cameras to medical technology, from deep sea to outer space – FAULHABER has been involved in all these and more. One of the most rewarding aspects about the business we are in is the wide range of customers and the various projects that we have been privileged to realize for them.

On a personal level, however, the most important achievement has been the organic growth that we have experienced during this period. We pay for all of our investments with our own hard-earned cash and are very frugal when it comes to borrowing money, e.g. for real estate. This approach has always served us well in the past. In addition, we are in the fortunate position of being able to align our corporate goals over the long term, without having to constantly demonstrate on a quarterly basis that we are able to increase our earnings or having to listen to a banker telling us what we can or cannot spend.

It is our own achievements that have allowed us to become the FAULHABER Group as it is today, with its workforce of around 1,500 people. It is also through our own endeavors that we have been able to broaden and expand our technology and product range and transform into reality our vision of creating the world’s most precise and compact moving objects that push to the limit that which is technologically feasible. I regard this as perhaps our greatest achievement to date.

Prior to 2009, financial losses and compulsory redundancies were unheard of at many German companies. How did the years of economic crisis impact on the FAULHABER Group and the Schönaich facility in particular?

Of course, like many other companies, the crisis did not just pass us by. On the contrary, because we produce industrial components we were faced with a very
difficult time, like most companies in the sector. The Schönaich facility and the firms in our production network suffered as a result, and we were also forced to make some structural adjustments, primarily in the production area. However, as our products are very sophisticated, our team members need a long and very thorough period of familiarization to work effectively at such a high level. This is why we preferred to take some losses on board in order to retain our staff, rather than put up obstacles to our future progress, at least for as long as this was possible. It was the first time in FAULHABER’s history that such a step had been necessary. And I hope that we demonstrated consideration and foresight in taking it. On the whole, I think we have recovered and are back to where we were before the crisis.

**How do you see Germany as a production base in terms of FAULHABER’s future development?**

Our products are not just a byword for high-tech, above all they represent the high quality that our customers expect. And that is hardly surprising when you consider the kind of applications in which our products are used. In areas like medical technology, it is now no longer a question of whether one out of a hundred parts can have a fault in it. It has been a very long time since this was acceptable. Nowadays, the quality of such products has to be impeccable.

Regarding Germany as a production base, we recognized very early on that there are challenges associated with this. This is why we automated our production facilities many years ago, but without having to reduce our workforce, thanks to the growth we were enjoying. I think that this has put us in a position of being able to produce a large number of parts today in the required premium quality at a cost level that is competitive in the global market.

**Have quality standards really changed so dramatically?**

Significantly. There are many reasons why quality requirements have become increasingly more stringent, not least due to legal constraints. For the manufacturers of industrial components, too, it is therefore absolutely vital to make as few errors as is humanly possible. And nowadays, quality management has to be proactive; this means we have to eliminate potential sources of error before they actually materialize.

In addition, the trend towards miniaturization is more pronounced than before. Developers are pushing the envelope in respect of what is possible. And on top of the pressure to deliver high performance in the smallest possible dimensions, we are now also being required to integrate as many functions as possible. In many areas of application, products have to cope with extremes at both ends of the scale, or to put it another way, they have to be all-singing and all-dancing and yet still work reliably and accurately. The demands are becoming steadily more exacting, and development engineers need us to supply tried and tested quality products that reduce their workload as much as possible, so that they can achieve their goals in the shortest possible time and without risk. And to accommodate these needs we always have to be one step ahead in terms of our technology and the quality of our products.

