Precise

ZEISS Research & Quality Solutions

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The new era of metrology
ZEISS TALOS reshapes quality control in production

Humanoid robot motion
X-Humanoid: The data behind every move

Precision for the AI era
Wiwynn: Manufacturing reliable hardware for trusted AI infrastructure

ZEISS

Seeing **beyond**

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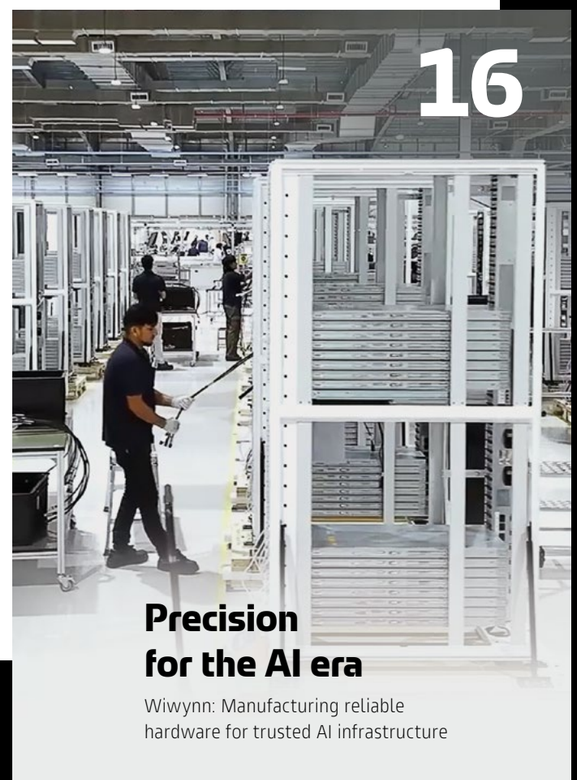
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Editorial

We are living in an era shaped by technology, one in which artificial intelligence, automation, digitalization and advances in research are redefining what is possible. Technologies are evolving faster than ever, blurring the boundaries between the physical and digital worlds and accelerating innovation across industries.

For manufacturing companies, this transformation is fundamental. Products are becoming more complex, while development cycles need to be shorter and production environments increasingly connected and autonomous to ensure business success in the future. Data is becoming a strategic asset: it enables companies to understand processes in real time, identify deviations earlier and make faster, better-informed decisions. As a result, quality assurance is evolving from a final inspection step into an integral part of the entire value chain, from the first idea to reliable, scalable production.

In this issue of PRECISE, we show how companies are taking on these challenges by using different technologies and connected data to accelerate innovation. Their stories demonstrate how automation, AI-powered data analysis, connected quality processes, and shopfloor metrology can transform quality data into better production outcomes and meaningful impact.

We are also introducing a new breakthrough in metrology systems. For the first time, we are showcasing our new optical metrology robot, which combines speed and reach with precise feature measurement and full-field surface inspection in a single solution. Designed for use directly in production environments, the system delivers reliable measurement results and imaging data at industrial speed. Discover this new technology on page 10.

