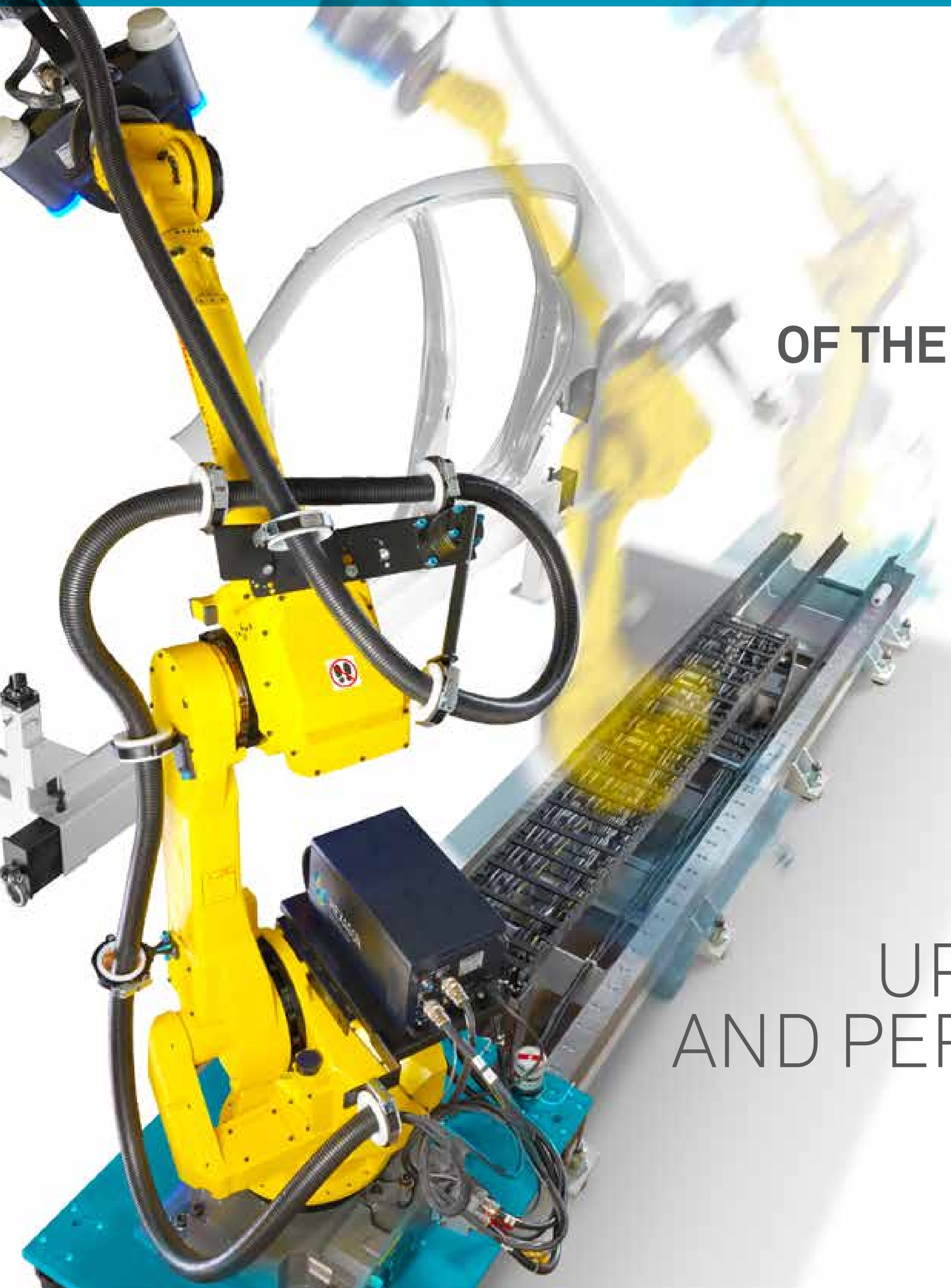
Our partner's landspeed record
PAGE 8

Automation on tour
PAGE 12

HxGN LIVE 2013 Have you registered?
PAGE 19

MEASUREUP

HEXAGON METROLOGY MAGAZINE | EDITION 1/2013 | WWW.HEXAGONMETROLOGY.COM



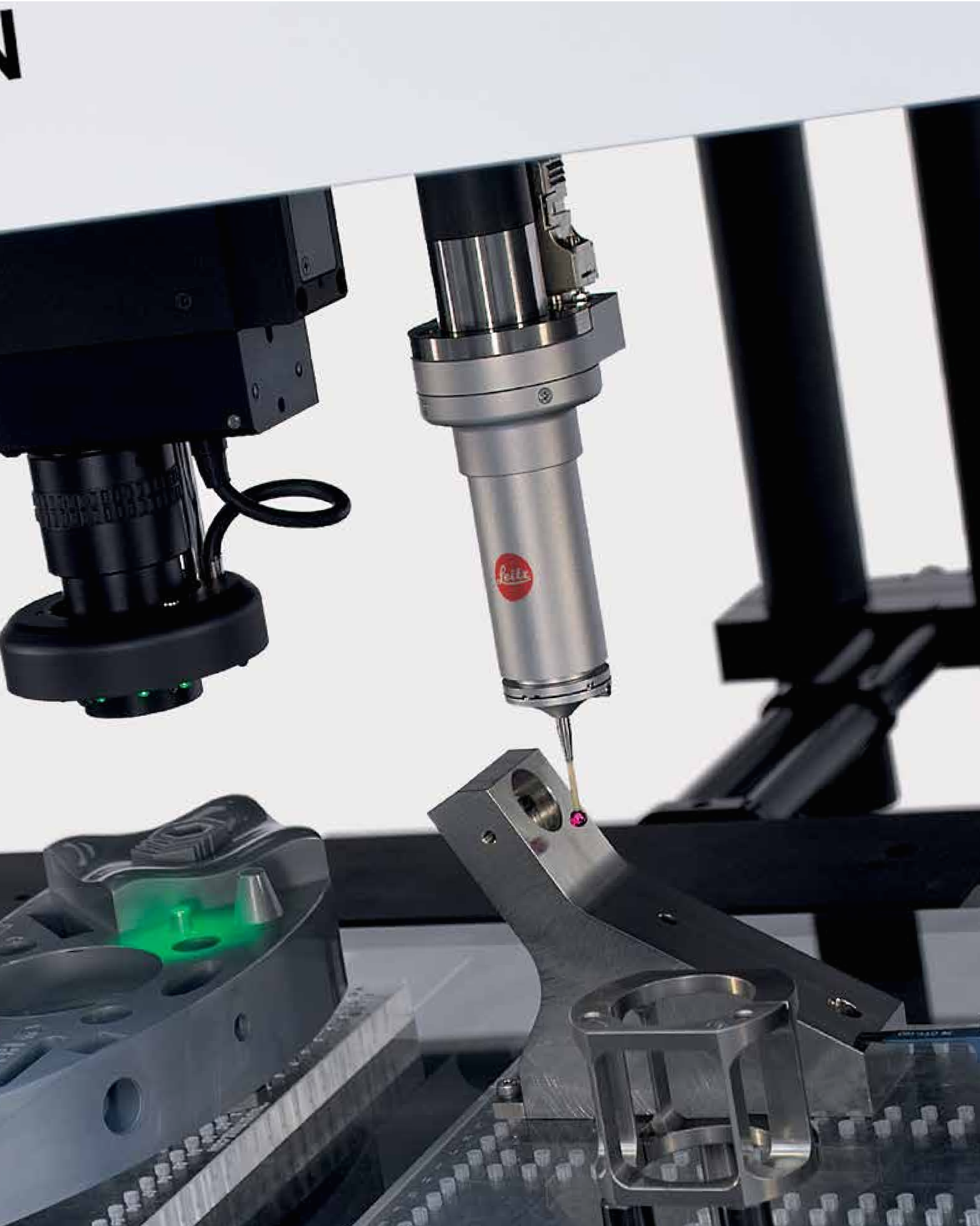
RISE OF THE MACHINES

UP CLOSE AND PERSONAL

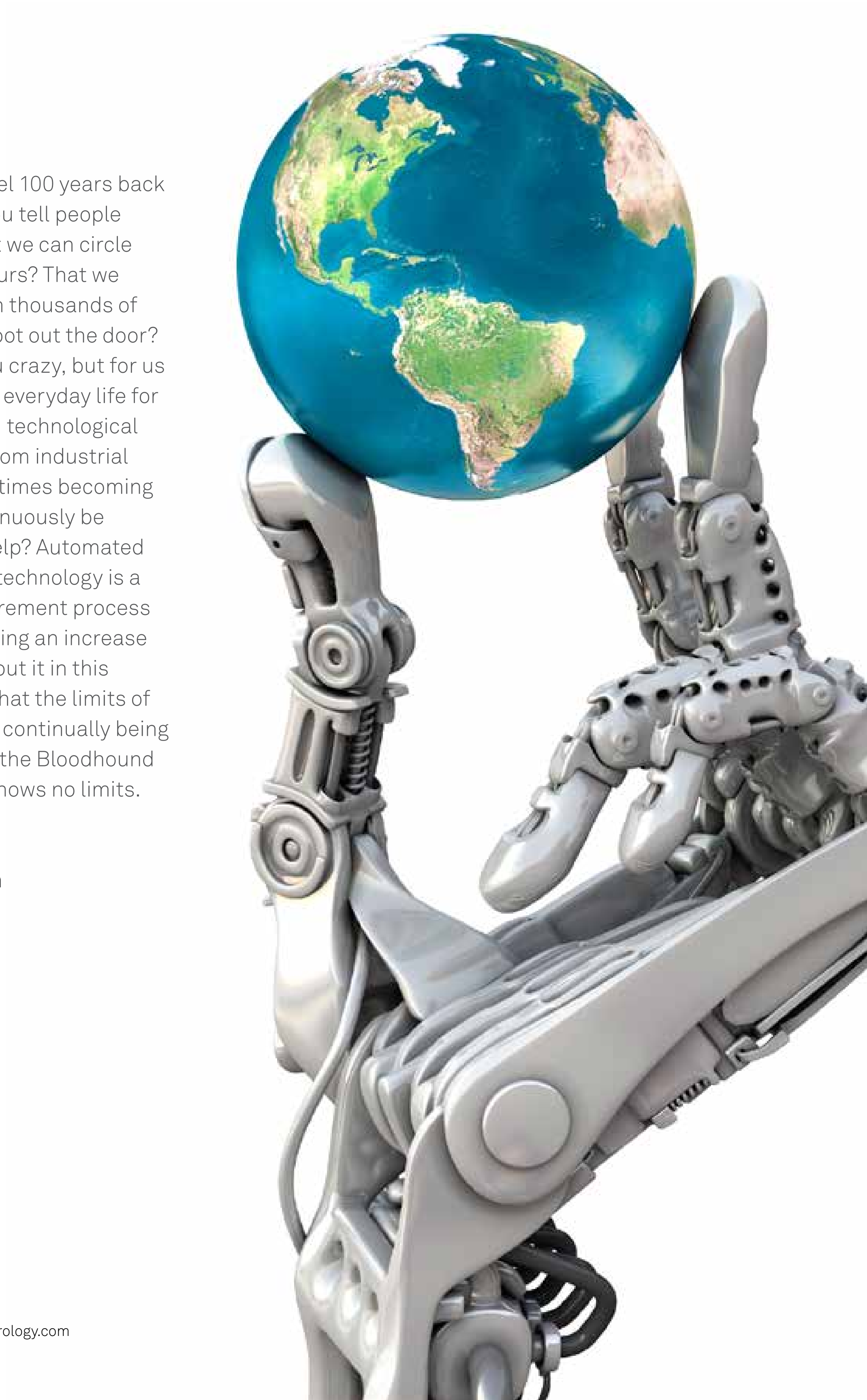
HEXAGON METROLOGY

CLOSE UP

A "double pack" of measurement processes: With some high-precision components, a single measurement process just won't cut it. That's why there's Optiv. The multi-sensor measuring machines accept vision sensors and tactile, high-speed scanning sensors on two separate Z-axes. The sensors can be easily positioned and capture every feature of a component in one single measurement routine.


Leitz

EDITORIAL MEASUREUP



Imagine you could travel 100 years back in time. What would you tell people about the future? That we can circle the globe in just 32 hours? That we can communicate with thousands of other people without setting foot out the door? People would probably call you crazy, but for us these things have been part of everyday life for some time. Today's fast-paced technological changes demand something from industrial companies. Not only are cycle times becoming shorter, but quality must continuously be optimized as well. What can help? Automated 3D co-ordinate measurement technology is a way of speeding up the measurement process and at the same time maintaining an increase in quality. You'll learn more about it in this issue of measureup. The fact that the limits of what's technically feasible are continually being tested is shown in the story of the Bloodhound Project on Page 8. This team knows no limits. Be inspired!

Your measureup editorial team

CONTENTS

MAY 2013

ONLINE: GO TO **WWW.HEXAGONMETROLOGY.COM/MEASUREUP** FOR PAST ISSUES

UP CLOSE AND PERSONAL

One of the distinctive aspects of Hexagon Metrology is that we pride ourselves in getting up close and personal with our customers. As the world recovers from the economic downturn of the last few years we have been continually making investments in infrastructure and services right on our customer's doorsteps.

New Precision Centre close to Airbus in Chester, UK

New measuring arm calibration lab, Wixom, MI, USA

New PC-DMIS Training Centre in Telford, UK

Expansion of Laser Tracker and Theodolite calibration lab, Miamisburg, OH, USA

New plating facility at TESA production in Renens, Switzerland

New office in Contagem, Minas Gerais, Brazil

New showroom in São Bernardo do Campo, São Paulo, Brazil

Whether customers are looking to invest in new equipment, need product services, require training or just have a quick software question, having Hexagon Metrology close by makes all the difference.

WHY LOCAL MATTERS

So what does it mean in practice? Brought down to its most basic level, it's all about listening to the customer and delivering tailored local services based on their needs. In face-to-face situations or on the telephone, we find out just what the customer needs and then aim to deliver it.

Over the last few months Hexagon Metrology has realised numerous new and improved facilities across the world. Some of the activity has concentrated on improving existing facilities, but just as importantly we have been expanding our reach to new countries and regions in order to be closer to our customers than ever before.

INVESTING IN A BRIGHTER FUTURE

As new markets continue to open up, Hexagon Metrology intends to be there to support companies as they evolve and expand in these regions. Engineers are the problem solvers of today; Hexagon Metrology is here to support them wherever they may be, helping to build an ever-stronger world economy.

New production hall for ultra-high accuracy CMM's in Wetzlar, Germany

New Commercial Operation Hexagon Metrology Oy, Finland

New Demo Centre in Warsaw, Poland

New Commercial Operation Hexagon Metrology Kft., Hungary

New Rep Office in Kragujevac, Serbia

New Aftermarket Centre in Ankara, Turkey

Expanded 'Solutions-oriented' demo facility, Qingdao, China

New office and demo centre in Singapore

CASE STUDY

OUR PARTNER'S LANDSPEED RECORD TEAM

Hexagon Metrology is proud to provide expert metrology consultation and services to The Bloodhound Project – the UK attempt to set a new FIA (Fédération Internationale de l'Automobile) land speed record while inspiring the next generation of engineers. Combining the aerodynamics of a car and a jet fighter, the Bloodhound SSC supersonic car will cost around £20-million pounds to develop and aims to exceed 1,000mph (1,609km/h). The world record attempt will take place in 2014 on the Hakskeen Pan in South Africa's Northern Cape Province – the world's largest and flattest dried-out lake bed.