**At the moment, what are the most important industries for your company? And what do you consider to be the growth markets for the future?**

In Germany, the key sector for us is industrial automation, i.e. high-precision and special purpose machines, for example SMT assembly or solar cell manufacture. Medical technology comes a close second, and in global terms is probably the most important and also the most rewarding sector for us. We have been involved in a lot of different areas here, such as laboratory automation with analysis equipment, surgery with operating theatre robots, intracardiac pumps or technologies used in implantology. The aerospace industry is also an important market for us, although in the past our areas of application were more complex, because flight instruments were predominantly driven by mechanical means. Nowadays, they are mostly digital. This is progress. Markets come and markets go. Several years ago, for example, we were producing hundreds of thousands of motors for dictation machines. Nowadays, virtually none. The cheap brands are all manufactured in Asia and the more expensive ones are digital in the meantime. One market where there is a strong demand for our drive technologies is the military sector.

**Why the military sector in particular?**

Now most people probably think that the armed forces always use state-of-the-art technology. And there are certainly some areas, such as satellite surveillance, where military equipment is very high-tech. However, there are many other areas where technology used by the military is currently lagging very far behind the standard in industry. For our products, there are very interesting applications primarily in optical systems and robotics.
In the USA we currently have an application for a scout robot, which is thrown in front of you like a ball and then opens up to reconnoiter the area.

How is the FAULHABER Group adapting to current and future global competition, in particular regarding the development of the Asian market?

It is very difficult to answer this question in general terms, because every market has to be considered separately. The Asian market too has its own very specific rules. The great challenge for us as Europeans is to understand how this market works in the first place and how to do business there. This has nothing at all to do with the product as such.

If you attempt to implement German methods in China, you will find that you run out of ideas very quickly. You have to adopt a different style there and open up to the market and the culture in order to be successful. And there is absolutely no doubt that we can enjoy success there. Because in respect of technology we have the best products, and secondly, we are able to produce small to medium-size batches. We are also specialized in the appropriate technology for a scout robot, which is thrown in at the moment. And there are plenty of variants. This is the kind of cycle we are considering.

In 2010 FAULHABER also opened its first branch in China. As a European manufacturer, how has FAULHABER been able to position itself on the market there so far?

On the whole, our approach of marketing our products worldwide via distributors has proven successful. Nevertheless, our business is now less about standard products and more about customized special solutions. With a few exceptions, of course, a distributor does not have the capacities and know-how to provide customers with expert support for these kinds of applications. This is why, in concert with our distributors, our strategy is to have our own offices wherever the markets demand this kind of proximity to customers. And China is just such a market.

First and foremost, we opened the office in China for those European customers who were using Faulhaber products, operating locally with production facilities and then re-exporting their goods. For the Chinese market itself, initially the products made by European companies were too expensive. In the meantime, a larger proportion of the population is located in China's major cities, which means of course that they also have a higher disposable income. In other words, the Chinese market is now also attractive even for Western companies producing products such as ours. Nevertheless, the price differences are still very high and above all, there is growing competition from Chinese companies. Nowadays, companies in China are not just making cheap copies of western products, they are increasingly developing their own high-end products and marketing them locally as well as internationally. Although this therefore makes China a difficult market, it is nevertheless a market which we believe offers the greatest growth potential in real terms.

You have mentioned that in technological respects you are pushing the boundaries of what is feasible in many areas. So just how is it possible today for a technology leader like FAULHABER to keep enough of those product innovations coming in the appropriate time frame?

As I have already suggested, our development capacity is extremely important for our future prospects. Strategically, we rely on constantly bringing new products out of the pipeline and in the process always staying one step ahead of the competition. And in most cases until now we have also managed to do so. We have pioneered almost all technologies in our industry. Our focus is not purely on production, but what we do produce is so technologically sophisticated and unique, that other companies cannot match it at first. And so we always enjoy a two-year lead until the competition catches up with us.

Our development cycles are relatively long. To develop a new technology to market readiness is quite simply a completely different matter from changing the color of a product. We cannot afford to bring a product to the market that is not reliable or ready to go into production. We would very quickly have to pay a heavy price for doing so. To make sure that this does not happen, development phases simply have to take a bit longer.

What is your vision for the future? Where do you envisage drive technology and your company in five years time?

