CONNECTED

A MAGAZINE BY

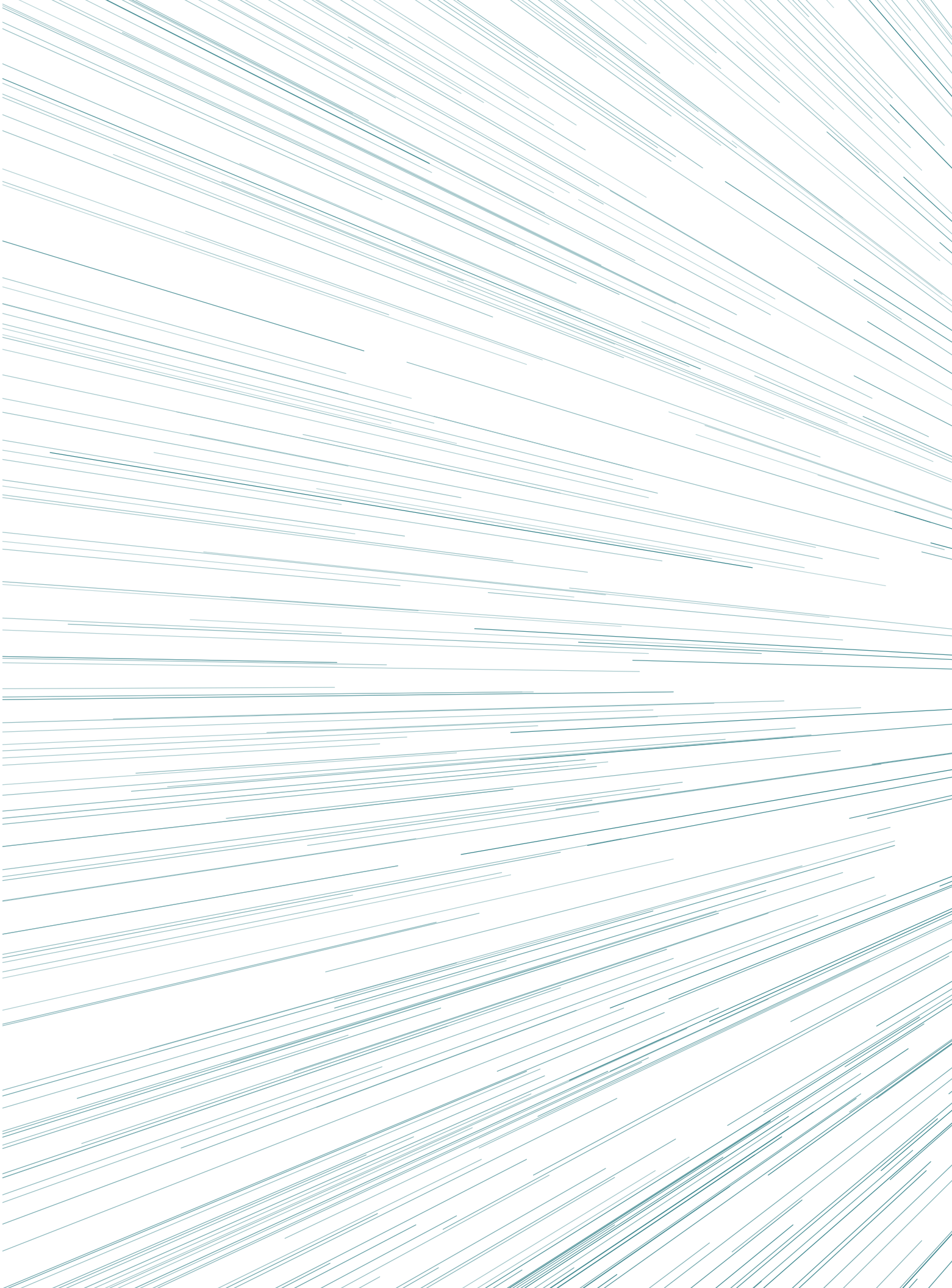
LEMO

AUTUMN 2018 N° 11

Hyperloop: a Quantum Leap in Transportation

Yves Rossy, the Flying Swissman

TMT to Discover the History of the Universe



WILD DREAMS ARE THE DRIVING FORCE OF INNOVATION

Innovation is reliant upon technology companies making effective progress, but it also requires dreamers to imagine a future that may at first seem unrealistic.

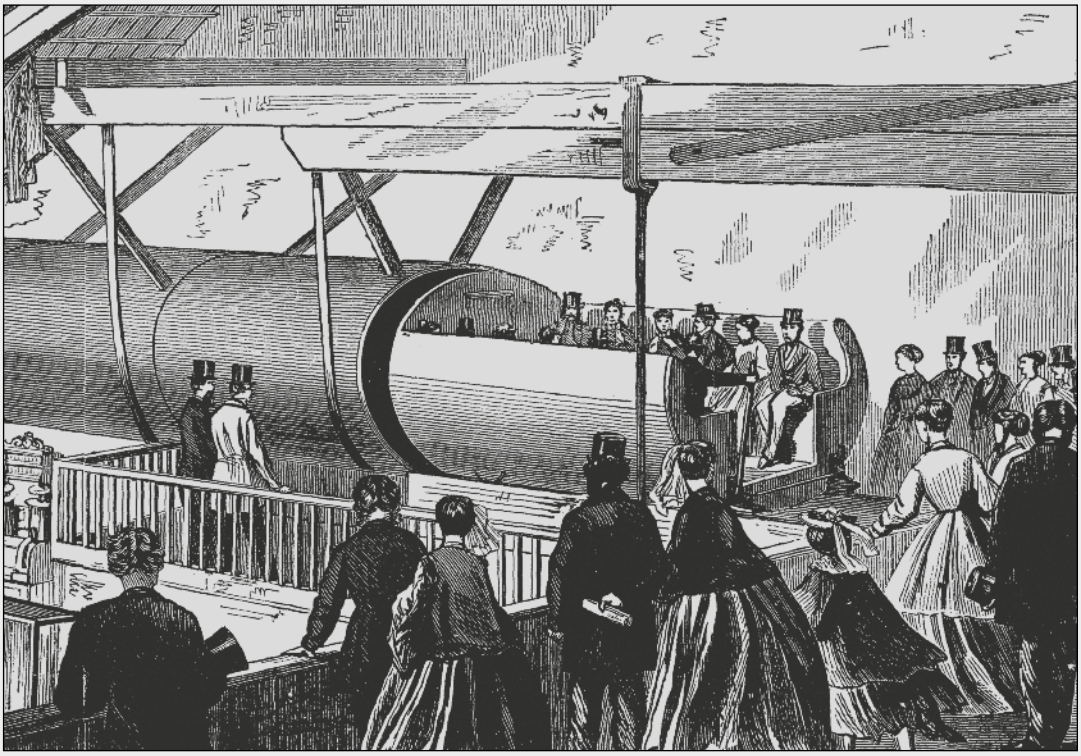
Jules Verne is one of these great dreamers. Considered as one of the forebearers of science fiction, as during the second half of the nineteenth century the French writer had already imagined a space module landing on the Moon, life on board an electric submarine, video conferencing, robotic soldiers, newscasts and much more. All of these “What-ifs” have been countered with “Why-nots” from engineers.

Hyperloop (see special feature on page 10), a steel tube in which trains levitate at over 1,000km per hour, is an excellent example. It was one of Jules Verne’s wild dreams, relaunched by Elon Musk in 2016. The idea still seems somewhat far-fetched — it arouses as much hope as doubt and its outcome is still uncertain.

Yves Rossy aka Jetman (see “The flying Swissman” on page 24) had dreamt about flying like a bird since he was a young boy. Another far-fetched dream? Not at all. In innovation, as a young engineer once told us, the path is the goal. Failures as much as successes are meant to move the world forward.

So it goes for technology: dreamers may be wrong, but engineers always make progress.

Alexandre Pesci
CEO LEMO



“Think of the railroads of the olden time, and you will be able to appreciate the pneumatic tubes through which today one travels at the rate of 1000 miles an hour.”

Jules Verne and Michel Verne, “In the Year 2889”

Back in 1889 already, Jules Verne and his son Michel made their characters travel on trains launched through pneumatic tubes at 1600km per hour, very much like what we call today a hyperloop, see our special feature on page 10.

IN THIS MAGAZINE

IMPRESSUM

EDITORIAL BOARD:
Alexandre Pesci, Judit Hollos Spoerli, Peter Dent, Serge Buechli, Raymond Voillat, Essencedesign

ENGLISH TRANSLATIONS:
Judit Hollos Spoerli

GRAPHIC DESIGN:
Essencedesign

TECH-BITS FROM AROUND THE

THE WORLD'S FIRST COMMERCIAL HYDROGEN TRUCKS

These next five years, Hyundai Motors will sell 1,000 hydrogen-fueled trucks in Switzerland. The deal, that will double Hyundai's hydrogen vehicle sales, was made in partnership with the Swiss hydrogen company H2 Energy. The buyer is Coop, a national retailer. According to Hyundai, these will be the world's first commercial hydrogen trucks. No dedicated service stations will be necessary, as the trucks will fill their hydrogen tanks (32kg each) in the morning at the warehouse during loading. Unlike battery-powered models, electricity is produced on the vehicle by a fuel cell. This technology is more adapted to commercial vehicles than to cars. Advantages include shorter charging time and no cargo capacity reduction unlike in the case of the huge batteries required for electric trucks.