Accurate metrology and access to a range of market-leading products and expertise are absolutely critical to the success of the project. Hexagon Metrology's support will ensure the car is built exactly to design specifications, optimising performance and minimising the risk of issues such as high speed flutter on the fin.

Jon Kimber, Area Sales Manager (South) for Laser Trackers at Hexagon Metrology UK, comments: "Vehicles such as the Bloodhound SSC cannot be built without metrology. Hexagon Metrology was the only company which could provide the full range of metrology equipment and the technical expertise required to make this project a reality."

Hexagon Metrology has the largest selection of metrology equipment of any manufacturer. Its entire range is be-

ing used on the Bloodhound SSC project, including its portable measuring arm, the ROMER Absolute Arm, which provides instant readouts, and laser trackers from the Leica Absolute Tracker AT901 series, which are augmented with the unique handheld probing device Leica T-Probe. This device can be tracked through six degrees of freedom and enables the measurement of points that have no direct line of sight to the laser tracker. Spatial Analyzer application software is also enabling project engineers to see if component parts are in the correct place before they are drilled off and fixed permanently. The project is also benefiting from Hexagon Metrology's considerable experience working with Formula 1 racing teams and its position as the leading metrology supplier to the aerospace industry.

For example, the company is measuring composite moulds and components at different production stages. It's also measuring and positioning high accuracy components such as the D-nose brackets on the rear sub-frame using portable laser tracker equipment and the handheld Leica T-Probe. While the inside of the newly built carbon composite monocoque is being scanned to ensure that cockpit interior fixtures and fittings can be designed in a CAD environment and will fit the first time.

As a result of the Hexagon Metrology team's input, changes are even being made to the way the Bloodhound SSC car is being built. Hexagon Metrology is also contacting sister divisions (Leica Geosystems) to provide additional services such as measuring the flatness of the Hakskeen Pan racetrack with a high accuracy GNSS (GPS) Sensor – a product whose previous uses include measuring runway flatness for the Concorde.

In addition, the company is training the Bloodhound SSC team to use its mobile Leica Absolute Tracker AT401 to ensure accurate car assembly in the Bristol workshop. The battery powered, dust and waterproof tracker will also be the ideal instrument for conducting field checks of the car's structural integrity in the South African desert.

Commenting on the contribution of Hexagon Metrology, Bloodhound SSC Project Director, Richard Noble said: "As we push the boundaries beyond 1000mph we need a partner that can match our ambition and provide us with mission critical measurement services using a range of leading-class equipment at the forefront of metrology. From the smallest detail on the car to the alignment of the major car components over its total 12.8-meter length, everything has to be right."

Jon Kimber has even become a Bloodhound SSC Educational Ambassador and will be visiting schools and colleges throughout the UK to talk about the project and stimulate interest in STEM (Science Technology Engineering and Maths) subjects. “Being involved with a project like this gives us a rare opportunity to give youngsters an understanding of what engineering is really about,” says Jon. “In the UK there is a real shortage of engineers and our hope is that the Bloodhound SSC project will enable us to inspire the engineers of tomorrow.”

FAST FACTS

1. The project will cost £20m – the amount an F1 team spends on two race weekends
2. It takes just 55 seconds to go from 0 to 1,000mph and 17 seconds to go from 500mph to 1,000mph
3. The engine generates 135,000hp
4. The fuel pump is an F1 engine
5. Its solid 90cm aluminium wheels are V-shaped to minimise surface drag
6. When a wheel reaches 10,200rpm, the G-force will be 50,000G
7. It will be louder than a 747 on take off
8. There will be 20 tons of drag on the car at 1,000mph
9. The driver will be wearing a fire-proof suit – a world first
10. The engine will use £8,000 worth of fuel per run

Available on the App Store

http://hex.ag/jf12T

BLOODHOUND SSC IN 3D

View the car in 3D right here on this page. Download the app then point it at this image – the car will pop out of the page!