Even at the risk of sounding a little tedious, we are simply going to remain true to our principles and continue to bank on stability. At present, Europe certainly does not appear to be witnessing the recovery of a healthy and vibrant economy. Therefore for the time being, we are not planning on taking any audacious steps but are focusing strongly on our product development.

On the whole, we will also stick to our drive technology environment. We would be capable of manufacturing other products, pumps for instance, but we are not going to, because we build drive systems. We will remain committed to the dimensions of less than 100 mm, we will deliver maximum accuracy and reliability, we will combine electronic and mechanical systems accordingly and will always provide the market with products offering maximum performance in a compact design.

In the past year we have launched 16 new products on the market including subvariants. This is the kind of cycle we are in at the moment. And there are plenty of products in our development pipeline for the next few years.
The timely tracking down and disarming of bombs, IEDs, booby traps and other dangerous munitions from the extremist arsenal is most definitely a job for the professionals. Prior reconnaissance – to avoid calling in the specialists unnecessarily and to ensure a confirmed threat is handled as safely as possible – is an essential element of this process. In this scenario special remotely operated devices can drastically reduce the risk to the human beings involved in such activities, with high-precision micromotors replacing manpower to undertake the necessary hazardous operations at the bomb scene.
AB Precision (Poole) Ltd., a UK company based in Dorset, has been supplying the British Ministry of Defence since the mid-1960s. To respond to the currently heightened risks in tracing and defusing explosive devices, the experts from Dorset developed the latest generation of their Guardian MROV (Miniature Remotely Operated Vehicles). The modular miniature vehicle is designed to carry additional equipment as required. Universal deployment capability also means that it has to cope with any terrain.

**Compact design in demand.** Equally important is the compact design, so that it can be manoeuvred in narrow passages, e.g. in trains, aircraft or underground rail carriages. With a view to accommodating as many different functions as possible in a slimline design, including a powerful four-wheel-drive transmission, ABP’s security experts collaborated with microdrive specialist Faulhaber. In the basic Guardian module, fifteen different microdrives accurately execute the control commands. The entire procedure is managed from a control station in a carrying case. A 17” LCD monitor shows the images captured by the cameras, while a 10.5” touch screen with soft buttons and 3D imaging of the vehicle offers intuitive control of the device and any additional modules installed. The “command center” is rounded off by two joysticks for the drive and manipulator arm.

As reconnaissance often has to be performed in confined spaces, a compact design is essential. The dimensions of the device 417 mm (tracks), maximum length 1280 mm (extended) and height 504 mm are designed to facilitate navigation in narrow passages. In addition, the reconnaissance radius has to be as large as possible. Therefore a telescopic arm extends the reach of the pan and tilt head up to 2.10 m. At the same time the head can also be lowered so that it can inspect vehicle underbodies. A low center of gravity and sturdy caterpillar tracks provide a stable base for sharp, shudder-free images as well as accurate manipulation using the cantilever head. Depending on the terrain involved, the chassis can also be fitted with wheels, allowing it to move faster on solid ground and thus enhancing mobility.

**Highly flexible thanks to modular design.** The complete vehicle can be quickly assembled at a safe distance from readily portable modules. This makes it easier to transport and allows the experts to deploy the right tool for each individual situation by choosing a particular module. Apart from the four on-board cameras providing color images, there are numerous other modules available such as various hardware devices (e.g. lockpick gun), X-ray unit, water jet and many more. Additional equipment can be transported in an optional trailer.

**Customized solutions from the modular drive set.** The drives used in this system are just as diverse as the range of applications. However, all of them must meet certain general requirements such as absolute reliability, compact design, high performance combined with high-precision handling, and the greatest degree of efficiency for long battery life. In a nutshell, the product philosophies of the Guardian and the Faulhaber drive motors are very similar. Both rely on a modular product to ensure the widest possible range of applications. This similarity is also reflected in the deployment of the fifteen drives. Motors and gearheads are selected depending on the task in hand and combined to meet the required performance. For example, each of the four drive modules is powered by a 38 mm diameter motor with matching diameter planetary gear. With over 200 W and around 150 mNm at the motor shaft, the combined motor output of 1 metric HP is more than sufficient to move the vehicle and its equipment through terrain or over inclines.