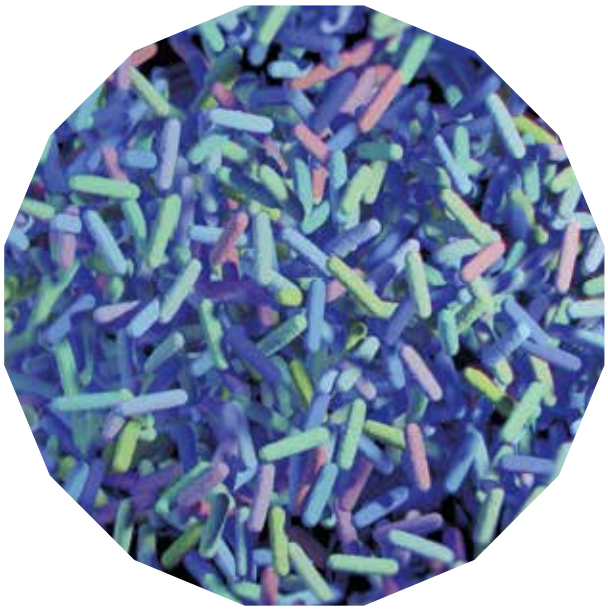
NOW YOU CAN SPRAY ON THE ANTENNA

With the development of the "Internet of Things", the number of interconnected objects has multiplied and so has the need for RF antennae to enable communication. As they are made of metal, these antennae are rather bulky for applications that are becoming increasingly miniaturised. The use of nanomaterials has been explored, but they are poor conductors. A research team from Drexel University in Philadelphia (USA) has just presented a new solution in Science Advances: RF antennae made of MXene (characterised by a metal like titanium or molybdenum bonded with carbides or nitrides). It is possible to dissolve MXene in water to create an "ink" that can be sprayed into any shape (see above). Once it's dry, this "ink" is ready to serve as an antenna as tiny as 100 nanometres (30 times finer than the smallest copper antenna currently used) which can even be transparent.

WORLD

LET'S CLEAN UP THE SPACE JUNKYARD

In late September, 300km above the Earth, the space clean-up started. The prototype of a one-cubic-metre garbage collecting satellite, aptly named RemoveDebris, projected a large net and successfully captured an object weighing a few kilos that it had released earlier. This complex space fishing exercise has proven the feasibility of such a technique. The mission, financed by the EU Commission, will also test a harpooning system. Over 100 million pieces of debris are orbiting at high speed above our planet: inactive satellites and entire launchers or their parts, various components and even paint or liquid particles. The risk of collision with satellites, spacecrafts or a space station will soon become intolerable according to specialists. Hence, a large number of "space clean-up" projects have been launched. |



MICROBIAL FLORA FIGHTING AGAINST OBESITY

Reducing caloric intake by 40% has a beneficial effect on the health of mice: their metabolism burns more fat, their blood sugar drops faster and they live longer. Scientists think they have identified the origin of these changes: intestinal bacteria. Their discovery has just been published in the journal Cell Metabolism. These researchers extracted intestinal microbes of mice subject to calorie reduction to transfer them into mice without microbial flora, which made them lose weight. They have also detected molecules that trigger the same effect and so enable the development of new treatments against obesity. There is enormous potential: according to the World Health Organisation, there were 1.9 billion overweight adults in the world in 2014, of which 600 million were obese. |

X MARKS THE SPOT

By Corine Fiechter

LEMO, inventor of the Push-Pull connector, is expanding its product range by adding, for the first time, a new series equipped with a bayonet coupling system, code name: X Series.

For optimum ruggedness, the locking pins of LEMO's bayonet coupled connectors are machined directly into the shell.

Internationally renowned for the high quality and reliability of its products, LEMO offers a wide range of circular Push-Pull and screw-coupling connectors. They are used in a large number of high-end applications, including military and motorsport, which traditionally would use bayonet coupling systems. It was exactly in response to requests from such customers, an Italian race car team in particular, that LEMO developed its new X Series.

As a first step, the X Series will be available with an aluminium shell in three sizes: XX, 0X and 1X, which have all been prototyped, field tested and laboratory validated. Before their release onto the market, planned for the first quarter of 2019, LEMO plan to complete even further testing and will expose the new range to "Gunfire" vibration, which is the benchmark in terms of testing the product's resistance to extreme shock and vibration. *"The X Series have been designed to offer the same characteristics as our M Series, the preferred connector for applications subject to extreme vibration"* specifies Noman Hashemi, in charge of the development of the X Series.

One of the first steps was to analyse which components from the existing product ranges could meet the specification requirements. Hence, the X Series have borrowed several features from the F and especially from the M Series connectors, which have already been widely used in motorsport applications. Therefore, the difference comes mainly from the usage patterns.

The principle of bayonet coupling is nothing new, since it has existed for over a century. However, LEMO goes further than most bayonet-type connectors that you'd come across on the market.

In order to ensure optimum ruggedness and durability, the locking pins that are normally inserted into the male connector are not separate items but machined directly into the shell. Moreover, in spite of their small size, all X Series connectors, including the smallest, are equipped with three pins instead of two.

"The XX reference of the X Series is probably one of the smallest in diameter of what you can find on the market." adds Noman Hashemi. *"This reduced diameter may represent a major advantage for certain applications and can make it possible for example to insert several connectors in a limited space."*

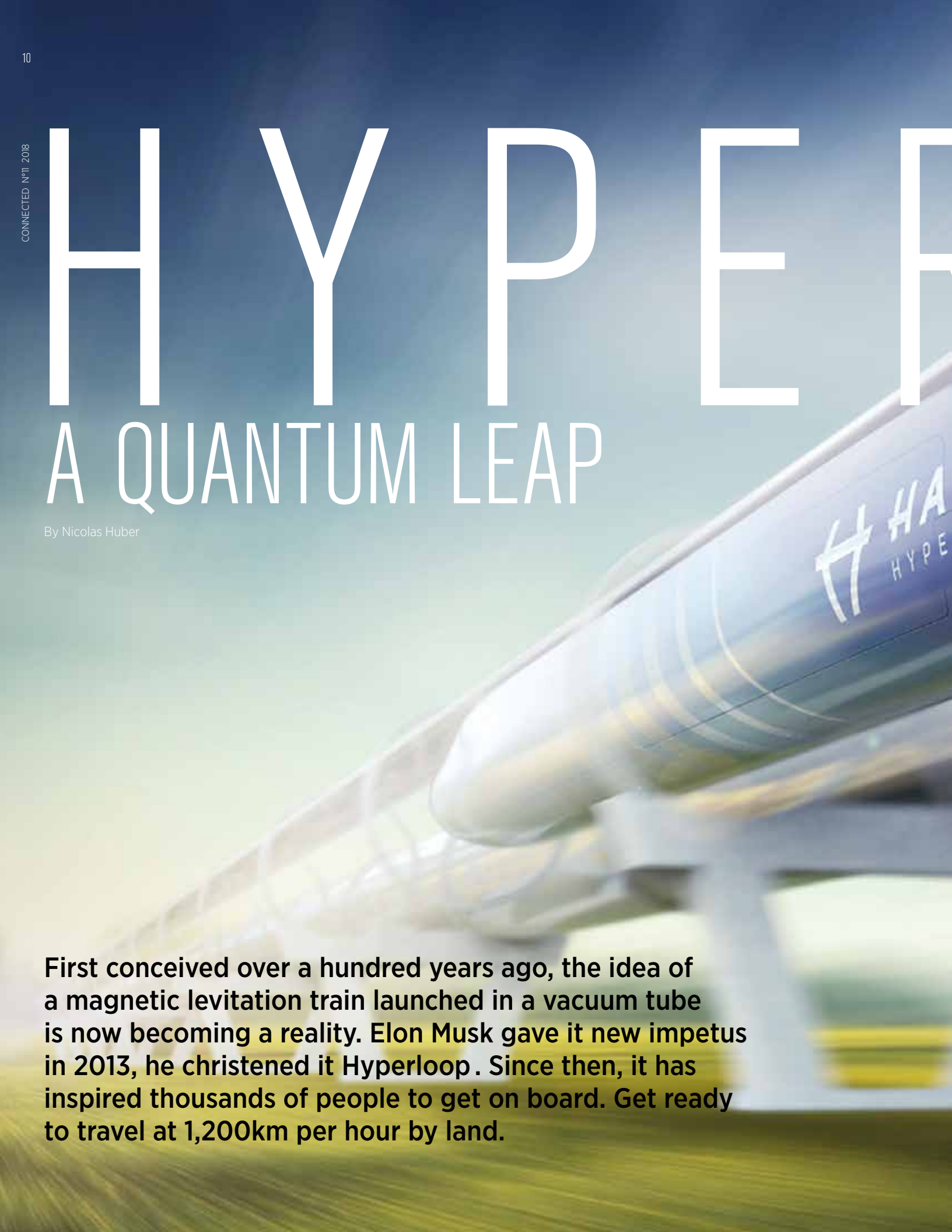
This small size is one of the greatest technical challenges taken up by LEMO. *"Unlike a Push-Pull connector, where the inner groove of the female counter-part is straight, the bayonet coupling system requires a helical groove, which is particularly complex to machine in such a small part. Therefore, our production teams had to develop specific tooling to create this helical groove on the inner surface of the machined part."*

Lightweight, compact, watertight, shock and fuel resistant, the first three sizes of the X Series have been designed in aluminium to meet the specific requirements of motorsport applications. All three are available in two types of finish: knurled for standard use and arctic grip for applications where gloves are worn. The X Series will be subsequently developed in further sizes and in other materials, such as stainless steel or brass, depending on customers' future needs. |

HYPER

A QUANTUM LEAP

By Nicolas Huber



First conceived over a hundred years ago, the idea of a magnetic levitation train launched in a vacuum tube is now becoming a reality. Elon Musk gave it new impetus in 2013, he christened it Hyperloop . Since then, it has inspired thousands of people to get on board. Get ready to travel at 1,200km per hour by land.