FOR FURTHER INFORMATION PLEASE VISIT...

www.bloodhoundssc.com

TECHNOLOGY FOR TRAVELLERS

In every issue of measureup we will give you travel recommendations for one of the world's important "metrology cities". In this issue we would like to give you insight into two German cities: Wetzlar, the headquarters of Hexagon Metrology Germany and the city of optics and Stuttgart, the venue for CONTROL, the most important quality trade show in the world.

VISEUM WETZLAR

What is light? The answer to this question can be found in the museum of Optics called Viseum. It's located in an 18th century building in the historic city centre of Wetzlar. Since 2007 people from around the world have the opportunity to find out more about light in Wetzlar. In the museum, supported by 14 industrial companies (including Leica Microsystems and Leica Camera) you can explore the world of Optics and Precision Engineering.

Viseum Wetzlar
Haus der Optik + Feinmechanik
Lottestraße 8-10, Wetzlar
Phone: +49 6441 99 41 40
Opening times:
Tue – Sun: 10-13 pm, 14-17 pm
Closed Mondays
Entrance price: EUR 3.50 (adult)

MERCEDES-BENZ MUSEUM

The modern Mercedes-Benz Museum, located in Stuttgart-Bad Cannstatt, displays 120 years of automobile history. Among the 1500 exhibits which show the evolution of the automotive industry perfectly, you will see a Daimler Motor Carriage from 1886, the legendary Silver Arrow and Pope John Paul II's Popemobile. It's a place where you can see extraordinary design and unique technology, two underlying features of the great history of the Mercedes-Benz brand.

Mercedes-Benz Museum
Mercedesstr. 100, Stuttgart
Phone: +49 711-17 30 000
Opening times:
Tues – Sun: 09 – 18 pm
Closed Mondays
Entrance price: EUR 8.00
(adult, the whole day)

PORSCHE MUSEUM

The enthusiasts of luxury cars should visit the Porsche Museum in Stuttgart. Since 2009, more than 80 unique cars and other 200 smaller exhibits are presented in a unique atmosphere. In the museum you can see and feel the whole Porsche story: the legendary models such as 356, 550, 911 and 917, as well as the outstanding technical achievements in the early years of the 20th century issued by Professor Ferdinand Porsche. Besides the Porsche exhibition, the museum offers also reparation and service of old vehicles to private customers.

Porsche Museum
Porscheplatz 1, Stuttgart-Zuffenhausen
Phone: +49 1805 356 911
Opening times:
Tues – Sun: 09 – 18 pm
Closed Mondays
Entrance price: EUR 8.00 (adult)

TRAM MUSEUM

The Tram Museum in Stuttgart presents more than 50 historic vehicles dated from 1868 to the present. Among them is, for example, the first horse-drawn tram. Additionally, visitors can decide on the following attractions: special islands called "track maintenance" and "driver training". The Museum also organizes a historical drive to the Stuttgart city centre every Sunday.

Stuttgarter Straßenbahnen AG
Straßenbahnwelt, Veielbrunnenweg 3,
Stuttgart (Bad Cannstatt)
Phone: +49 711 7885-7770
Opening times:
Wed, Thu, Sun: 10 – 17 pm
Entrance price: EUR 4.00 (adult)

AUTOMATION ON TOUR

In every company that considers using automated, robot-based measurement systems, many questions arise when automated metrology first becomes a topic: Is probing the right choice or should scanning be considered? Are there sensors which are compatible with industrial robots that have already been purchased? Which is the best software? Are there successful installations for similar environments? Hexagon Metrology developed a training format that answers these questions.

To provide better understanding of automation technology to interested audiences such as metrology users, quality managers or system integrators, Hexagon Metrology developed a workshop format tailor-made to automation. These Automation Workshops offer participants an information-packed day full of know-how and hands-on experience around the application of 6 DoF laser tracker technology in robotic environments. Nik Suter, Commercial Support Manager for Hexagon Metrology's Laser Tracker Product Line, explains: "The Automation Workshop is basically a training offering. Based on technology demonstrations and real-life applications, we pave the way towards the most efficient use of metrology. At the same time, we get real-time market feedback and a profound understanding of our customer's needs today, tomorrow and beyond."

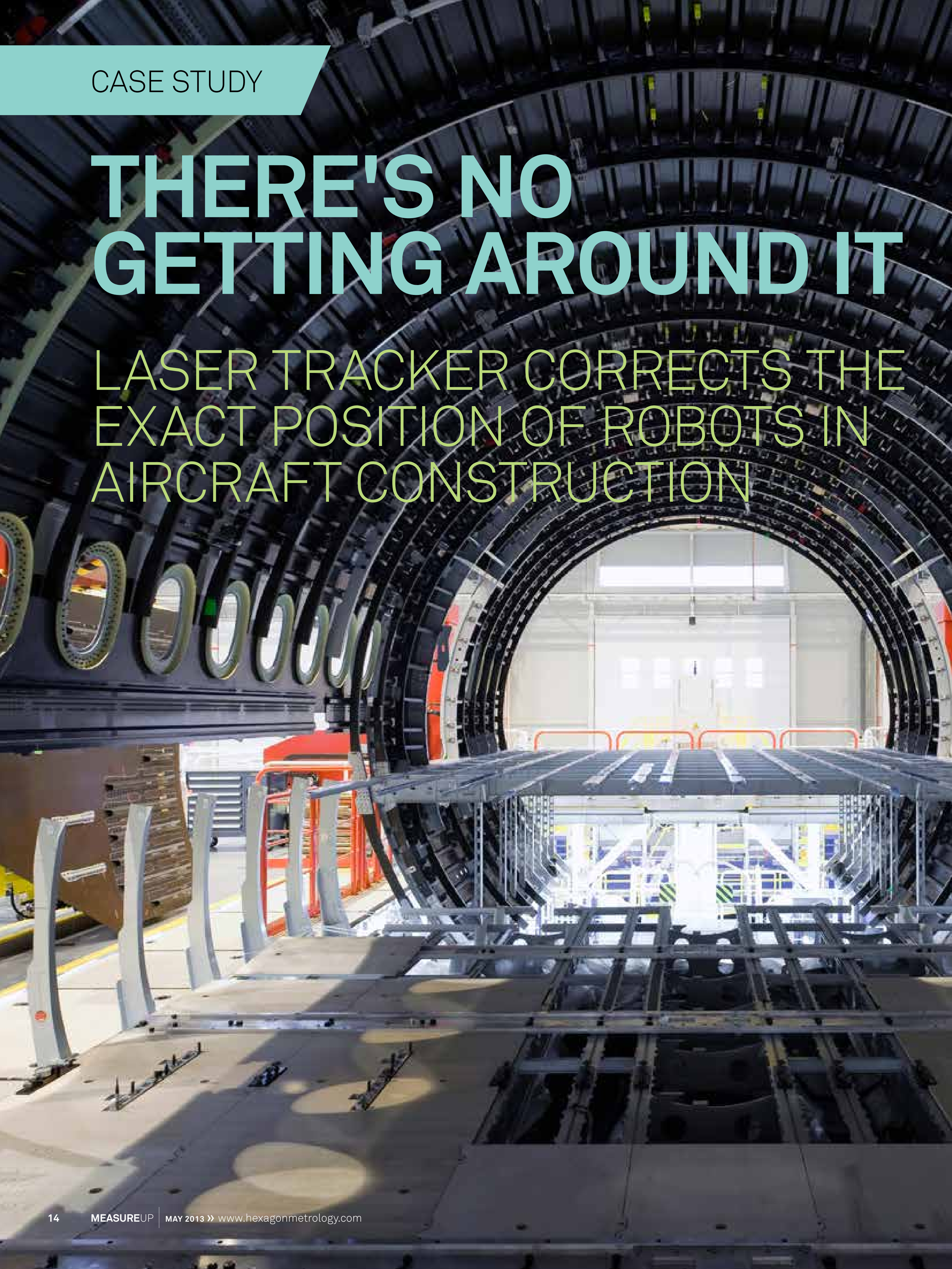
Workshops are held regularly in Hexagon Metrology's Precision Centres or in partner's organizations. In November 2012, Hexagon Metrology hosted a large event at the University of Sheffield’s Advanced Manufacturing Research Centre. In April 2013, the German Precision Centre in Wetzlar was the location of a very successful event. The next Automation Workshops will be held on June 12th and October 12th, 2013 in Hexagon Metrology's Precision Centre Aarau-West, Switzerland.

Sign up for free today at
www.hexagonmetrology.com/Events
Spaces are limited.

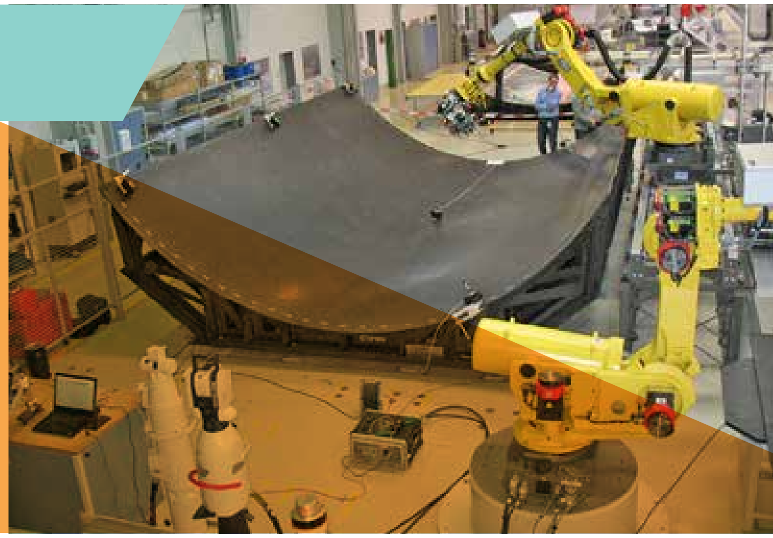
CASE STUDY

THERE'S NO GETTING AROUND IT

LASER TRACKER CORRECTS THE EXACT POSITION OF ROBOTS IN AIRCRAFT CONSTRUCTION



To achieve higher assembly quality, Premium Aerotec is striking out in new directions for the A350. Robots are to take over the task of inserting stringers on CFP fuselage sections. A mobile laser tracker system enables exact positioning of the robot heads.