Two structurally identical motors with different reduction ratios are also responsible for raising and lowering the telescopic arm. The wide range of gear ratios therefore allows the ideal output torque and speed to be selected for both operations. Smaller 32 mm motors with an output of around 80 W extend and retract the telescopic arm. To keep the weight of the head low, light 26 mm diameter, 44 W drives perform the “turn and tilt” function. The camera and optional weapons, on the other hand, are actuated by two identical drives 23 mm in diameter and with around 20 W output. Depending on the function required, the manipulator works with a 23 and 26 mm drive. All motors come in rugged DC brush design and are therefore capable of starting even at very low voltages. The comparatively simple yet robust drive control system using pulse-width modulation is also ideal for this application.

Further information
Electro Mechanical Systems Ltd., UK
www.ems-limited.co.uk
AB Precision (Poole) Ltd., UK
www.abp-eod.com
Modern microscopes have become an indispensable part of medical research. The procedure for quickly and precisely examining the relevant sections of a sample has always been to adjust the slide’s position by moving the stage under the lens. But thanks to technological advancements, manual adjustments are quickly becoming a thing of the past. The task is now given to microdrives. But not all microdrives are created equal. In order to avoid mechanical play and ensure quick movement with utmost precision, a new concept uses small linear DC-Servomotors. With drive lengths in the decimeter range, it boasts a repeat accuracy of a few microns.
The new stage with linear DC-Servomotor impresses with its smooth operation and flexibility.

The more we focus on one point, the more limited our field of vision becomes. This particularly applies to modern microscopes with their high levels of magnification. In order to evaluate a sample entirely and not just at select points, the sample needs to be systematically moved while remaining in focus. Objective Imaging Ltd in Cambridge has developed its new OASIS Glide Scanning Stage to meet the requirements of modern microscope techniques. The moveable stage uses the latest drive technology from microdrive specialist FAULHABER based in Schönaich near Stuttgart. The direct-drive linear motor sets new standards in flexibility and precision. **Expanding the field of vision.** The OASIS Glide-S1 works with an “adjustment window” of 75 x 52 mm. The new linear drives offer previously unattainable precision and speed, as well as boasting the ultimate in smooth operation. The latter was an important criterion in choosing this drive system. Mechanical play, such as that seen in lead screw drives, is eliminated. Along with its advanced technology, the stage also offers standard features such as a dovetail guide and screw fastening suitable for the majority of microscopes. A new manual entry unit with color touchscreen and 3-axis joystick greatly simplifies adjustments for various positions. Compared to previous systems, the new stage comes with superior mechanical specifications despite being smaller and lighter. Mechanical play is almost completely eliminated by the drive as is operational noise. Exceptional vertical stability and lack of vibration accommodate the improved resolution at higher progression speeds. The entire system does not require any maintenance and is easy to equip.

At the heart of the adjustable stage are two linear motors with +/- 30 and +/- 80 mm strokes that work together in concert. Along with considerably better mechanical resolution, this drive solution also represents better value compared to traditional drive solutions in this segment. **Compact linear technology.** The linear drive combines the quick and easy control of an electrical system with the simple construction of pneumatic cylinders. Instead of the usual “surface rotor” with slides and guides, the microdrive is built within a new, rotationally symmetric design of the rotor. The rectangular, easily flange-mounted stator is designed for close to universal fit and can therefore be easily integrated with the scanning stage. The slimline design also benefits from the fact that the stator (motor) measures only 12.5 x 19.9 x 49.4 mm (W x H x L), including the plug connector (Image 3). The forcer rod is currently offered in six variations, each with a diameter of 6.3 mm and selectable lengths of 82, 109, 127, 154, 172 and 190 mm. This makes stroke lengths of up to +/- 10, 20, 30, 40, 50 and even 60 mm possible, or to put it another way: the forcer rods can be used for applications with lengths ranging from 20 up to 120 mm. Impressively, the motors only weigh between 57 and 82 g.