RLOOP IN TRANSPORTATION

▲ Like trains (and unlike airplanes), the Hyperloop system will take passengers right into city centres (shown above: a concept by HyperloopTT). ©HyperloopTT

◀◀ A number of companies and start-ups have embarked on Hyperloop, each with their own concept (shown on previous page: the Dutch Hardt Hyperloop). ©Hardt Hyperloop

It was around 2012 when Elon Musk almost choked upon learning about a traditional high-speed train project that California was looking to develop for 60 billion dollars. Too slow, too expensive, unworthy of a State that hosts the Silicon Valley. Elon Musk's teams set to work on a new project, borrowed and assembled already existing ideas and technologies and published a 60-page white paper in August 2013. This was Hyperloop Alpha, a system of pods on an air cushion (to avoid the friction generated from contact with the ground) transporting around twenty passengers, "flying" at 1,200km per hour in vacuum tubes (to avoid air resistance). This project would link Los Angeles and San Francisco (a little more than 600km apart) within only thirty minutes and it would cost 6 billion dollars.

Once he presented the idea, Musk announced that he would not have the time for it. He was going to focus on his other projects, namely Tesla and SpaceX. He filed no patent applications for the concept and called for "open source" development.

Innovation, like nature, abhors a vacuum, so others went for it. Start-ups were created to launch projects to take Elon Musk's incomplete proposal further.

Hyperloop One is one of the major players. Launched in 2014, they developed the technology and applied for dozens of patents. Richard Branson joined the Board of Directors in 2017 after forming an investment partnership with the company, which was then renamed as Virgin Hyperloop One. General Electric, the SNCF (French national railway company) and Dubai Ports World are also among the investors. Hyperloop projects have been planned in several countries around the world, namely in Dubai, the USA and England. In February 2018, India joined the race by signing an agreement for a demonstration line between Pune and Mumbai.

Hyperloop Transportation Technologies (HyperloopTT) is another big player. Based in Los Angeles, the company, founded in 2013, relies on an international collaborative network of hundreds of specialists. They have reportedly filed 27 patents, built R&D centres and launched several feasibility studies. They have projects in the USA, in France, in the Czech Republic and in several Asian countries, including China. Like Virgin Hyperloop One, they have already developed their test tube and pod.

Among the competitors, there are also Transpod in Canada, DGWHyperloop in India and Arrivo in the USA. For them, just like for all the others, the aim is to gather knowledge, along with millions of dollars of investments to fund the maximum number of experimental projects which pushed the boundaries. Hyperloop represents a quantum leap in transportation and a huge commercial opportunity should it become the technology of the future. Companies around the globe are already jostling for position to ensure they are ready to fully capitalise on this potentially multi-billion dollar race.

Hyperloop sparks the imagination as its speed alone has the potential to shrink the world.

A Hyperloop pod could be almost three times quicker than even the fastest of trains currently running (the Shanghai Maglev with its maximum speed of 431km per hour). As geographers and urbanists have observed, such speed would not really be useful for gaining time on shorter journeys (such as reduced commuting time), but mostly for travelling further afield. Hyperloop would place New York as little as 30 minutes from Washington. It would be perfectly possible to livein one city, to go to work 500km away and to be back home by supper time. Land development concepts would need to be completely rethought.

According to Elon Musk and others, the costs of building and operating Hyperloop would be lower than those of a modern railway network. This is a lot harder to calculate.

Passive magnetic levitation, as envisaged by Virgin Hyperloop One, would certainly save costs compared to classic maglevs. In fact, they require huge amounts of electricity to supply electromagnets set up along their route. With passive magnetic levitation, there are magnets permanently on the vehicle. As the trains move over conductive arrays, they generate the magnetic field that "carries" the pods – there is no need for electricity. Levitation, in addition to a vacuum created in the tubes, drastically reduces friction. The linear electric motor drives the train that "glides" with a minimum of loss. Energy would even be recovered during braking.

However, the biggest questions about the costs are related to infrastructure. Tunnels will have to be drilled or aerial structures built. Tubes have to be built and assembled. The tubes will also need to be vacuumed (which requires a lot of energy), airlocks need to be multiplied so that passengers can enter and exit without depressurising the tubes. Flawless maintenance must be provided over thousands of kilometres: tubes need to prove to be vacuum tight and tracks must be kept in perfect condition, so that wear does not jeopardize the system's efficiency, or safety.

Travelling onboard a Hyperloop pod is like climbing into a window-less rocket launched in a steel tube, like a bullet in a gun barrel. How comfortable would that be? What would happen if, at the speed of 1,200km per hour, the tube would be damaged or depressurised? If terrorists would blow up a section? How many G's would passengers experience in the event of an emergency braking? How would they come out of their pod and the tube to get back into the open air? There is plenty of cause for concern. The promoters of Hyperloop insist that it seems to be perfectly normal to travel in a steel tube launched at high speed – aka airplanes.

> Land development concepts would need to be completely rethought

As for all major infrastructures, the main constraints will neither be technology nor people's concerns. They will come from politics and administration. It is quite common for "simple" road, rail or air infrastructures to be subject to endless opposition or delays. Therefore, the development of an as yet non-existent means of transport, using new technology, with as yet unproven safety and maintenance costs may very well take years or even decades of standstill before obtaining all the authorisations, finetuning and complying with all the regulations.

For all these reasons, many people consider the Hyperloop system utopian and unfeasible. However, such doubts will not stop entrepreneurs like Richard Branson or Elon Musk. By the way, the latter has not stayed away from the Hyperloop project for too long. At the end of 2016, he announced the launch of

WHY ONLY 1200KM PER HOUR?

There is no traction thanks to magnetic levitation, no air resistance thanks to the vacuum, an electric engine capable of accelerating the pods to incredible speed. So, why put the limit of 1200km per hour? Simply because no one knows how the tube, the pod or passengers would react the moment they break through the sound barrier (1224km per hour). In the meantime, it is better to stay reasonable.

The Boring Company, an infrastructure and tunnel construction company, which was selected, in particular by the city of Chicago to build a high-speed rail connection to its O'Hare International Airport. Not an actual Hyperloop (no vacuum tubes), but enough to position itself on the market.

In parallel, Musk has also launched, via SpaceX, the Hyperloop Pod Competition, a student competition to design and build Hyperloop pods. The first round took place in January 2017. A Dutch team from Delft University won the first prize in engineering. The speed competition, using the mile-long vacuum tube built on the grounds of SpaceX in Hawthorne, California, was won by a German team from the University of Munich.

The second round took place in August 2017. Over 1,200 projects were submitted to SpaceX, who invited the 27 best on site. This time, the focus was on speed and the University of Munich won again with their prototype racing at 323km per hour.

The third round was held last July with even more interest: out of thousands of applications, 20 teams were invited to California with their prototypes (see our account on page 16).

For both SpaceX and the students, it's a win-win deal. Musk's company has an attentive technology monitoring service and can use the data collected during the week of the competition. The students hugely benefit from a great training programme, they are judged by the best rocket engineers and can test their prototype on an infrastructure of which there are only a few examples worldwide.

The competition has given rise to several start-ups founded by teams that had participated. For example, Delft University launched Hardt Global Mobility and is working on a Hyperloop tube project in Europe. The Spanish Universitat Politècnica de València is another example, who launched Zeleros dedicated to sustainable transport.

Whether too far-fetched or not, Elon Musk managed to boost technological advances to an amazing extent. Thanks to the passion and know-how of thousands of scientists, engineers and entrepreneurs who embarked on this "Hyperloop Movement", we will soon be able to travel like Jules Verne had imagined. |

A DEEP-ROOTED SCI-FI PROJECT

Elon Musk's initiative has rejuvenated a means of transport that has been envisaged for longer than you think: the vacuum tube train (vactrain), which in fact, could not have been imagined at all without the physics of vacuum to start with.

Otto von Guericke, was a 17th-century German scientist, inventor and politician, considered as the father of this field. He invented, in the early 1650's, the first vacuum pump which he used for studying vacuum properties, in particular the force of air pressure. In 1657 one of his experiments caused a sensation: Otto von Guerike machined two 50-cm copper hemispheres that he locked together with a vacuum seal. With the help of his pump, he created a vacuum of air between the two hemispheres. Eight horses harnessed to each side tried in vain to pull them apart: hence, vacuum force was demonstrated. Since then, man has often tried to make use of it.

Fast forward to the 19th-century, when one of its applications, parcel and message transport systems through pneumatic tubes, was flourishing: (some of them still exist). Since it worked, why not use it for transporting people as well? Pneumatic railways were then built in Paris and Dublin. In England, the London Pneumatic Despatch was large enough to accommodate passengers and the Duke of Buckingham climbed into it during its inauguration in 1865 (see illustration on page 4).

In 1889, French writer Jules Verne and his son imagined what could come next, in their short story "In the Year 2889" and made their characters travel by train at 1,600km per hour through pneumatic tubes laid on the ocean floor.

In 1910 Robert Goddard, an American rocket pioneer gave the science-fiction project a concrete form by developing the concept of a magnetic levitation train (maglev) travelling through a vacuum tube from New York to Boston in 12 minutes. However, the project never materialised.

During the second half of the 20th century, commercial maglev lines were indeed launched — only three of them — but not in vacuum tubes. Birmingham Maglev in England (operated between 1984 and 1995), the M- Bahn in Germany (between 1989 and 1991) and the Chinese Shanghai Transrapid (launched in 2004), the only high-speed maglev and the fastest commercial high-speed electric train in the world (431km per hour top speed).

Although never yet achieved, the idea of operating a maglev in a vacuum has been an ambition for some time. It was promoted by companies such as Rand (in the 1970s) and ET3 Global Alliance (since the late 1990s). In Switzerland, such a project — Swissmetro — was deemed unfeasible and abandoned in 2009, approximately ten years after it was launched.