Both Fanuc robots grip a stringer, move it to the semi shell and finally hold it just centimetres above the material surface.

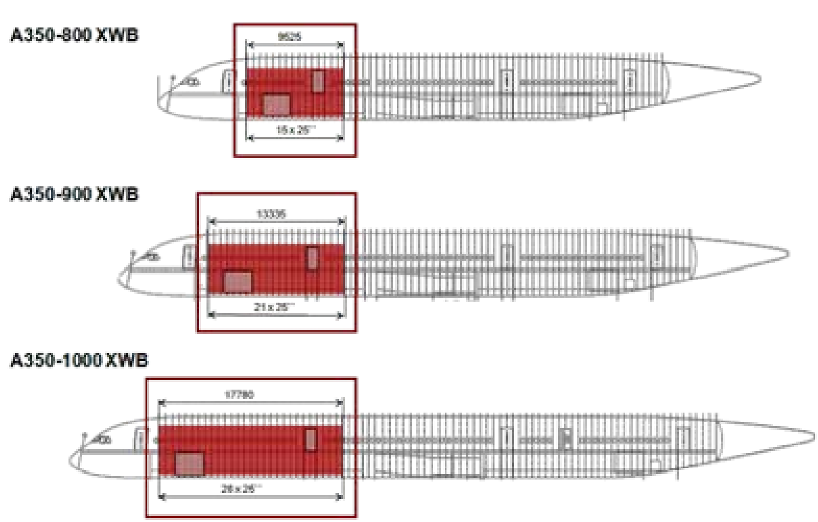
The Leica Absolute Tracker monitors the robot during its traversal over the stringers and immediately corrects any deviations compared to the 3D model.

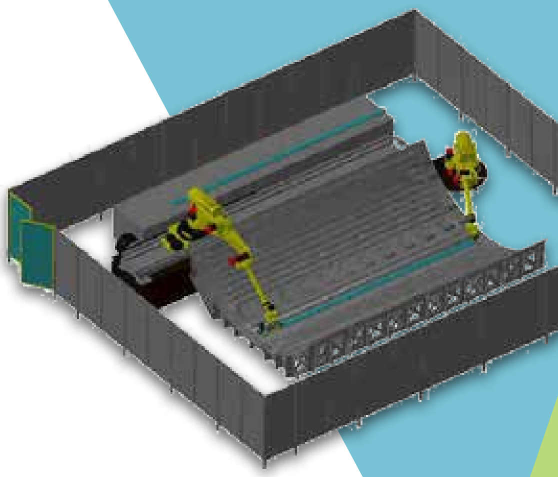
With A350, it's a different story. Each aircraft fuselage is provided with profiles, so-called stringers, for reinforcement. Up until now, they have mainly been made of aluminium. In general, they are manually positioned over holes created by a milling machine. With the A350, which is primarily comprised of carbon fibre-reinforced plastics (CFP), this doesn't work. The material hardens in an autoclave, a pressurised oven, so it can't be drilled.

"As a result the stringers, which are also made of CFP, must be attached to the shell," explained Tim Lewerenz, responsible for the project at Premium Aerotec, which focuses on optimised stringer integration.

As an aerostructure supplier, the aircraft manufacturer supplies large parts for the new generation of Airbus' long-haul aircraft, the maiden voyage of which is scheduled for the middle of this year. This includes the entire front fuselage. "The stringers have to be attached precisely to avoid subsequent drops in quality. Manual positioning is uneconomical here, as ultimately up to 13 aircraft of this type are to be built per month in the future. Our goal is to automate aircraft assembly with robots as well. The requirement, however, is that the robot works as precisely as a milling machine."

Put more specifically: to not jeopardise subsequent production and assembly processes, stringers for the A350 XWB (which can be up to 18 m long) must be set in place in the





The CFP stringers used for the A350 are up to 18 m long. They must be positioned with a precision of +/- 1 mm in the longitudinal direction.

circumferential direction with a tolerance of +/- 0.3 mm and in the longitudinal direction with a tolerance of +/- 1 mm. After initial experiments, disillusionment spread in Nordenham. The first robot was supposed to move 3,000 mm, but stopped after 2,997 mm. The second always moved 1.5 mm too far. "A difference of 0.1 percent seems marginal at first, but with a stringer length of 18 m, it adds up. This was unacceptable to us," said Lewerenz.

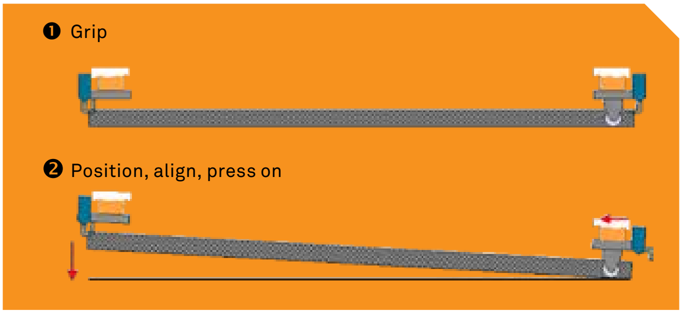
Robot manufacturer Fanuc wasn't at fault, though, as the values were within the robots' specifications. This means that robots work less precisely than milling machines, as they respond to changes in weight and force, which leads to deviations. The automotive industry gets around this by "teaching" the robots, but Lewerenz dismissed this possibility: "The system technology is designed for 800 aircraft in all. Sample components for teaching are thus not economically feasible. This is why we at Premium Aerotec have to assume that the machines are programmed fully offline so that everything is right during production."

So the aerospace industry supplier began searching for an option to move robots to the correct position without teaching them, that is, after taking corrective measures. A system was needed which could be placed on the robot head.

With the Leica Absolute Tracker, a camera (the so-called Leica T-Cam) and a Leica T-Mac the 3D co-ordinates of a point and its orientation in space (i, j, k or roll, pitch and yaw) can be captured simultaneously. This is important because 6D monitoring of the robot is required (it has six degrees of freedom). This means not only the position of the robot head can be monitored, but also its orientation.

If the three spatial orientations (roll, pitch and yaw) are required as in the application at hand, they are determined using the Leica T-Cam for the LED arrangement of a Leica T-Mac. The vario zoom enables nearly distance-independent precision of these photogrammetrically determined measurement values within the volume of work.

According to Lewerenz: "Another thing the laser tracker has going for it is that measurement results can be fed back, i.e. they can yield an accepted result. The degree to which this is important to us remains to be seen, as the components must still be measured and checked later. We also use the Leica Absolute Tracker for this purpose." In the first production cell two robots, one mounted to the floor and the other mounted to a traversing axis and holding the tool head, take the two ends of a stringer and place it on the fuselage section.



The Leica Absolute Tracker monitors the robot during its traversal over the stringers and immediately corrects any deviations compared to the 3D model.

As soon as the robot has positioned the stringer at one point, the measurement system switches on automatically. The robot informs it of its position, and the measurement system prompts the robot to make any corrections. In current trial runs, this takes about 20 seconds, but once the control circuit has been optimised, this will be reduced to just a few seconds. Following this, the connection is interrupted. The stringer is adhered in place and the tracker can correct the next robot head at the same time.

In any case, Lewerenz sees it as a great advantage that Premium Aerotec has on-site experience with the laser tracker. This means the method of operation, the system characteristics and their reliability are known and new systems do not absolutely need to be acquired if the existing laser tracker systems are available (and training costs don't come into play either).

The test cell was intentionally designed openly with centralised software for any 3D measurement system in the series to achieve maximum flexibility. The external measurement system overrides the internal measurement systems of the robots here, according to Lewerenz. "What's important to us is the separation of machine and measuring system. In our opinion, this concept has great future potential, since we are able to combine such an optimal measurement system with an optimum machine."
"This also appeals to us because we are ultimately able to do without an expensive specialised machine, and this extends beyond the positioning of the stringers," related the project manager. Because at Premium Aerotec an ever more important priority is to reduce cycle times in production and assembly. Today, lots of manual work and permanent jigs, such as gantries, are required for this. The problem here is that they make flexible assembly difficult, i.e. the assembly of different products on a single line. "In addition, products change over the course of their life cycle, and we have to be able to respond flexibly to this."

Very seldom are two aircraft exactly alike. Even if it's just a toilet that's positioned in a different place, the aerostructure needs to be adapted accordingly. This is essentially why each shell looks different," explained Lewerenz.

He sees robots and mobile measurement systems as the future. They could herald a paradigm shift in mechanical engineering. This is why he hopes the project partners, including system supplier FFT-Edag, will develop and offer a turnkey solution. "We want to buy a finished product that works. And if something should go wrong at some point, there's only one contact partner we need to get in touch with," said Lewerenz.

He also had a request for Hexagon Metrology. The Leica Absolute Tracker operates internally at 3,000 Hz and outputs 1,000 measurement values per second. However, these 1,000 data sets were output at a maximum rate of 10 Hz. "We need 100 Hz, because the robots operate internally at around 100 Hz and we want to be able to correct every single calculation cycle of the robot. This is why the new real-time interface (Ethercat), which enables data output at 1,000 Hz, is an important step in the right direction."

The production concept: Six or eight robots are to be used, depending on the aircraft size, and the stringer is held by three or four robots on each side. Two rows of robots and two trackers work independently of one another.