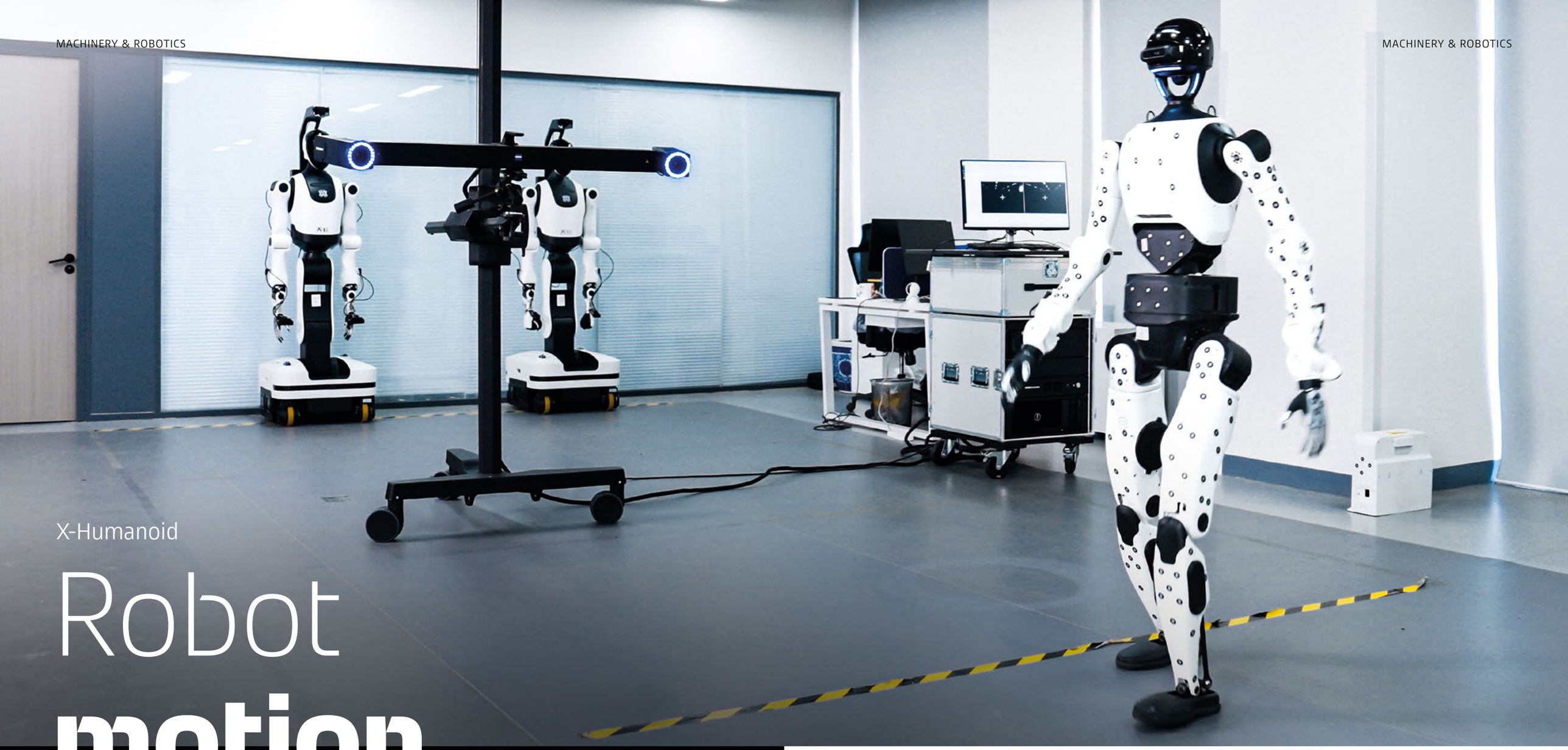
Welcome to PRECISE. Welcome to the stories that provide insights into what progress and innovation look like in the era of technology.

Enjoy reading.



Dr. Marc Wawerla,
Member of the Executive Board of the ZEISS Group and Head of the ZEISS Industrial Quality & Research Segment