The maglev/vacuum tube combination — proposed by Goddard almost 120 years ago — is the basic principle behind today's Hyperloop concept. Using trains travelling on an air cushion, as proposed by Elon Musk's team in 2013, was finally not adopted by the competing companies. |

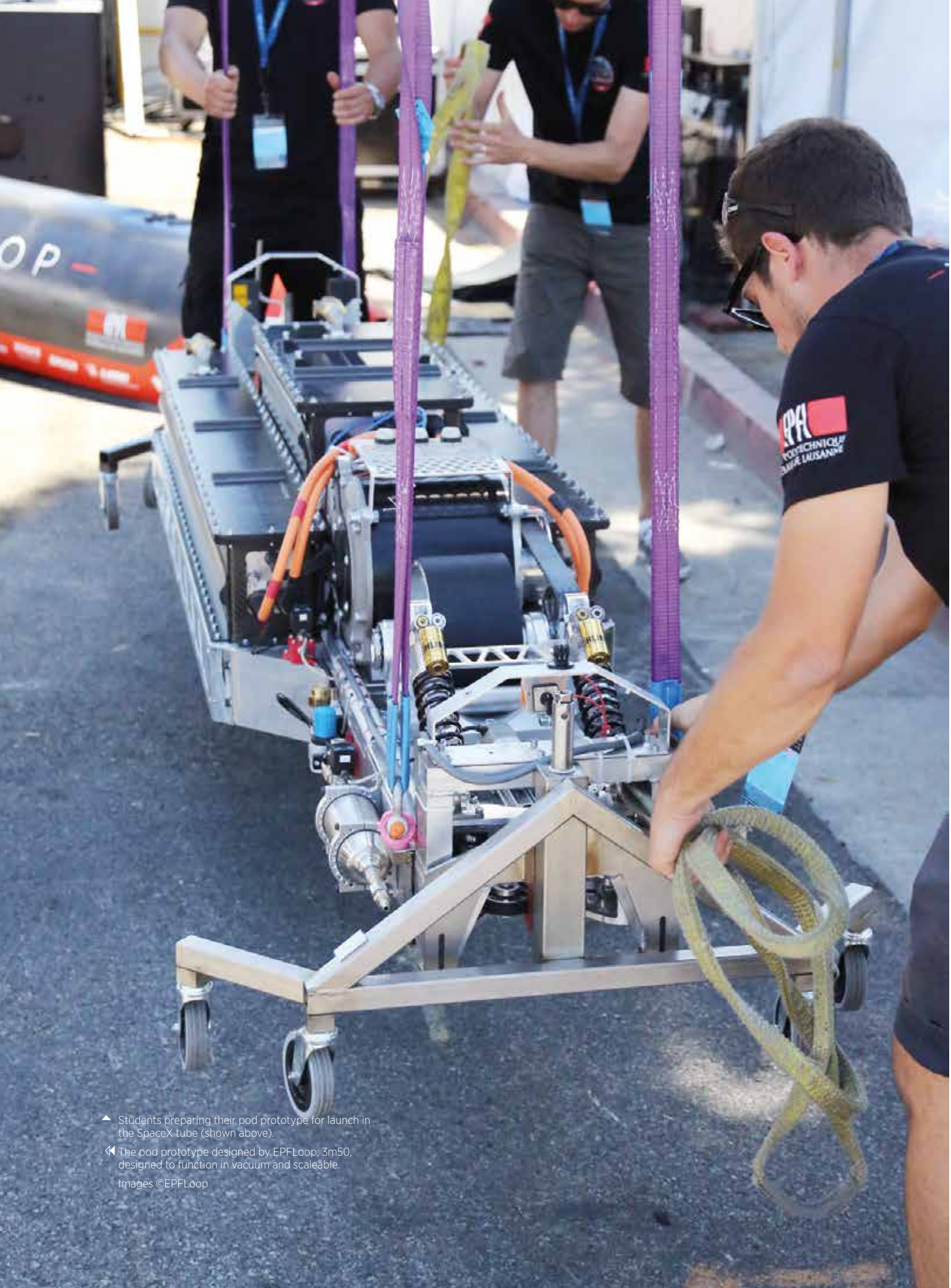
IN THE HEART OF ELON MUSK'S STUDENT COMPETITION

By the time they arrived at SpaceX's premises in Hawthorne (California) at the end of July, the EPFLoop team had already won an incredible technological race. In just a matter of months, the students designed and built the prototype of a pod that SpaceX engineers have selected among 18 others, out of the thousands of projects that they had received from all over the world.

The team leader is Denis Tudor, a 24-year-old Romanian PhD student in electrical engineering. He himself had already run in the Hyperloop Pod competition launched by Elon Musk, but with another team. For EPFLoop, the team set up by the Swiss Federal Institute of Technology in Lausanne (EPFL), this was a first. Around 50 students with various specialities (mechanics, aerodynamics, electronics, software, avionics) have participated in the project and 35 of them travelled to California.

The EPFL invested the necessary resources. The software was designed and tested (including a test with a 230kg flying motion wheel to imitate the pod's mass inertia). The propulsion system was tested on rails laid on the campus grounds. Unlike the "real" Hyperloop, the race does not use magnetic levitation — the SpaceX tube, which is only a mile long, is too short for accelerating in levitation. On the other hand, the vacuum is still present and the students have designed a pressure vessel to protect critical components that would not withstand the vacuum in the tube. *"Vacuum is THE major constraint for Hyperloop,"* emphasized Denis Tudor. *"A vacuum environment generates differential force problems. Without appropriate equipment, there is no chance."* (see "Vacuumtight M Series High Power connector" on page 19).

During the week before the speed competition, SpaceX engineers analyse and rate each project with great severity. *"They put a lot of pressure on you by asking a host of questions. They are some of the world's best rocket engineers. You must follow the procedures and*



▲ Students preparing their pod prototype for launch in the SpaceX tube (shown above).

⏮ The pod prototype designed by EPFLoop, 3m50, designed to function in vacuum and scaleable.

Images ©EPFLoop

Denis Tudor (the first person on the right) and the EPFLoop team presenting their battery pack to Elon Musk, initiator of the competition.

be extremely professional." EPFLoop's work made a great impression: the Swiss prototype neglected no detail and it was declared *"best engineered product"* which sealed their qualification for the speed competition on Sunday.

On Saturday evening, the three finalists were entitled to test runs over 300m of the tube. Launched at half power, the EPFLoop pod exceeded 200km per hour, which was very encouraging: it would be able to run much faster over the full length of the tube. Based on their calculations, the students confidently decided to increase the tensile force on the wheel by 30% and targeted 500km per hour. *"We knew what we were doing"* said Denis Tudor, who nevertheless had problems falling asleep that night.

On Sunday, the Dutch team from Delft University were the first to launch their pod. Due to engine problems, it couldn't exceed 120km per hour. Once the tube was depressurised and the pod removed, it was EPFLoop's turn to run. This was when Elon Musk himself suddenly showed up in person to have a chat with the Swiss students. *"He is not like he's presented by the media,"* says Denis Tudor. *"A really nice guy who's pretty straightforward. A businessman, who's technically very strong."*

After 40 minutes' discussion with the billionaire, the Swiss pod was prepared. The vacuum was applied and the systems verified. Off we go! After only 5m, the pod was already racing at 60km per hour. However, this breakneck acceleration melted the wheel's coating. The students had not been aware that the new wheel mounted the day before did not have the same coating as the one used for the test runs. It disintegrated and the wheel lost traction. The EPFLoop pod did not exceed 85km per hour and finished third in the speed competition. Recorded at a speed of 466km per hour, the German WAAR Hyperloop team from the University of Munich won the race, just as they had done twice before.

> "As fast as a plane, as convenient as a train"

Denis Tudor was disappointed, but not overly. His team got the official feedback from SpaceX by e-mail praising the very clean design, the incredibly well engineered product, the very good braking design, the thorough testing before competition. *"We can be very proud of ourselves!"*

For the young engineer, such a competition is a unique experience. *"Starting off with the design and carrying it through to the end is the best training for an engineer. Moreover, competition has always boosted innovation!"* He firmly believes in the feasibility of Hyperloop, a means of transport that he nicely describes as: "as fast as a plane, as convenient as a train". Investors may not get their money back before long. *"But we can only measure the benefits of such large-scale projects on the long term"*, he added. *"In any case, it will make technology progress. The journey matters even more than the destination."* |

VACUUMTIGHT M SERIES HIGH POWER CONNECTOR

When a prototype is designed with a view to winning a competition, each element can make all the difference. In April, EPFLoop did not have to think twice about where to find the best connector solution. The Swiss Federal Institute of Technology, Lausanne is only a stone's throw away from LEMO's global headquarters and the two institutions have been linked by many years of partnership.

The EPFLoop team needed a solution to connect the engine interface with the battery interface of their pod. The requirements were to carry high electric current (with a peak amperage of 600 amps) for about 15 seconds, not to heat by more than 30 degrees (to save battery power and to avoid damaging surrounding parts), withstand high acceleration and possible shock. Moreover, and obviously, it should perfectly function in the vacuum environment of SpaceX's hyperloop tube.

By a fortunate coincidence, LEMO's R&D were actually working on the development of the M Series High Power connector for motorsport applications (see CONNECTED 10). Powerful, lightweight, robust, all it needed was to be made vacuumtight to meet the students' specifications.

Given the tight schedule, Alex Patenaude, the engineer in charge of the project, went for the most pragmatic solution: he started with simple O-rings. The size and contact arrangement were adapted to this solution, which was less complicated and cheaper than the usual vacuumtight technique of epoxy resin potting. After fitting an O-ring on the contact and two on the socket outer shell, the tests could start running. The socket was mounted on the test equipment — low pressure was generated, helium sprayed around the connector and the quantity of helium that passed through the connector was measured. Great surprise: the results (1.2×10^{-8} mbar.l.s^{-1}) were fully in line with the LEMO standards for vacuumtight connectors. The engineer has taken an even further step by radially constraining the contact in its socket, in order to test such limit positions through new measurements. The socket stayed perfectly vacuumtight in spite of the constraints.

All that was left to do was to verify the heat-up of the connector. Alex Patenaude measured a modest 25-degree temperature rise at 400 amps, in ambient temperature or at 40°C.