From the user’s perspective, the drive consists of only three individual pieces: the stator (motor), the plug with cable and the forcer rod. A non-magnetic steel case holds the self-supporting three-phase AC coil winding as well as the rotor’s sleeve mounting made of special plain bearing material. The connector plug and a printed circuit board for three Hall sensors, which are used for positioning, are hidden under the upper cover. The precision sliding metal rod, which refers to the forcer rod, is equipped with super-strong permanent magnets.

The mechanical properties of the linear DC-Servomotor are impressive: the continuous force of the rod amounts to 3.6 N, with a peak or strike force of up to 10.7 N available. Depending on the stress scenario, the acceleration for the 20 mm version equates to 198 m/s², in other words 19 times faster than gravitational acceleration, while the 120 mm version manages 82.9 m/s². The robust plain bearings for the forcer rod smoothly accommodate speeds up to 3.2 m/s. The permitted operational temperature range spans from -20 to +125 °C, covering all of the usual application areas. Despite these outstanding performance figures, the linear motor is precisely adjustable using the motion controller. Repeat accuracy (maximum deviation during multiple repeated movements) amounts to 40 μm. The three linear Hall sensors in combination with the motion controller limit the maximum positioning margin of error, meaning the difference between predefined and measured position of the system, to 120 μm for the 20 mm version and up to 220 μm for the 120 mm model. Since all values are determined purely electrically, mechanical tolerances, wear and thermal expansion of the components are of no relevance.
Small and miniature aircraft, also known as UAVs (unmanned aerial vehicles), require reliable propulsion systems in order to achieve extended flight times with minimal quantities of fuel. Previously, the only option available for fuel delivery to the engine was a carburetor. The latter, however, is not able to provide an optimum fuel mix for all of the various phases of flight. A newly developed miniaturized electronic fuel injection (EFI) system designed specially for small combustion engines now provides the benefits of fuel injection, long enjoyed in larger engines, for small UAVs. The most striking characteristics of this system are higher performance combined with reduced consumption and considerably increased reliability. Microdrives are used to power the fuel pump to ensure the correct pressure in the fuel system. The properties required include high performance density together with low weight and superior reliability.

Electronic fuel injection in UAVs

Higher performance with lower consumption

Research, military and – increasingly – industry, media and emergency services are using miniature aircraft, known as unmanned aerial vehicles (UAVs), for reconnaissance flights and measurements. They are considerably cheaper to purchase and maintain than manned flights. Because they are so compact, they need small internal combustion engines for power, but to date these have virtually always been fitted with carburetors for the purpose of fuel delivery. Currawong Engineering Pty Ltd from Kingston, Tasmania, Australia, is now coming to the rescue by producing miniature electronic fuel injection (EFI) systems. This guarantees an optimum fuel mix at all stages of flight, even for miniature aircraft. The fuel, which is under pressure within the system, is injected into the intake manifold using specialist fuel injectors and the fuel/air ratio is electronically controlled by a multi function electronic control unit (ECU). Auxiliary energy is required to build up the necessary fuel pressure. A high-performance, low-weight DC-Micromotor ensures consistent fuel pressure, irrespective of height, fuel levels and flight maneuvers.
In-flight mixing. Engines used in aircraft are particularly demanding when it comes to controlling the fuel/air ratio. Fuel and air will only ignite within specific limits, and the window is even smaller if the engine needs to run with optimized performance and minimum specific consumption at all times. Efficient consumption is especially important in small aircraft; every gram saved extends flight time or increases the usable load. As most miniature aircraft have only a single engine, any problems automatically result in a crash, so extreme reliability is required of all components.