Author: Sabine Koll
Appeared in Quality Engineering, May 2013.
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www.qe-online.de/home/-/journal_content/56/12275/778651


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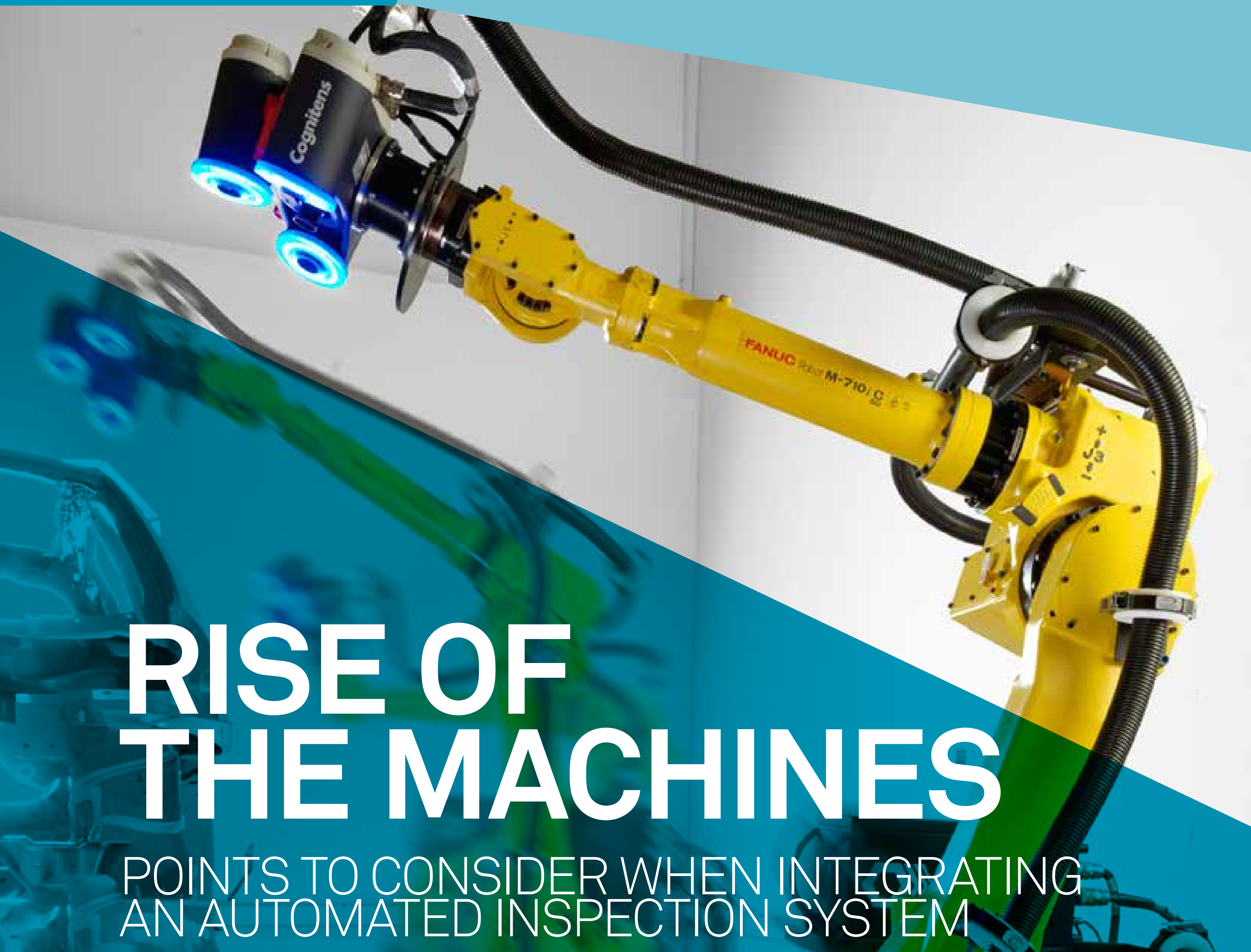


RISE OF THE MACHINES

POINTS TO CONSIDER WHEN INTEGRATING AN AUTOMATED INSPECTION SYSTEM

Hexagon Metrology's fully automated shop floor white light system WLS400A.

Automating the manufacturing environment is nothing new. Control systems and information technologies that reduce the need for human involvement have been available for decades. The relatively new concept to the automation paradigm is the idea of incorporating metrology equipment. With quality integrated at the point of production, a company can benefit from increased repeatability in their inspection process, as well as increased inspection frequency, which leads to better process control.

A GLOBAL CMM in an automated EDM cell is loaded and unloaded with a slide mounted robot.

A CMM from Hexagon Metrology measures blades that were placed on a mount (left side of the granite table) by a robot outside the enclosure.

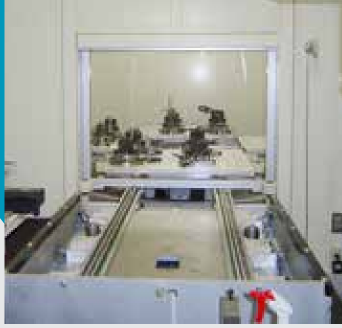
Automated systems, as they pertain to metrology integration, encompass a wide range of potential choices. Automated coordinate measuring machines (CMMs) which use direct computer control (DCC) have been widely available for some time and in many cases have replaced manual versions. Machine tool feedback, in which a probe measures components during the machining process, is an available option as is robotic in-process measurement and metrology-guided assembly and manufacturing. The advantages of using one or a combination of these technologies are lower operating costs, consistent throughput, improved lean manufacturing capabilities and improved product quality. There are, however, risks involved with implementing these systems.

ROADBLOCKS TO METROLOGY AUTOMATION

Although increasing in popularity, there are limitations to an automated system. Common automated manufacturing systems employ robotic equipment to facilitate part handling. In certain scenarios, such as those employed with lights-out manufacturing, fully automated machining cells incorporating metrology tools are the most efficient solutions to improve throughput. In most applications, however, a semi-automated solution incorporating automated and manual processes maximizes throughput. A company debating the merits of these systems needs to carefully consider when they make sense, when they don't, and the associated risks and rewards.

The most challenging aspects of implementing the system are technical limitations. Integrating a high-precision CMM on the shop floor is typically not feasible due to vibrations and temperature fluctuations. Another limitation may be the cycle time of the manufacturing cell. Longer cycle times lend themselves to a semi-automated solution. For example, a parts handling system is difficult to justify if the robots only move four times per hour. Additionally, if a cell is able to manufacture parts in less time than it takes the metrology equipment to inspect them, a parts buffer may be needed to hold the waiting components.

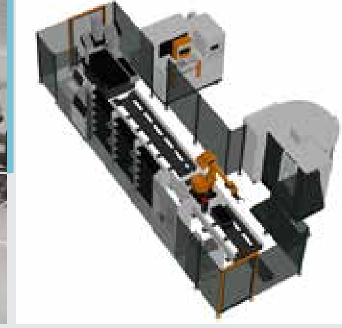
An even-greater problem facing manufacturers, which many do not realize, is the cleanliness of the parts. After machining, a part may have metal chips and oily residue on its surface. Components in this condition cannot be accurately measured and may damage the CMM after repeated inspections. Financial considerations come into play as well. Though many expect high initial costs,



Looking through a Brown & Sharpe CMM into a cooling chamber. The parts buffer loads a pallet onto a mechanism bolted to the CMM's granite table.

This parts buffer holds waiting parts and is configured to sit behind the Leitz PMM-C High Accuracy CMM.

This parts buffer is composed of four pallets. One pallet at a time is loaded onto the CMM, located in the inspection room.



An illustration of a potential automated manufacturing cell.

they may neglect to factor in all potential expenses. For example, there may be enclosures and parts buffers needed. There may also be costs associated with the lack of turnkey software solutions since no standard code exists for communication between the robotics and the CMM. Lack of experienced personnel to implement the system and the development costs are other factors which must carefully be considered.

To combat some of these issues, Hexagon Metrology is actively working to improve available solutions. Our engineers custom program middleware that manages communication between the CMM and the manufacturing environment to synchronize events on the shop floor. The middleware communicates with the parts handling system to gather information about the environment when the robot loads and unloads parts to and from the CMM and interfaces with external devices such as parts fixturing systems. It manages and displays all the measuring system statuses and can advise if a measurement is in progress, the cycle is on hold, the cycle has ended and what the nature of the part is, e.g. good, critical or rejected.

SEMI-AUTOMATED SYSTEMS

At times, a semi-automated system may be a more cost-efficient solution that is as productive as an automated one. The final goal for any manufacturer is not to completely automate their facility, but rather to maximize throughput within the given parameters of the application. Instead of focusing strictly on automation, a more achievable goal would be to minimize capital expenditures; for example they may be able to run efficiently with two CMMs rather than needing three. Another cost consideration when deciding between a fully or semi-automated parts handling and inspection system is labour. Whereas the company may think it is best to eliminate five low salary positions, it may need to hire three high salary ones to program, implement, and maintain such a high-tech system.

Though a semi-automated system may require a high level of human intervention, it could potentially be the best solution for the application. Take for example a carousel that has four pallets of parts that are automatically loaded onto the CMM. Although a person must fixture the parts onto the carousel, a constant supply of components is ready for inspection. If the CMM operator is therefore required to tend to other tasks, the parts won't sit idle.

WHICH IS RIGHT?

For those considering an automated parts handling system that integrates inspection, the final decision is based on the specifics of the application. Some of the initial considerations will encompass the accuracy required, the complexity of the parts, the ability to clean the parts before they are measured and the preferred technology—though most application specs will mandate the technology used.

Consultation with the professionals at Hexagon Metrology to discuss all factors involved, along with their associated risks and rewards, will give an organization a better idea of what it can realistically expect.