Based on EPFLoop's extrapolation, the increase in temperature would still be perfectly manageable at the required 600 amps. There seemed to be no risks at all from this point of view, all looked just perfect.

LEMO assembled 16 pairs of connectors and supplied them to EPFLoop in May 2018, a mere two months after their initial request. At the end of July in California, the new connector raced through the hyperloop tube without a glitch. Elon Musk's competition was to be its testing campaign and EPFLoop its first user.

There will be other users: the vacuumtight option of the M Series High Power connectors will be available in several sizes and will be included in the LEMO product range. Few applications require a vacuumtight option — maybe some major research institutes with vacuumtight installations. However, vacuumtight also means waterproof and there are potentially quite a few applications which require high power AND weatherproof sockets: electric cars and scooters, vehicles, large drones... a bright future lies ahead of the M Series. |

▲ Solar car Zephyr logged 7000 miles since its first race in 2014. With it, CalSol has achieved back to back podium in Formula Sun Grand Prix 2017 and 2018.

▼ In order to accelerate battery recharge between two legs of the race, the cars are turned towards the sun.

Images ©CalSol Berkeley

THEY FOLLOW THE SUN

By Alexis Malalan

The CalSol team at the University of California, Berkeley have been successfully developing solar race cars since 1991. It has been an excellent springboard for both the promotion of renewable energies and the students.

©CalSol Berkeley

Many young people dream about building or repairing a car in their garage. The CalSol team members have pushed the idea much further by designing and building futuristic and ultra-sophisticated solar vehicles.

The team's primary objective is to compete in specialised races. Furthermore, CalSol is dedicated to inspiring interest in new technologies and new forms of mobility amongst future generations. They have received an extremely enthusiastic response from the public and the achievements of this group of around fifty students, most of them undergraduates, are closely followed by energy companies and car manufacturers. By the way, they don't hesitate to recruit future talents from CalSol, like Tesla who have employed more than one ex-team member. CalSol is a pioneer in the United Sates. In competition since 1991, the team has designed a total of eight generations of single-seaters in thirty years. Zephyr, the latest model was created in 2012 and has been enhanced and fine-tuned since then, to become one of the most reliable models in its category and even win the 2017 Formula Sun Grand Prix. Its average speed is 65 to 75km per hour, ensured by 4m^2 solar panels that generate 1.3kWh power, as well as by an auxiliary battery for climbing the steepest slopes

In order to guarantee such performance, efficiency is the key word. No detail is left to chance for optimising performance. In addition to the streamline which leaves ample space for photovoltaic sensors, wheel fairings were added for enhanced aerodynamics. They open up in every bend thanks to a retractable trap system. As for the electrical circuits, they were custom designed by the team — which is quite uncommon in the field and makes the vehicles unique.

Having proven itself at a number of Grand Prix races, Zephyr will be withdrawn from the circuits. A new exciting challenge awaits CalSol: to build Tachyon, a 4-passenger model.

This car will compete in the "Cruiser Class" against other 2+ seater solar vehicles. In addition to speed and efficiency, the judges are interested in other criteria as well, such as the practical aspects and passenger miles. Bigger, more powerful and equipped with a higher capacity battery, Tachyon is expected to run in upcoming competitions, including the prestigious World Solar Challenge in autumn 2019 in Australia. Another brilliant opportunity for CalSol students to push back the limits of technology.

LEMO has been offering connectors and technical support to the team since 2014.

"Currently, LEMO's connectors are being used for our steering wheel connection," explains Ray Altenberg, CalSol's Operations co-director. *"We have also used them for the connection between the top and bottom shell of our car. We began using these connectors around 2014, which was the start of our Zephyr car. We chose LEMO products since they provide high connector density and are low weight, but still are designed to be robust in high vibration environments. In particular, we liked the M-Connector for its small size and impressive robustness."* |

Composed of over 50 undergraduate students from a variety of disciplines, CalSol provides them with hands-on experience with real world engineering, project management and business aptitude, including during races.

Images ©CalSol Berkeley

LEMO A PARTNER IN WASHINGTON TOO

CalSol Berkeley is not the only university team sponsored by LEMO in the field of innovative car design. LEMO is also a partner to UWashington Formula Motorsports. This team won the overall third prize at the Formula SAE Electric 2018, an engineering design competition for undergraduate and graduate students held in Nebraska (USA) last spring. At this competition, electric vehicles are judged based on the overall package of design, construction, performance and cost. |

By Renzo Monti
Images ©Yves Rossy

THE FLYI SW

With his self-invented jet engine powered wings, Jetman has crossed the English Channel, flown over the Grand Canyon, soared through the skies of Rio de Janeiro and circled around Mount Fuji. Above all, he has fulfilled one of the oldest dreams of mankind, that of flying like a bird.

Jetman's wings can make him fly at 350km per hour and up to 5000m.

NG VISSMAN

On a perfect afternoon in August 2018, somewhere in the skies above Spain, Jetman was reaching the end of a perfectly controlled jet flight. At an altitude of 1,500m, he pushed the throttle down to slow the four jet engines under his carbon-fibre wings and left them idling to slowly cool down. He opened his parachute which deployed normally. Then, as usual, he slipped the small throttle control lever into the sleeve of his suit. However, when he lifted his arms to grasp the parachute handles, the elastic band of his sleeve got caught up in the control lever. All four jet engines restarted at full power. Jetman got projected upwards into his parachute and the hangers got entangled around the wings, making it impossible to eject his harness. Caught up in the canvas, he thought there was nothing more he could do.

The extraordinary story of Yves Rossy aka Jetman started like that of millions of children. Fascinated by everything that flies, he was passionate about airplanes and especially about military jets. In 1972, his father who had dreamt about becoming a pilot, but had to choose a safer career, took him to an air display by the Patrouille Suisse. As the Hawker Hunter MK 58 soared through the skies above the boy before disappearing behind the mountains only seconds later, the thirteen-year-old Yves Rossy became overwhelmed by emotion. *"It was so beautiful and powerful! I discovered a three-dimensional world and that we could go high up."* There and then he decided *"I will be a jet pilot"*.

His passion gave him wings. He learnt to become a mechanic after graduating from technical high school. When he enrolled in the military, he managed to get selected into the top 1% candidates to enter the Swiss Air Force pilot school. A certified pilot at 21, he became a military pilot and started by taking control of Pilatus P-2 and PC-7 propeller-driven aircraft.

▲ Jetman became famous all over the world, in particular through air demonstrations with various aircraft (shown above with L-39 Albatros).

Yves Rossy, civilian and military pilot, has always dreamt of flying without a plane.

He then started flying jets: first the de Havilland Vampire and Venom. Then he learnt to fly the Hawker Hunter, the ones he got ecstatic about at thirteen and which he has carried on flying all his life. Finally, he discovered the Northrop F-5 Tiger and the Dassault Mirage III, his favourite jet, with which he has accomplished over 1000 flight hours. These were decisive experiences: *"These aircraft are very demanding for the pilot. Without sophisticated electronics nor flight control assistance, you learn to become responsible for your life."*

Since Switzerland has a militia army, Yves Rossy started a parallel career as a commercial airline pilot. *"I used to fly Boeing 747. I would fly to Bombay, then 2 or 3 days in Hong Kong, then back to Zurich. I flew across the world, had afternoon tea in one country and supper in another."* However, he ended up getting bored with this luxury routine. *"I needed to create something. As a mechanic, I have always loved to see a piece of rusty metal turn into something functional, such as an aircraft component."* In his free time, he enjoyed hang-gliding. He later discovered free fall: a new revelation.

When a child plays "airplane" he opens his arms like wings and runs leaning from side to side. He doesn't control any aircraft, he IS the aircraft. This is how Yves Rossy wanted to fly. *"I had tried all the existing solutions to fly, but I was frustrated, because there were controls to be operated and it was the machine that would carry me. What I really wanted was to manoeuvre my body, like a child, like a bird. Like in a dream."*

Free fall enables him to sail by using air resistance on his hands and to move forward with his own body, like he wanted. *"Pure flight at last! I got closer to my dreams. However, even if you get the impression of flying, you are actually falling and it's very short."* Jetman was about to be born. He tried skysurfing at first, but *"standing on a wing, which is totally unnatural"* didn't give him the ultimate flying sensation he was looking for.

He realised that he had to invent the solution for himself and develop a harness that would enable him to fix himself under the wing. *"I've tried various wings since the early nineties and they worked out better and better. I jumped from an airplane and flew with my body, like a bird!"* In 1999 he designed an inflatable wing which made it possible to spend more time in the air. *"But in order to move further, I needed to be propelled by something."*

Soon enough, Yves Rossy discovered scale model jet engines. He first fitted two of them onto his new lightweight and resistant carbon fibre wing and managed to fly horizontally. He then started using four much more powerful target drone engines and his performance grew immensely! A tank full of kerosene enabled him to fly for ten minutes and to soar as high up as 5,000 metres at a speed of 350km per hour. His wings are ejectable and fitted with its own parachute to enable it to land safely.

In 2008, he became famous after crossing the English Channel, a classic feat of aviation pioneers. In the following years, his equipment kept evolving. For the airdrop, the plane was replaced by a helicopter. His invention is simple: four jet engines under a pair of carbon fibre wings, but original and safe, since no accident has happened in over twenty years.