The problem of aircraft engines with carburetors is the fact that the mixture is too rich at altitude if the carburetor is perfectly tuned at sea level. If the mixture is ideal at altitude, it is too weak on the ground. A compromise is always required – and this reduces performance and increases fuel consumption. The only solution is electronic fuel injection.

As the fuel is under several bar of pressure, the vaporization of fuel is ruled out even at high altitudes. Injectors spray the fuel into the inlet pipe. This allows a free, aerodynamic inlet path with no Venturi nozzles. The engine can “breathe” freely and unleash more performance. This is most noticeable at greater altitudes where the air is thinner. The amount injected is constantly recalculated electronically based on engine data such as inlet temperature, air pressure and performance required. The injection point and duration are coordinated with the crankshaft angle. In conjunction with the shape of the injectors, the pressure in the fuel system ensures extremely fine vaporization of the fuel; very small drops vaporize more easily than large ones to give a more consistent mixture. This guarantees an optimum mixture not only on ignition where there is practically no flow at all but also in thin air at high altitudes and at full power on the ground in thick air. Overall, use of an injection system translates into 15 to 30 percent better consumption, increased performance and improved engine reliability.

Injection in practice. Although the principle is very simple, designing an injection system for miniature engines is incredibly complex. The specialists from Australia have managed to supply engines of between 10 and 250 ccm with their compact system. The entire system consists of a number of components that can be tailored to the relevant engines. As well as the controller, the sensors for crankshaft position, and inlet and cylinder head temperature, the system also incorporates an ignition module, the injector, a fuel pressure accumulator and the fuel pump. The high-precision mechanical components weigh a total of less than 200 g and take up just 74 x 58 x 39 mm (h x w x d). The area of application of the certified components covers a temperature range of -30 to +50 °C and an altitude of up to 6000 m. Non-stop test runs over 1500 h and 700 h confirm the components are extremely reliable.

There is a piston pump to ensure the essential pressure build-up and a downstream pressure accumulator with pressure controller to guarantee a constant pressure of 2.9 to 3.2 bar in the system. In the fuel pump, a microdrive works with a bevel gear system on a crankshaft which powers the actual pump pistons. The 90° force transfer in the gearheads means the 27 g precious-metal commuted DC-Micromotor can be positioned behind the pump cylinder to save space. The entire pump unit measures just 65 mm in height and 22 and 34 mm respectively in width and depth. The pump is controlled by means of pulse width modulation, with the service life being more than sufficient for this application. In order to increase torque and enable optimum transfer of the 2.5 W output to the pump crankshaft, there are planetary gearheads connected downstream of the engine. The input ratio reduces 19:1 for a 15 mm diameter. It works in a temperature range of -30 to +65 °C, which is more than adequate for UAV flights anywhere in the world. The torque for the two-speed plastic gear weighing just 5 g can be up to 200 mNm.

Further information
ERNTEC Pty. Ltd., Australia
www.erntec.net
Currawong Engineering Pty Ltd
www.currawongeng.com
New Products

Minimal power, maximum precision

**FAULHABER Motion Controller Series MC 3002**
In the field of controls, FAULHABER completes its range of controllers suitable for all motor types with the Motion Controller series MC 3002 for microdrives in the lower power spectrum. The MC 3002 series also includes drives with absolute encoders and offers even more flexible and easier configuration.

- User-selectable operating mode for brushless 2 or 4 pole drives
- Activation via RS232 or CAN interface
- Available in enclosure or on a board
- Simple programming using Motion Manager Software 4.7, optionally also via USB interface adapter

![Image of Motion Controller Series MC 3002](image)

High-precision linear movement

**FAULHABER Ball Screws Series BS 32-2.0**
The new ball screws used in Series BS 32-2.0 allow the rotational movement of micromotors to be converted to linear stroke or tensile movements with minimal travel variations of less than 5 μm over the absolute travel distance. Combined with drives with integrated Motion Controller, they provide accurate and powerful positioning systems.