SEE **HEXAGON METROLOGY'S AUTOMATED WHITE LIGHT SYSTEM** IN ACTION

http://hex.ag/jK1f8

CURRENT TRENDS IN METROLOGY AUTOMATION

Giacomo Barilà, Sheet Metal Product Line Manager

MU: What are the current trends in metrology automation?

GB: Strong competition within various industries drives the need for metrology automation. Our customers constantly require tighter tolerances, higher quality control and improved efficiencies within their facilities to reduce production costs. As their metrology partner, we work hand-in-hand to develop solutions based on their needs.

MU: What are the benefits of such systems? What are the drawbacks?

GB: The clear benefit is a customer's ability to react quickly with the proper data. This means no quality degradation and no need for costly rework during production. The main drawback to an automated system is the lack of a standard turnkey solution. Because each application is unique, and there is no standardization among robotic software, automated systems must be adapted to the particular customer. To mitigate the drawback, we are developing solutions based on configurable platforms that minimize the customized portion of the installation.

MU: How does automation improve overall quality and process control?

GB: Automation combines quality and process control in a highly effective way by providing actionable intelligence for production managers. Additionally, data can be organized so each user gets the specific information for the decision he or she has to take. The data is configurable and flexible according to the customer's workflow.

MU: I understand that automated manufacturing cells that incorporate shop floor metrology products are somewhat common practice for large companies in the aerospace and automotive industries. As a company, are we involved in making these solutions more attainable for smaller companies in other industries?

GB: Yes, we are definitely pursuing this goal. It will be a further development to provide configurable solutions to satisfy different workflows. It is a big challenge, but we have a clear strategy and are proceeding step by step.

MU: What do you see as the future of metrology automation?

GB: Metrology automation can be applied to almost any metrology device, for large or small parts, as long as the throughput fulfils the customer's requirements. Metrology technology is evolving by moving out of the laboratory and into manufacturing, by integrating it on the shop floor where parts are produced. It provides the necessary data to correct manufacturing processes in almost real-time. This contrasts with the current down-time companies suffer as they wait for inspection results far from the manufacturing cell. We will continue to implement metrology automation solutions closer to the point of production to give our customers a competitive edge.

NEW FROM **TESA**

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TESA offers industrial customers global solutions

Continually increasing requirements in the industrial environment increase expectations of metrology. First and foremost, it must be possible to smoothly integrate measuring instruments into industrial workflows, thereby improving both product quality and production efficiency.

TESA remains in close contact with the market, which is indicating an increasing tendency towards automated processes. "How can we improve our products and link them in an intelligent way? How can we create the ideal workspace for our customers?" These are the kinds of things TESA considers about customer needs. Today TESA is much more than just a renowned manufacturer of measuring instruments. On the way to becoming a global company, the Swiss supplier has increasingly focused on high-performance measurement solutions. A continual exchange of information and close co-operation with end users are of fundamental importance. TESA conducts pilot projects with select, demanding customers in the automotive and aerospace industries. This enables the development of large-scale, sustainable solutions which can be used around the world.

From precision measuring instrument to global solution

The current product offering from TESA is based on a very comprehensive range of high-precision hand-held measuring instruments, top-notch vertical height gauges, intelligent optical measuring machines, powerful, yet affordable, co-ordinate measuring instruments and connectivity solutions.

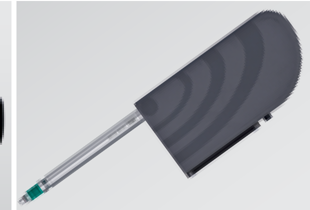
Today, digital hand-held measuring instruments are an integral part of metrology. TESA's vernier calipers, outside micrometers and indicators offer a host of advantages in flexibility, readability, reliability and traceability and can improve work flows decisively.

When the goal is to offer centralized solutions, the aspects of connectivity and interfaces, in particular, have considerable importance in the overall concept. The recently unveiled TWIN-Cal IP67 vernier caliper clearly shows how benefits to the customer can be maximised. TESA TWIN (TESA Wireless Interface) connectivity enables smooth and secure data transfer to the PC. Devices equipped with this technology feature an in-built connectivity output with a simple plug-and-play mechanism. Whether the transfer takes place over a USB or digital interface, the data can be processed further straight away.

This is where TESA's STAT-Express software for statistical measurement data acquisition comes into play. The software can simultaneously manage measurements with various measuring devices, make available measurement logs and reports, control charts and statistical analyses and ensure that data are stored in the CSV format. Most hand-held measuring instruments, height gauges, inductive probes, roughness testers and setting benches are compatible with STAT-Express; even the MICROHITE 3D co-ordinate measuring machine.

Connectivity is ensured via optical USB or wireless connection, available for many devices. In the area of one-dimensional inductive probes and their corresponding electronic interfaces, TESA has developed high-tech solutions which open up a broad range of options to the user. The versatility of use of the



wireless TWIN probe, together with the TWIN station, enable a very high level of flexibility, particularly in the area of multi-point measurement. TESA's own communication protocol, which enables the independent operation, synchronisation and security of the data transfer, is an advantage which once again paves the way for further combination options.

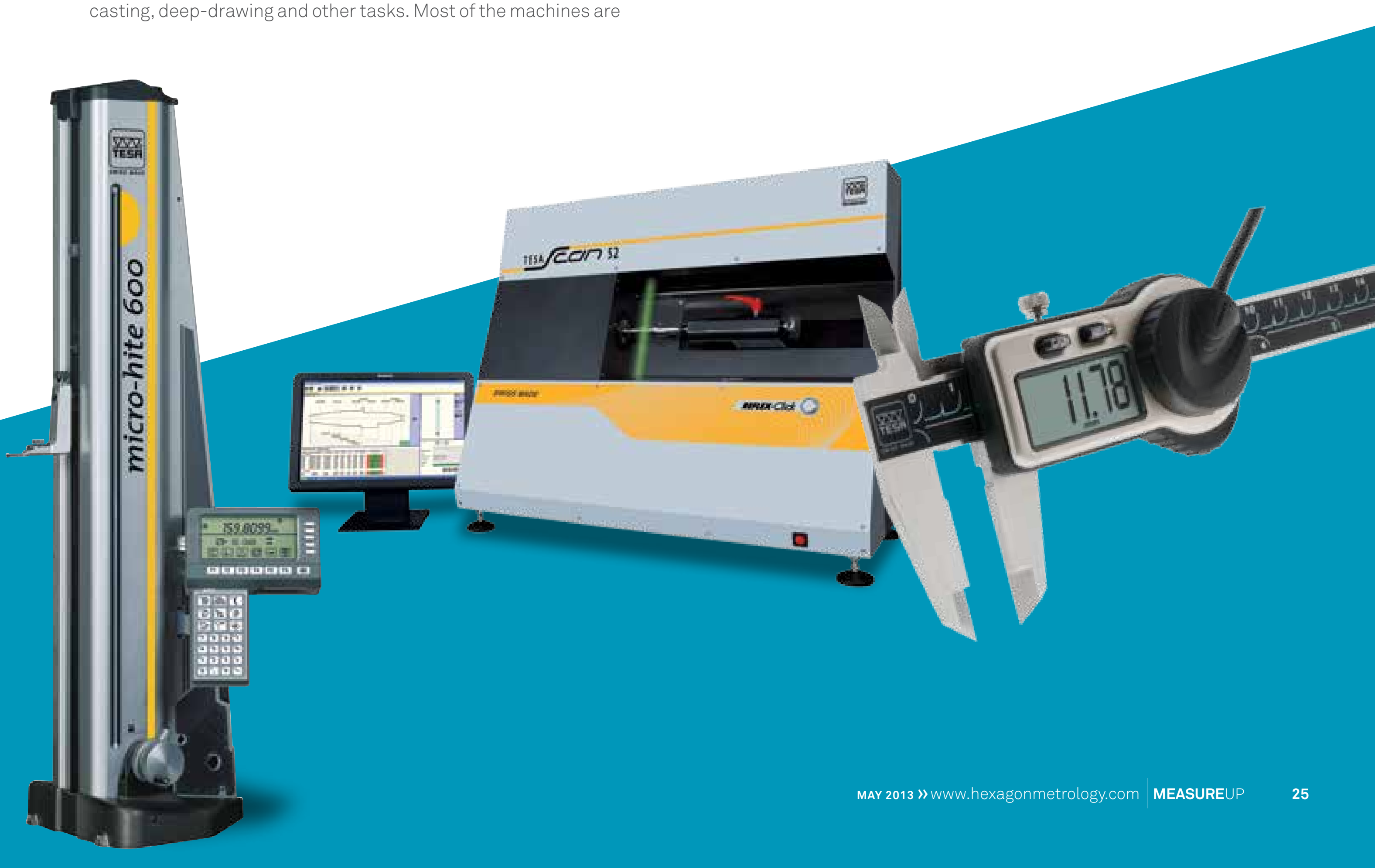
TESA responds immediately to the needs of the market. This being the case, the company successfully integrated wireless options into their portfolio and will continue this strategy into the future. A wireless connection for the new TWIN-Cal IP67 will soon be unveiled and elegantly round out the latest innovation from TESA!