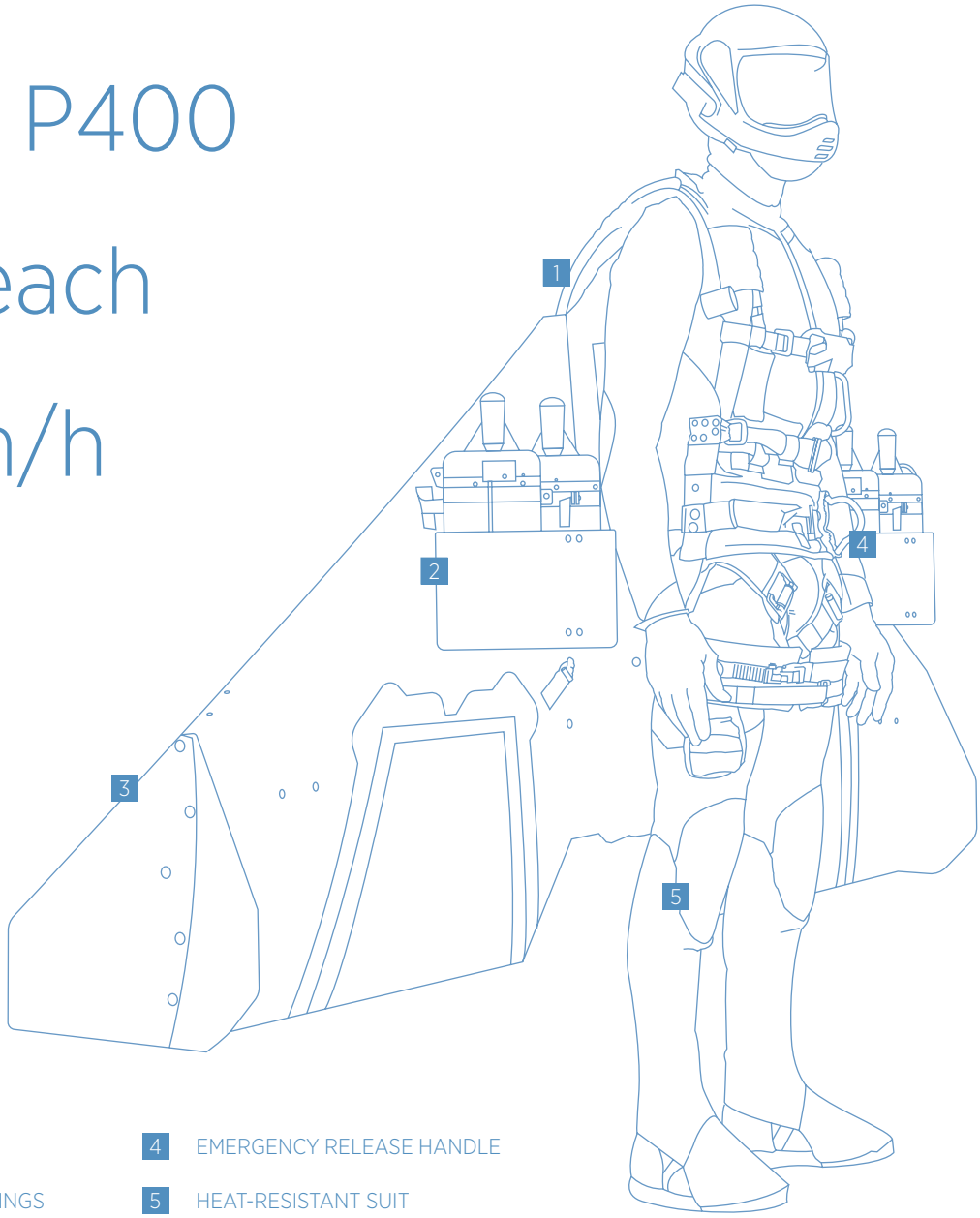
ENGINE TYPE
JetCat P400

ENGINE THRUST
22kg/each

MAX SPEED
350km/h

TOTAL WEIGHT
150kg

WINGSPAN
2.4m



1 PARACHUTE

2 ENGINES

3 CARBON-KEVLAR WINGS

4 EMERGENCY RELEASE HANDLE

5 HEAT-RESISTANT SUIT

However, in this mid-August afternoon, in the skies above Spain, things didn't happen as planned. In a fraction of a second, Jetman understood that he could do nothing but wait for the fall to end. This was when a parachute cord got drawn in by one of the engines and blocked it, which resulted in the automatic stop of the opposite engine. This made Yves Rossy, suspended from the parachute, start whirling down. Two of the engines still being active, he was spun at high speed. At this point, his hand got hold of the ejection handle. By reflex, he pulled it and the harness and wing passed miraculously between the hangers. Even the wing parachute opened normally. Out of pure luck, this wasn't going to be Jetman's last flight. The whole episode took less than 7 seconds.

Today, Yves Rossy has thought over all his procedures and developed his activities. He has been training other "Jetmen" and has been trying to transmit the essence of what has made him hold on: *"The eagerness to use time, which is the luxury of modern man and technology, another luxury, to do great things. To make dreams come true"*. He also passes on what he learnt from his recent experience: *"For the first time since I have been flying, I survived only by chance. As it happens, I was going through difficult times and this small obscure spot in my mind almost killed me. Never forget that man was not made to fly. This is a wonderful success story, but also an act of folly. Whenever we have a doubt or a problem in life, we must not go out until we are back to normal."* His new challenge is not to go up higher, nor faster. He has been working on ground-launched flight with his apprentices and he is developing new equipment, fully packed with LEMO connectors, to improve safety and radio communication between flying men. Now it should become possible to take off and land alone, without the help of a helicopter and without a parachute to land. Only then will Jetman fully make his dream come true. |

QUANTUM OFFERS PATIENT SOLACE

By
Sheena Kennedy

Spectrum Medical began its journey into innovation in 2006. Since then, it has been improving medical technologies and using the best quality components. One key product line — Quantum Perfusion Technologies — exemplifies this.

Modular, Quantum includes a range of devices, software and equipment. ©Spectrum Medical.

The Quantum line integrates perfusion technologies and patient safety systems for a range of clinical therapies that use extracorporeal circulation for patient support. These systems are vital to keeping patients stable during procedures by monitoring and supporting certain organ functions.

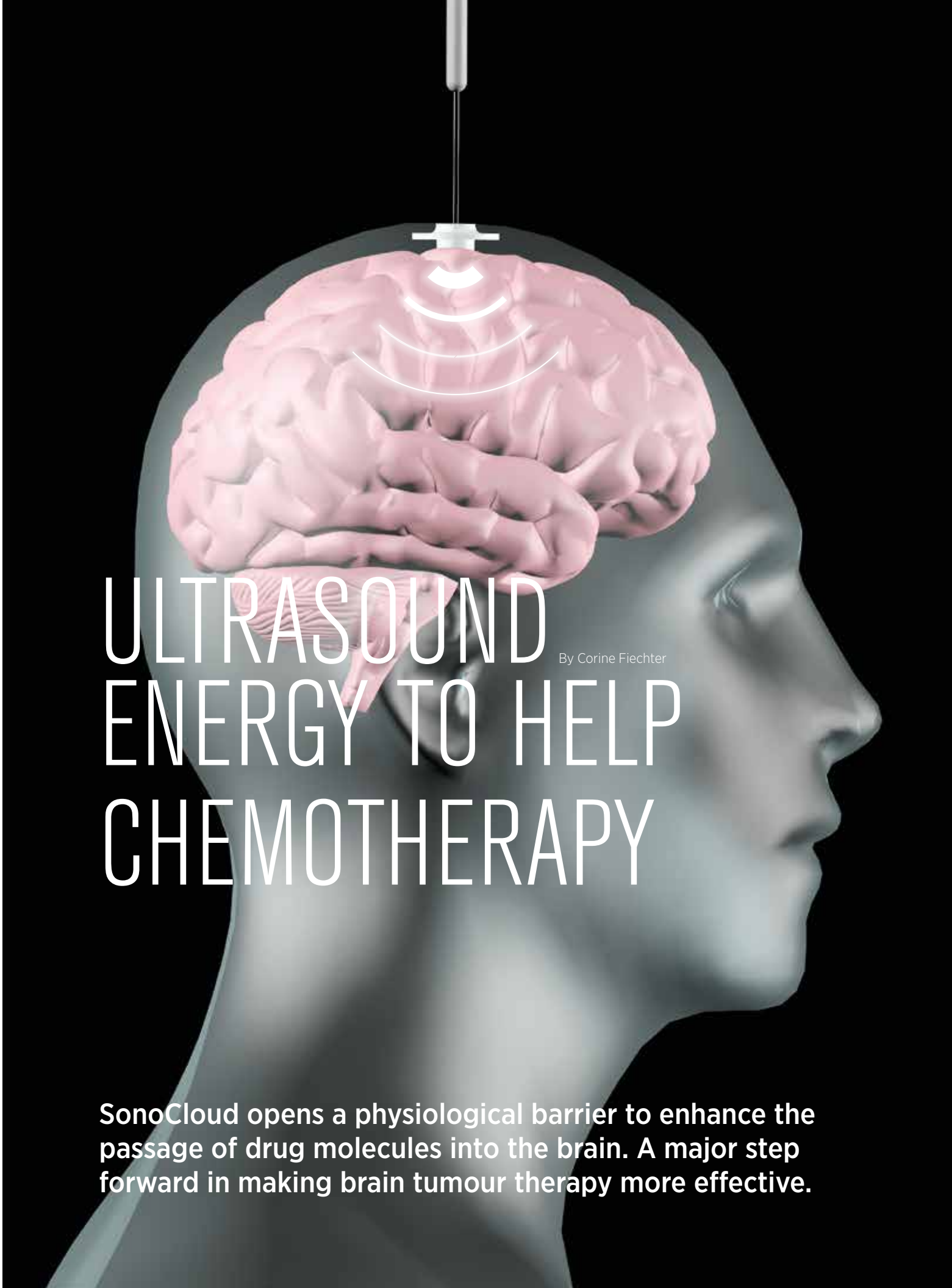
For example, during cardiopulmonary bypass surgery, a surgeon needs a bloodless and motionless field. This is achieved by a perfusionist operating an extracorporeal system — a heart-lung machine in this case — that temporarily takes over the functions of the heart and lungs.

Quantum Perfusion Technologies include a range of devices, software and equipment to support this. The system is modular so end-users can select components to integrate with their existing equipment or compose an entire system to suit their needs.