MACHINERY & ROBOTICS



X-Humanoid

Robot **motion**

The data behind every move

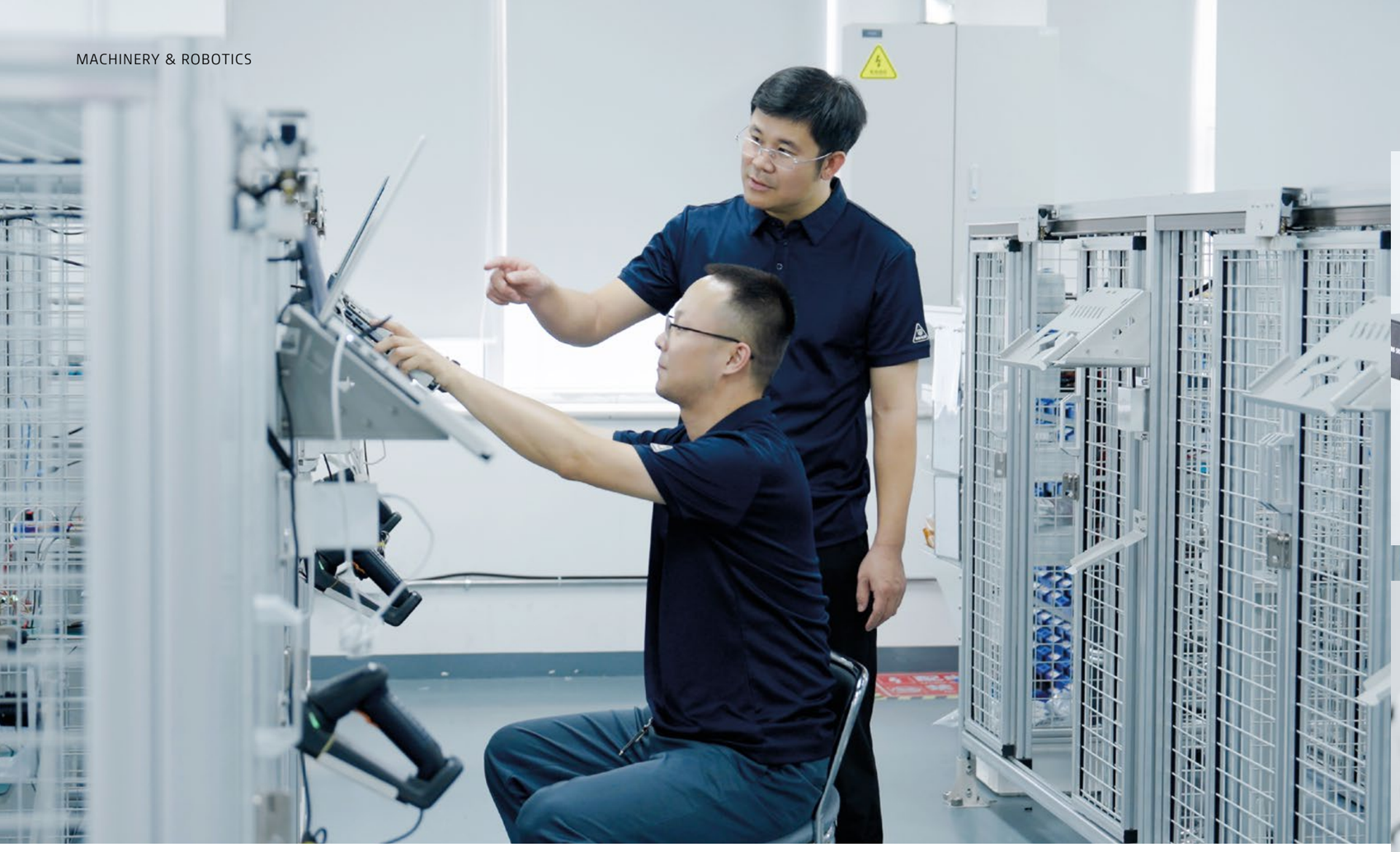
Humanoid robots are increasingly moving beyond laboratory environments and into real-world applications such as racetracks and factory floors. The question is no longer simply whether they can move, but whether their movements are stable, accurate, and repeatable. For X-Humanoid, officially known as the Beijing Innovation Center of Humanoid Robotics, this has become a question of measurable quality. What distinguishes a robot that can complete a half-marathon from one that can simply run is not just the sophistication of its algorithms, but a quantifiable and traceable set of quality standards that governs how reliably it performs.