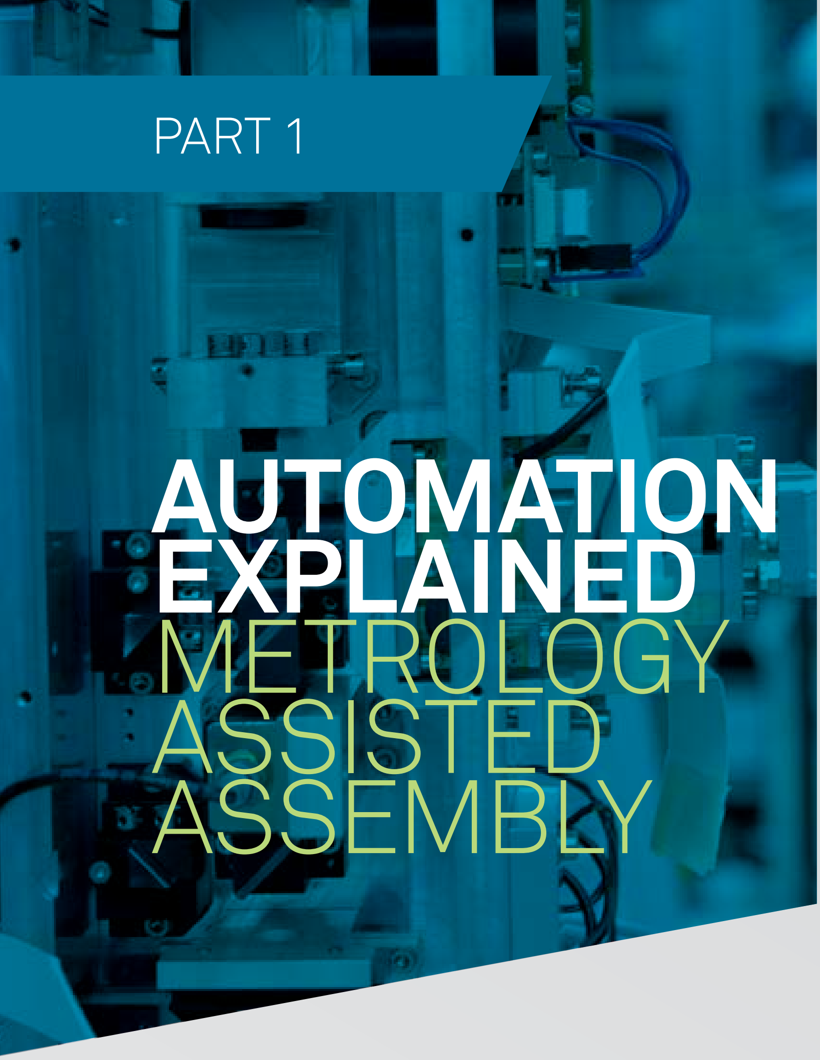
Measuring machines for every user

Beyond the comprehensive range of precision hand-held measuring instruments, TESA is also paying attention to the approaches being taken around the globe to solve problems in the area of measuring machines. The TESA REFLEX concept combines machines and software in a unique way. A multi-purpose, intuitive program covers the entire spectrum of optical and co-ordinate measuring machines. Five software modules cover every type of application, such as milling, lathing, cutting, casting, deep-drawing and other tasks. Most of the machines are also compatible with additional software options such as STAT EXPRESS so that immediate, further data processing is possible.

When it comes to automated processes, a single machine which has revolutionised contact-less measurement and inspection of turned parts deserves special emphasis, the TESA-SCAN 52 machine. Thanks to its simple operating principle of "measurement results at the push of a button", the user can save valuable time while inspecting turned parts. If quick, automatic measurement without prior programming is desired, this device is an excellent addition!

TESA will continue to view benefits to the customer as a starting point and to develop comprehensive, user-friendly solutions, including both standard solutions and tailored measurement solutions. A broad spectrum of services supplements TESA's product offerings and also helps customers improve quality and reliability at their end.





PART 1

AUTOMATION EXPLAINED METROLOGY ASSISTED ASSEMBLY

Leica Geosystems Laser Trackers were among the first technologies that helped the aerospace industry with Metrology Assisted Assembly (MAA). Dozens of laser-tracker-based installations all around the world are operated successfully every day.

In this and the next edition, measureup will detail two different Metrology Assisted Assembly concepts that will allow both the front-end (Human Machine Interface) and the backend (Analysis and Database Management) of the metrology software to be completely independent of the final hardware solution.

Automated Assembly using 3D point networks and the Leica Geosystems 6DoF MAP System

A hybrid combination of 3D point based assembly with the addition of 6 Degrees of Freedom (6 DoF) real-time tracking creates the Leica Geosystems Metrology Assisted Positioning, or MAP system. This system could cut the standard MAA joining times by as much as a third, or at least a quarter. In a standard application a Laser Tracker would have to measure a network of between 6 – 8 points on the wing, plus a series of points on the body. This process would typically take between 30 to 40 seconds to complete. However, it is not the measurement time that slows this process down. The limiting factor is the time it takes to move the jigs and re-measure the parts in an iterative process.

For a single wing, the time required to move it into position could take up to 45 minutes. This is assuming roughly 5 seconds per point for positioning and measurement of the Laser Tracker, and between 10 – 15 iterations to bring the wing into the final alignment position. In comparison, using the same wing, but this time rather than calculating the positioning deltas from a network of points, we'll use the Leica Geosystems 6DoF MAP System to track the wing in real-time. The 6DoF MAP system consists of a Leica T-Mac machine control sensor in combination with a Leica Absolute Tracker AT901 and Leica T-Cam. The Leica T-Mac is attached to the part to be aligned (in this case the wing), and the 6DoF deltas are fed back in real-time directly to the wing positioners. The Leica T-Mac has the same 3D positional uncertainty of a standard Laser Tracker measurement, but also generates pitch, roll, and yaw angles. The 2 Sigma angular uncertainty is 0.01° as long as the Leica T-Mac is mounted no more than 6 meters from any edge of the mating surface. The achievable accuracy along this surface is equal to about 1.0 mm (where b = Sin* Radius). This allows for a very flexible setup process where the Leica T-Mac could even be placed meters above the wing for extremely easy line of sight requirements.

Application Specific Measurement Processes

Communication from the Leica T-Mac position to the wing positioners is a direct feedback loop to keep data latency as low as possible. This helps position the wing with maximum time savings. To guarantee that the wing never touches the body during the MAP process, a positive gap of 5 mm should be maintained. This is roughly equal to a doubling of the Maximum Permissible Error of the Leica T-Mac rotation angles at these distances (e.g. 6 m).

Once the Leica Geosystems 6DoF MAP system finishes, and the wing is within 5 mm of its final location, the standard process of measuring the fixed reflectors and calculating the best-fit positioning for the final location should start. This process would run as it does with other processes that are already well proven. Whether the process is controlled from an external Application Process Manager or from an integrated metrology package is inconsequential to the overall difference in solutions. The main differences would be that if it is implemented in an integrated metrology package (e.g. SpatialAnalyzer), all parts of the communication would need to be integrated in this metrology software. If however it is implemented as a measurement process in the Measurement Process Manager it could use the functionality that is integrated in a Measurement Process Manager or MPM (e.g. transformations, bundle, etc.) and communicate directly with the Assembly Process Manager that is controlling the wing positioners.

The time savings from the Leica Geosystems 6DoF Map system as described is detailed below:

Program function	Number of points	Details	Measurement positions	Time conventional	Time Leica T-Mac solution
Initialisation					
Fix point measurement	8		8	40	40
		wing left 5 points + 1 T-Mac	6	30	30
		wing right 5 points + 1 T-Mac	6	30	30
		center wing box left – 8 points	8	40	40
		center wing box right – 8 points	8	40	40
		fuselage joint points – 6 points	6	30	30
		HTTP / VTP joint 11 points + 1 T-Mac	6	30	30
Transformation and establishing Coordinate system		Calculation time 10 seconds		10	10
		wing joint left 13 points + 1 T-Mac	14	70	
Online measurement process	10 iterations	wing joint left 13 points + 1 T-Mac	13	650	30
		T-Mac solution need just actuator movement time		90	90
Best fit process	3 iterations	Conventional solution 2 x 15 positions	30	450	450
Conventional				2840	
Leica T-Mac solution					820
Time saving				2020 seconds	

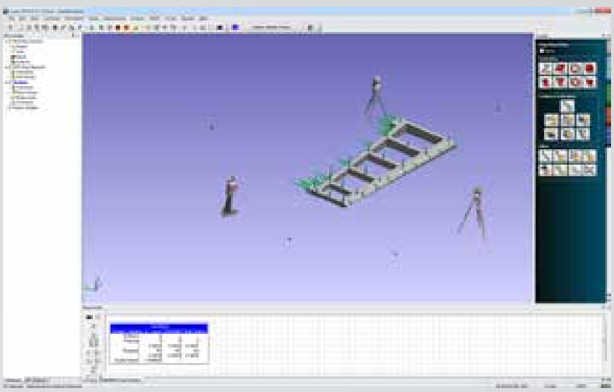
In addition, the cost of the complete system can be scaled by the number of Leica T-Mac sensors shared between all of the assembly structures. The trade-off is obviously the speed at which the complete process would run. An integration with three Laser Trackers and three Leica T-Mac's could do both of the wings and the stabilizer simultaneously in a period of approximately 15 minutes, while a system with only one Leica T-Mac would take almost three times as long due to the need to run the processes sequentially. These times only look at the estimates for measurements and do not take into account the times required for the positioners to actually move the parts. For instance this process in an existing installation takes approximately 2.5 hours, not just 45 minutes. However, the time savings noted above are directly proportional. It should also be noted that time savings is not the only major advantage here.

Transitioning to an on-line movement could also reduce the cost of the tools and jigs. This can translate into using fewer reflectors, as well as less accurate positioners since the true location would always be known from the MAP system.