These systems, of course, need cutting-edge technology to enable clinicians to provide optimal patient care. In terms of construction, they also need to be safe and suitable for a medical environment, physically robust, and ergonomically efficient. LEMO connectors fit these requirements and many different types are used in the various components. Spectrum explains that LEMO advantages include high configurability, strong Push-Pull latching, and a rating for 5,000+ insertions, supporting their 10-year overall equipment lifespan.

They are used, for example, in the Workstation, which is the primary interface for the Quantum Management System and a key element for patient safety. It centralises critical patient data through integrated software, such as blood flow management, patient ventilation and vitals management. You'll also find LEMOs in the flow pressure level sensor of the Quantum Ventilation System, a novel solution for managing extracorporeal patient ventilation. The Quantum Pump Console's support frame contains numerous connectors within the accessory ports, and all power management cabling is built within the frame for ergonomics and durability.

When using the system, you can bet that the medical team is not thinking about the LEMO connectors that are found throughout — a good thing for patients! But if the team is free to focus on patients, it is because the equipment is designed to not let them down. This includes the reliability, flexibility and overall performance of the connectors that Spectrum engineers have been known to call, *"the Rolls Royce of connectors."* |



ULTRASOUND ENERGY TO HELP CHEMOTHERAPY

By Corine Fiechter

SonoCloud opens a physiological barrier to enhance the passage of drug molecules into the brain. A major step forward in making brain tumour therapy more effective.

The transcutaneous delivery needle and the SonoCloud device.

Fixed to the skull, the implant — activated externally — makes ultrasound pass directly into the brain.

Images ©CarThera

Gliomas, glioblastomas, astrocytomas... many different types of primary or secondary brain tumours are affecting over 250,000 people every year in Europe and the USA.

The effectiveness of treatments is still rather low, since chemotherapy penetrates the brain to a very limited extent only. This is due to the blood-brain barrier, a natural barrier preventing substances present in the blood from passing into the brain.

The French start-up CarThera has tackled the problem. It's implantable SonoCloud device, fixed to the skull, emits ultrasound that temporarily opens the blood-brain barrier, which makes intra-cranial vessels more permeable to chemotherapy.

SonoCloud is activated during chemotherapy sessions with the help of a transdermal delivery needle linked to an external generator (equipped with a LEMO solution). The emitted ultrasound, with no bone obstacle to break through, passes directly into the brain and opens the blood-brain barrier. Drug molecules (administered intravenously) can then pass through the barrier in the targeted area and penetrate the brain more efficiently.

For the first time, it is possible to open the barrier upon request, repeatedly and in ambulatory care.

It is not even necessary to open the skull expressly to implant SonoCloud. A biopsy, or the surgical removal of a brain tumour requiring such an opening, can be the perfect opportunity to implant SonoCloud instead of replacing the bone flap or filling the drill hole.

Furthermore, brain tumours being diffuse, CarThera has aimed at creating the largest possible opening in the blood-brain barrier. Thanks to this technique it is possible to attain previously inaccessible tumour infiltration areas.

This major innovation is the result of Prof. Alexandre Carpentier's research. This neurosurgeon and researcher is also the founder of CarThera and the chairman of its scientific board, since its creation in 2010.

The start-up works in close cooperation with the French Brain and Spinal Institute of the Pitié-Salpétrière Hospital in Paris. It is endorsed by an expert committee of neurosurgeons and neurological oncologists from prestigious French and American hospitals.

Many challenges had to be met, miniaturisation to start with. SonoCloud had to be biocompatible and absolutely safe for the patients. It also had to be able to withstand MRI (inevitable in brain medicine) but not interfere with its images. This is why its supply generator is external.

Currently in the clinical study phase, focusing on the glioblastoma (the most common brain tumour), SonoCloud opens the way to broader applications in the treatment of neurological or neurodegenerative diseases, such as Alzheimer's. It should be released for sale by 2021 or 2022. For many patients, it will mean gaining precious months to live. |

1 Garret Brown operating his invention, the Steadicam, early on. Here with director of photography Haskell Wexler on the shooting of "Bound to Glory" (image 1). With Sylvester Stallone on "Rocky" (images 2 and 3). With special-effects supervisor Dennis Muren on "The Return of the Jedi" (image 4). Images ©Tiffen

2

3

4

IMPOSSIBLE SHOTS IN IMPOSSIBLE PLACES

By Sheena Kennedy

People who watch the credits at the end of movies will know. There's an Academy Award winner that has been on the set of virtually every major picture produced in the last 42 years. With good reason: Steadicam revolutionised movies by "making impossible shots possible".

A Steadicam is a camera stabiliser that is used by at least one specially-trained camera operator on nearly all films. It was invented in the mid-seventies by Garrett Brown and its first big screen roles came in 1976 in the movies Bound for Glory, Marathon Man and Rocky.

While there are today a few other camera stabilisers on the market, Steadicam is still considered the gold standard. Since 2000, the brand has been owned and manufactured by the Tiffen Company. Tiffen, which is celebrating its 80th birthday, is a leading manufacturer of imaging accessories for consumer/professional imaging, motion pictures and broadcast television. From manufacturing lens barrels for camera companies, to developing their proprietary process for camera filters, to the Steadicam, their offer evolves to meet real-life needs. They hold numerous patents and have won awards including several Oscars and Emmy Awards.

A professional Steadicam operator wears a harness or vest connected to a pivot system and weighted armature that the camera is mounted on. The counterweight keeps the centre of gravity at the operator's hand level, stabilising the image. The viewer gets a perspective much like real life — stable, but moving.

Tiffen continually innovates to improve Steadicams — with the inspiration often coming from clients. *"They'll come in and show me how they're using it in the field. Sometimes, for example, they'd come up with a makeshift idea for their Steadicam vest, and that will set us to work on a new accessory,"* says Robert Orf, Tiffen's Engineering Manager, from his office in Burbank, California.

Garrett Brown is also still involved in every Steadicam design. *"We're in touch almost weekly,"* says Orf. *"He'll come in with a design literally scribbled on a napkin and it will be my job to transform that, engineer it into a new product. I love the inventiveness of it all."*

Steadicams now come in all sizes to fit a wide variety of needs from smartphone and GoPro videos to live TV broadcasting to major motion pictures. Unsurprisingly, costs range greatly — from just over $100 for handheld consumer models to several tens of thousands for professional equipment.

▲ Steadicam Volt to stabilise Smartphone or GoPro images. ©Tiffen

"A great development we've recently introduced to the Steadicam is to augment the mechanics with electronic technology for horizon stabilisation," says Orf. *"This avoids a pendulum effect that the operator previously had to compensate for. It frees them to focus on the framing, the narrative and the navigation. We first did this with our Volt handheld systems for smartphones. Volt Systems are available as of this year for professional-sized rigs. Garrett Brown has called this the biggest advancement since the Steadicam's invention."*

▲ The M-1 Steadicam is completed with an "exovest" and a lever-arm supporting the system, as well as a Volt System, a tool that provides operators with horizontal stabilisation.

Orf says that using LEMO cables and connectors follows the approach they take to the Steadicam's hardware in general: it's got to be robust, it's got to be reliable. *"Steadicams are used in extreme conditions,"* he explains. *"Literally everything from arctic conditions to deserts to rainforests, not to mention things like pyrotechnics. More than once, you've only got one chance to make that shot, so you can't lose it because a cable or connector gave out."*

It's not just the elements that put the connectors to the test. *"Our users will push this equipment to the limits and beyond,"* says Orf. *"So we make sure it can go beyond limits."*

For Orf, constantly improving the Steadicam's robustness, technical capacity and ease of use comes down to one thing. *"Storytelling,"* he says. *"With evermore flexible Steadicams, we expand possibilities, so cinematographers and amateurs alike can tell great stories."* |

LOOKING FURTHER OUT INTO **SPACE** AND **TIME**

By Alexis Malalan

The Thirty Meter Telescope, which should be operational by the end of the next decade, will help us see further into the history of the universe and look for signs of life beyond Earth. The scope of the project, like its mirror, is truly gigantic.

Thirty metres: as its name suggests, is the diameter of the Thirty Meter Telescope (TMT). Until now, the largest ground-based telescopes were limited to ten metres. Together with two other similar programmes currently being developed, the TMT heralds the next generation of even more powerful telescopes.

The project was initiated by two legendary institutions in the history of astronomy, the California Institute of Technology in Pasadena and the University of California, joined by institutes and agencies from four nations: India, China, Japan and Canada, as well as the Gordon and Betty Moore Foundation (created by the co-founder of Intel).

The TMT is a reflecting telescope: stellar light is captured by its primary parabolic mirror. By reflection, it is focused on a secondary stationary mirror, then on a tertiary 3.5 × 2.5-metre mirror that can be directed into various state-of-the-art instruments, such as spectrometers, which carry out the measurements.

As far as reflecting telescopes are concerned, size matters.

At 30 metres, TMT's collecting area is 9 times larger than that of the 10-metre model and its resolution more than 12 times greater than the Hubble Space Telescope.

TMT should make it possible for researchers to see even further than today, almost to the beginning of time, 14 billion years ago. With the help of the TMT, scientists hope to shed light on new facets of the history of our galaxies. They also look forward to learning more about exoplanets — planets located outside the solar system — and perhaps even find an answer to THE question: is there life beyond Earth?

For sure, the idea of a reflecting telescope is nothing new (its invention is often attributed to Sir Isaac Newton himself). However, such a 30-metre primary mirror has never been created before.

It would have been impossible to produce such a gigantic mirror in a single block, for both cost and logistics reasons. Based on the method already successfully tested at the W. M. Keck observatory in Hawaii, scientists thought they would fragment it into 492 hexagonal segments. This approach is both practical and economical, even though manufacturing such segments is rather delicate and takes all together no less than 5 years! In fact, each piece has to be initially polished, cut, mounted on a specific support and finally polished again by ion beams to ensure perfect reflection quality.