- Minimal pitch deviation for maximum precision
- Compact design with 32 mm diameter
- Variable spindle length
- Long service life of more than 1 million cycles in continuous duty at rated load

![Image of FAULHABER Ball Screws Series BS 32-2.0](image)
High drive dynamics

FAULHABER DC Micromotors
Series 1336 and 1741 … CXR

The two drive series complement the proven FAULHABER range of DC-Micromotors in the medium power range. High drive dynamics, durability and an attractive price/performance ratio make the two series an appealing drive solution for numerous areas of application.

- Dynamic 4 or 8 mNm continuous torque with extremely flat gradient of the n/M curves
- Compact dimensions of 13 or 17 mm in diameter and 36 or 41 mm in length
- Rugged, durable design with proven copper graphite commutation
- Modules can be combined with encoders and matching gearhead range

Trade Fairs & Events 2012

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A solar-powered microdrive is the centerpiece of a highly symbolic and uniquely crafted gift.

Freiburg's gift to the Pope

For the first visit by a Pope in the city's almost 900-year history, the city of Freiburg commissioned a very special and symbolic gift. A hand-crafted, 18 cm diameter solid silver bowl with a circular solar cell, made especially for this occasion, powering a tiny drive unit in the bowl’s interior to rotate an ornament at its centre.

The silver bowl depicting city landmarks, with circular solar cell and rotatable ornament.
Not only does the bowl depict city landmarks like the cathedral and the Black Forest, it also underscores the city’s development model in the areas of environmental protection and renewable energies. The choice of material and the design at the same time evoke the gothic architecture of the cathedral and the silver deposits that bestowed prosperity and riches on the city in the Middle Ages.

The elaborate design and highly sophisticated mechanism of this unique piece was only possible as a result of active collaboration between several partners, including the Freiburg Fraunhofer Institute for Solar Energy Systems and the drive specialists from FAULHABER in Schönaich. The centerpiece of this artistically and technologically sophisticated work is a round, monocrystalline solar cell and a precious metal commutated microdrive. Unlike conventional solar cells, the energy-conducting “grids” were not given the usual lattice structure but were installed in the shape of a star. On completion of the cell, its measured power output was 5 A short-circuit current.

The interesting question now was whether this amount of energy would also suffice to turn the ornament. This is where the technological benefits of FAULHABER’s precious metal commutated microdrives came into play. Thanks to their commutation and coil technology, they can be operated at extremely low starting voltages and are therefore ideal for use in battery operation or with solar cells. A series 1516...S DC-Micromotor was chosen to turn the figure in the center of the silver bowl. This motor can run at a current intensity of just 10 mA, and with its continuous torque of up to 0.4 mNm has enough power to rotate the ornament at a speed of up to 20 rpm, even under poor light conditions.

Further information
FAULHABER, Deutschland
www.faulhaber.com
Fraunhofer-Institut für Solare Energiesysteme ISE, Freiburg
www.ise.fraunhofer.de
UEFA Euro 2012

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We are now on Facebook! While you are waiting for the next edition of our customer magazine, visit our Facebook page for interesting news and exciting activities like our UEFA Euro 2012 competition.

All participants get a chance to win one of five German national team shirts and five “Tango 12” official championship footballs.

Get your entries in fast - we are giving away these fan-cheering sticks (Airsticks) as long as stocks last!

Closing date for entries for the competition is May 31, 2012. Regrettably, employees of FAULHABER Group companies are not allowed to take part in the competition. The judge's decision is final.

Hagar the Horrible

Hamlet, if you were shipwrecked on a desert island, would you rather have me or a book for companionship?

Ham...I'd say that would depend on which book it was...

That probably wasn't the best answer...