An internal and external Measurement Process Manager in one piece of software

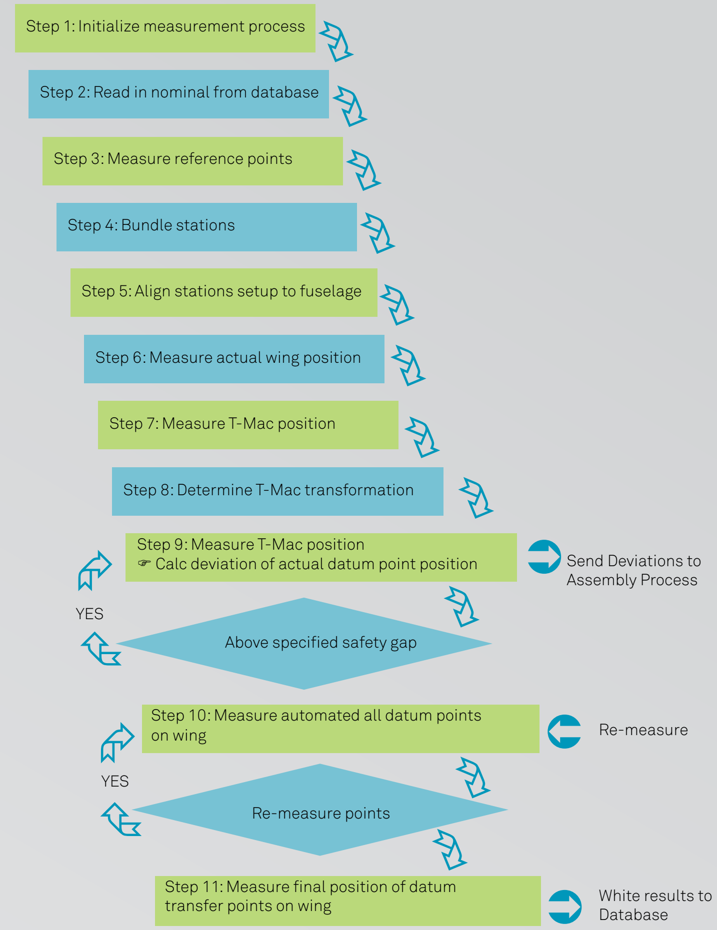
There are differences between measurement software that uses an internal scripting language, and an external Measurement Process Manager that wraps around the individual hardware's measurement commands (read more about the different approaches in the coming edition of measureup). However it should be noted that it is possible for one piece of software to be able to do both.

It is well understood that SpatialAnalyzer has the ability to run advanced measurement plans that contain conditional looping, and on the fly operator input to be able adapt accordingly. But it is less well known that SA also has an advanced external scripting language that allows 3rd party integrators to use the basic SW package as an MPM as previously described.



In this case it would be possible to replace the user interface completely. SpatialAnalyzer becomes the “brains” of the measurement process controlling the import & export of data, all measurement commands, bundle & alignment mathematics, and complete database control. The Human Machine Interface can then be completely customized based on the needs of the automation project with a simple program that no longer needs to worry about the actual metrology processes.

We can use the Leica Geosystems 6DoF MAP system as an example of how SA could be used as a Measurement Process Manager independent of the Human Machine Interface, or the final reporting database. The workflow assembly process could look as follows, where SA would be responsible for steps 1 – 9 below. Here the 3rd party integrators Human Machine Interface only needs call step 1, and then SA could take over the automation through step 9 until the Assembly Process Manager becomes involved to reactivate the measurement process after the jig has moved. This loop would continue until step 11 when SA would then send the completed measurement results to a global database storing the wings final location. At this point the Human Machine Interface would then become integral in detailing the next steps, or stating the process over again.



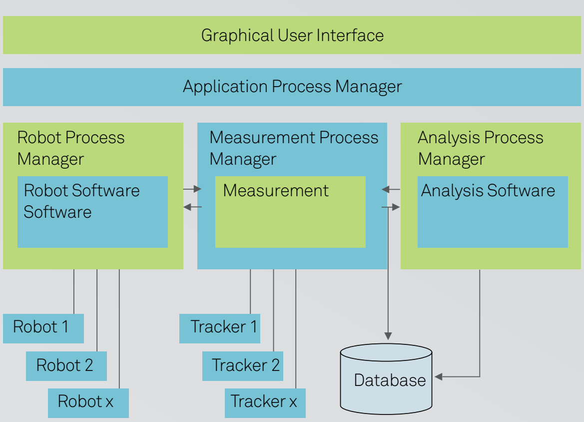
SpatialAnalyzer could also take the MPM concept a step further where it could also be extended to use CAD models as the mathematical nominal data, and to be able to do advanced analysis on the data such as automatic feature creation, and GD&T calculations.

This analysis data could then be output in a neutral format to a global database for storage and further calculations, or could automatically generate a standardized report for documentation purposes. In either respect, SpatialAnalyzer becomes an integral tool that allows all 3rd party integrators to create advanced automation projects based around 3D and 6DoF hardware without the need to create customized measurement applications.

Automated non-contact inspection utilizing 6DoF technology

The second advancement that has come from the integrated implementation of our 6DoF technology is the ability to do automated non-contact inspection applications. This obviously requires the addition of a robot, or gantry system to position the Leica T-Mac or Leica T-Scan sensor, but then allows for a highly accurate measurement system with a volume of up to 50 meters.

The Leica T-Scan is able to use a robot or gantry system to control its positioning – a fairly new concept. This expands on the concept where we use a dedicated Measurement Process Manager to control the full measurement process, but now we also add a third component being the Robot Process Manager.

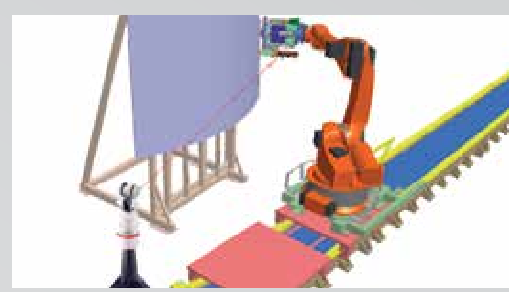


The Application Process Manager communicates separately to the individual sub-process managers. By utilizing SpatialAnalyzer we are able to treat the measurements just as we would if they were scanned by hand, but once we integrate the scanner with a robotic arm, we need to be able to control the arm as well. Here our Application Process Manager deals with the specific communication between the Measurement Process Manager, the Robot Process Manager, and the Analysis Process Manager (e.g. SpatialAnalyzer). This concept allows the measurement hardware to not only be independent of the front end of the software (including the GUI), but also the ability to be independent of the back end (including the analysis, and post processing). This allows the integrator to implement the measurement technologies, without constant software modifications for new Human Machine Interfaces, and new analysis processing requirements for each individual integration project.

Unlike in the Leica Geosystems 6DoF MAP system where 6DoF information is used to correct a positioning device, we now need to pre-program the robot to know how and where to scan. This needs to be programmed into the Robot Process Manager beforehand, but then once the robot program is started, the robots accuracy becomes arbitrary since the absolute position is measured using our 6DoF technology. This allows for a very accurate point cloud to be collected over an extremely large measurement volume. The appropriate software package, such as PC-DMIS or SpatialAnalyzer, should be selected depending on the type of analysis that is required by the job. No matter which way it is used, at the end the customer/integrator has complete control over exactly how the data is processed and how the results are finally reported.

This process could be implemented for "hand-held" usage as well by simply removing the Robot Process Manager, and replacing it with a trained operator. As mentioned earlier, the robotic positioning system has no relation to the achievable accuracy of the measurements. The robot (or operator) only needs to be accurate enough to make sure that the measurements are in the correct location. This same concept need not only be applied to the Leica T-Scan, but can be applied to a line scanner on the Leica T-Probe, or a Leica T-Mac as well. It is possible to mount a Leica T-Mac like the Leica T-Scan on any robot or gantry positioning system. It can even be mounted as a sensor on a machine tool to allow for in process inspection.

Take for instance a structural assembly stations, where additional measurement functionality could be extended from a standard Laser Tracker integration. A Leica T-Mac could be added to the machine tool to allow both positioning control, and adaptive control of the end-effector (i.e. a drilling machine). In addition to this, a touch probe could be added to this configuration to allow for surface and feature measurements aiding with as-built surface inspection, and or automated shimming. With one core piece of hardware (e.g. a 6DoF Laser Tracker) the entire structural assembly system could be controlled and automated.



In the above example we are using a Leica T-Mac and a touch trigger probe attached to a robot to measure like a standard shop floor CMM. This configuration effectively turns the system into an ultra large volume CMM with better than 0.1 mm absolute accuracy over the entire volume. A robotic arm could be mounted on a translation slide that would allow it to reach across, and slide down the full length of the structure. This would allow such a device to measure something as large as a full wing fixture.

Read the next part in the following issue of measureup

In the meantime, see Leica Automated Solutions in action at http://hex.ag/fLzUx or sign up to the next Leica Automated Solutions Workshop.

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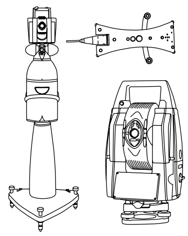

LASER TRACKERS
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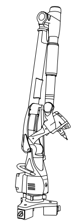
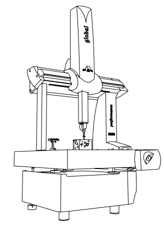


PORTABLE MEASURING ARMS



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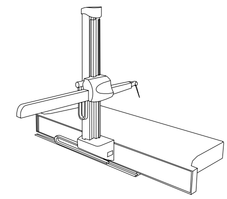

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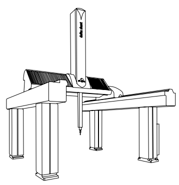

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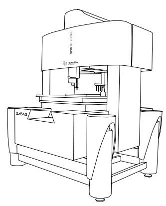
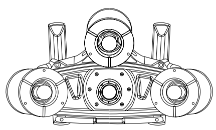


MULTISENSOR & OPTICAL SYSTEMS



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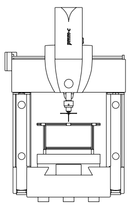

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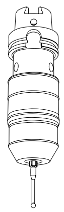
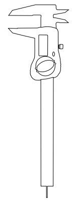


SENSORS



PRECISION MEASURING
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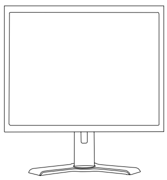

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