The construction of the primary mirror is well under way. However, it will take another decade before the TMT will be fully operational. The site of the observatory has not yet been confirmed: the initial choice of a mountain in Hawaii has been delayed by legal challenges to the process required for TMT to have permission to build. Hawaii remains the preferred option, but the observatory may end up being installed in La Palma on the Canary Islands (Spain). It will definitely be worth the wait, for the project is extremely promising! |

A QUEST FOR MAXIMUM RELIABILITY

It doesn't happen very often that a single installation is equipped with 10,332 LEMO connectors! This is indeed the case of TMT. The LEMO connectors are used for the TMT Primary Mirror Warping Harness system, whose primary function is to correct residual errors from the polishing and Ion Beam Figuring processes, as well as small installation errors. It will also compensate for the potential gravity induced errors (when the TMT's namesake mirror is tilted, its weight can induce local deformations). To correct these deformations, the warping harness situated underneath the mirror will be actuated by a control system developed by JPL. This control system allows scientists to compensate for known aberrations with nanometre precision. The warping harness will be remotely controlled and readjusted periodically (not continuously), allowing automated corrections of quasi-static and temperature-induced effects, up to 10 times per night. The number of connectors required and the 50-year lifetime requirement made reliability the key necessity. LEMO's solutions satisfy TMT's stringent requirements. The availability of the PC Board mounted options (EPG and EZG) were also important for the TMT project. |

2008

GROWTH SPURT FOR LEMO 5

By Brigitte Rebetez

Exactly 10 years ago, the LEMO 5 factory was extended to its current size. The company plays a crucial role in the LEMO galaxy, producing a significant amount of the brass components for its connectors.

43 years ago, outside of its headquarters, LEMO had only four locations in the world. So, when the fifth was opened in 1975, it was simply baptised LEMO 5. Its location was not chosen at random. The town of Delémont, nestling in the heart of the Swiss Jura, a mountain region of peaks and valleys, is the Swiss capital of screw-machining, and also the cradle of the world-renowned Swiss watchmaking and micromechanics industries.

Since the 19th century, the region has been home to technical schools that provide the specialist manufacturing training needed for the micromechanics and watchmaking industries. By setting up its factory in this area, LEMO got better access to the skilled labour required for its activities. *"More or less the same machine tools are used in screw-machining and watchmaking. They are high-performing and capable of working on a very small scale"* says Gérard Maret, LEMO 5's director.

For over forty years, the company has been manufacturing components for LEMO connectors. The smallest measure only 0.7mm in diameter, the largest 32mm. To give an idea of the quantities, the factory produces 470,000 hours of machines parts per year, almost 2,000 per day.

In addition to the wide choice of standard parts used across LEMO's connector ranges, LEMO 5 staff work on 220 studies and prototypes every year. Manufacturing processes, specialist tooling, new machines and raw materials, launching pre-series... for new, high-performing products, research and experimental phases are absolutely necessary.

"We produce test components which are then evaluated by the LEMO R&D department. For every new series, we validate the process. The aim is to make sure that the criteria can be fulfilled in a cost-effective way. It is fundamental to have the capacity to innovate" says Gérard Maret. *"We are continuously improving in order to meet customer requirements. We must be agile and efficient. It is not enough to only think in-house and implement improvements accordingly. Three years ago, we updated all manufacturing processes to comply with the ISO 9001/2015 certification. In order to remain at the cutting-edge of innovation, we also need to renew production tools constantly. Every year, we modernize our machine park. Through these substantial investments, we can keep up with a highly competitive market."* As summarized by Gérard Maret: *"In order to stay competitive, we need to keep training and investing consistently. The two go hand in hand!"*

PUTTING PEOPLE AT THE CENTRE

LEMO gives special attention to the human aspect of its organisation. LEMO 5's human resources department strives to be proactive. *"We ensure that our staff are motivated, empowered and well trained. With the right skills and a high level of knowledge, we will be able to face tomorrow's challenges."*

The company invests significant resources in training its 235 employees continuously, in order to further develop their skills and know-how. LEMO 5 has recently installed a training centre for apprentice mechanics and polymechanics (a 4-year programme), as well as for improving employee know-how through continuous training. This training area has its own machine park and a certified instructor.

These last years, LEMO 5 has made significant investment in workplace health and safety promotion, in order to reduce the risk of accidents and to improve working conditions and the well-being of employees. Safety standards have been reinforced at every production stage and all employees have been specifically trained to learn how to apply such standards on a daily basis.

In the end, this is all for the benefit of the finished product. LEMO 5 are able to demonstrate that the more ergonomic the workplace is, the better it is for the quality of work. Hence, LEMO 5 is well prepared to meet the challenges of the future. |

LEMO 5 IN 5 FIGURES

45
employees upon its creation

235
employees today

1999
year of the first extension

2008
year of the second extension

9000m^2
current surface area


REBELLION
RACING
FIA WORLD ENDURANCE CHAMPIONSHIP

BAYONET COUPLING. REDEFINED.

LEMO

LEMO'S BRAND-NEW X SERIES CONNECTOR

Our first connectors equipped with a bayonet coupling system are like no other.
Lightweight, compact, watertight, shock and fuel resistant,
they are ready for your most demanding motorsport applications.

essencedesign.com

HEADQUARTERS

SWITZERLAND
LEMO S.A.
Tel: (+41 21) 695 16 00
info@lemo.com

SUBSIDIARIES

AUSTRIA
LEMO ELEKTRONIK GESMBH
Tel: (+43 1) 914 23 20 0
sales@lemo.at

BRAZIL
LEMO LATIN AMERICA LTDA
Tel: (+55 19) 3579 8780
info-la@lemo.com

CANADA
LEMO CANADA INC
Tel: (+1 905) 889 56 78
info-canada@lemo.com

CHINA / HONG KONG
LEMO ELECTRONICS
(SHANGHAI) CO.LTD
Tel: (+86 21) 5899 7721
cn.sales@lemo.com

DENMARK
LEMO DENMARK A/S
Tel: (+45) 45 20 44 00
info-dk@lemo.com

FRANCE
LEMO FRANCE SÀRL
Tel: (+33 1) 60 94 60 94
info-fr@lemo.com

GERMANY
LEMO ELEKTRONIK GMBH
Tel: (+49 89) 42 77 03
info@lemo.de

HUNGARY
REDEL ELEKTRONIKA KFT
Tel: (+36 1) 421 47 10
info-hu@lemo.com

ITALY
LEMO ITALIA SRL
Tel: (+39 02) 66 71 10 46
sales.it@lemo.com

JAPAN
LEMO JAPAN LTD
Tel: (+81 3) 54 46 55 10
lemoinfo@lemo.co.jp

NETHERLANDS / BELGIUM
LEMO CONNECTORS BENELUX
Tel: (+31) 251 25 78 20
info@lemo.nl

NORWAY / ICELAND
LEMO NORWAY A/S
Tel: (+47) 22 91 70 40
info-no@lemo.com

SINGAPORE
LEMO ASIA PTE LTD
Tel: (+65) 6476 0672
sg.sales@lemo.com

SPAIN / PORTUGAL
IBERLEMO SAU
Tel: (+34 93) 860 44 20
info-es@lemo.com

SWEDEN / FINLAND
LEMO NORDIC AB
Tel: (+46 8) 635 60 60
info-se@lemo.com

SWITZERLAND
LEMO VERKAUF AG
Tel: (+41 41) 790 49 40
ch.sales@lemo.com

UNITED ARAB EMIRATES
LEMO MIDDLE EAST
info-me@lemo.com
Tel: (+971) 4 454 9833

UNITED KINGDOM
LEMO UK LTD
Tel: (+44 1903) 23 45 43
lemouk@lemo.com

USA
LEMO USA INC
Tel: (+1 707) 578 88 11
info-us@lemo.com

NORTHWIRE INC
Tel: (+1 715) 294 21 21
cableinfo@northwire.com

DISTRIBUTORS

AUSTRALIA
JOHN BARRY GROUP PTY. LTD
Tel: (+61 2) 93 55 23 80
lemo@johnbarry.com.au

CHILE
3GT LAB ST
Tel: (+56) 2 2235 08 35
contacto@3gt.cl

CZECH REPUBLIC
MECHATRONIC SPOL. S.R.O.
Tel: (+420 2) 679 13973
mechatronic@volny.cz

GREECE
CALAVITIS S.A.
Tel: (+30 210) 7248 144
technical@calavitis.gr

INDIA
PT INSTRUMENTS PVT. LTD
Tel: (+91 22) 2925 13 53
ptinst@vsnl.com

ISRAEL
AVDOR TECHNOLOGY LTD
Tel: (+972 3) 952 02 22
sales@avdor.com

NEW ZEALAND
CONNECTOR SYSTEMS
HOLDINGS Ltd
Tel: (+64 9) 580 28 00
sales@connectorsystems.co.nz

POLAND
SEMICON
Tel: (+48) 22 615 64 31
info@semicon.com.pl

RUSSIA
SCS
Tel: (+7 495) 223-4638
(+7 495) 997-6067
info@lemo.ru

SOUTH AFRICA
JAYCOR INTERNATIONAL
(PTY) LTD
Tel: (+27) 11 444 1039
jeff@jaycor.co.za

SOUTH KOREA
SUNG SHIN I&C CO., LTD
Tel: (+82 2) 2026 8350
mail@sung-shin.com

TAIWAN
EVERHARMONY ENTERPRISE INC
Tel: (+886 2) 27 07 00 69
ever.harmony@msa.hinet.net

TURKEY
MAK SAVUNMA LTD STI
Tel: (+90 312) 256 16 06
sales@maksavunma.com

UKRAINE
U.B.I.
Tel: (+380 44) 568-5765
info@lemo.ua

CONNECTED ONLINE

LEMO®

www.lemo.com

info@lemo.com