In 2025, Tien Kung Ultra, a humanoid robot developed by X-Humanoid, won titles at the world's first humanoid robot half-marathon and at the World Humanoid Robot Games. Yet more important than the titles are the fundamentals behind them: the angle of every leg lift, the trajectory of every landing, and the repeatability of every joint. Once invisible, these fundamentals are now being translated into traceable precision data.

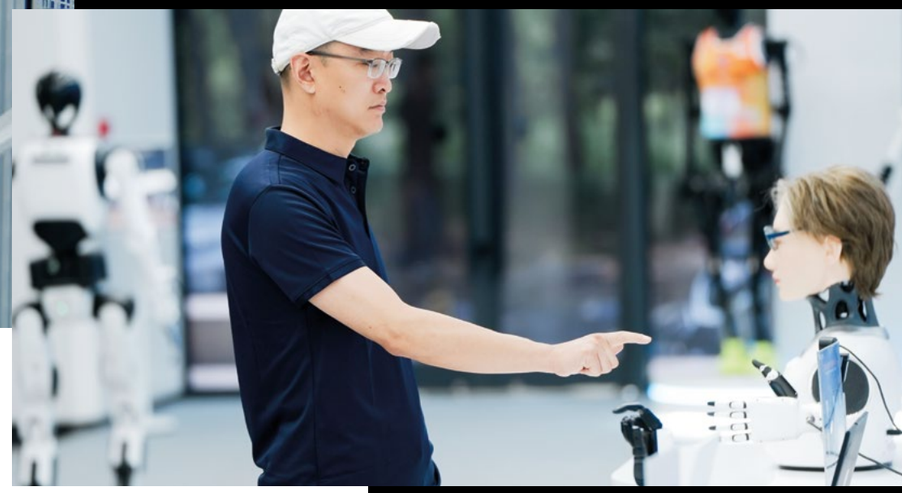
Detailed motion analysis is key for development

As X-Humanoid advanced its motion-control algorithms, its R&D team encountered a critical bottleneck: it lacked a high-precision external measurement system to verify how closely the robot's actual motion matched the commanded trajectory. *"In the past, all we had was the naked eye. We could judge whether the robot had completed a movement, but we couldn't quantify the height and angle of an arm swing, the height of a leg lift, or the trajectory of the movement as a whole,"* says Zhen Liu, a system R&D test engineer at X-Humanoid.

MACHINERY & ROBOTICS







ZEISS ARAMIS helped the team establish a quantitative feedback loop for motion development. If Robot A pushes itself up with its elbow joint at 40 degrees while Robot B does so at 45 degrees, both may still be able to stand up, but the difference in the data reveals an inconsistency in the robot's motion-control algorithm that needs to be resolved. *"Without this system, all we could see was that the robot stood up — not how it stood up,"* explains Liu.

The non-contact optical 3D measuring system records displacement, strain, and deformation with sub-pixel accuracy, enabling the team to capture precise, real-time trajectory and deformation data for every joint and other critical areas while the robot is in motion.

Part quality defines the robot's service life

But reliable motion does not begin with the assembled robot alone. As humanoid robots move closer to production, the same logic extends from motion analysis to part quality. Joint modules are becoming increasingly compact and complex, making them highly sensitive to deviations in quality: even 0.001 mm can affect a robot's motion trajectory and service life.

Here, coordinate measuring technology adds a second layer of quality assurance. ZEISS coordinate measuring machines inspect profile, lead, pitch, and key dimensional characteristics of roller screws with high precision and in multiple dimensions in a single setup. This helps ensure that critical joint components meet the requirements for stable, repeatable robot motion before the modules are assembled.

"With a humanoid robot, incoming parts and materials, the manufacturing process, and the robot body itself all feed into unit-to-unit consistency," says Zhen Liu. Together, ZEISS ARAMIS and coordinate measuring machines close the quality loop: coordinate measuring technology verifies the precision of the components that make controlled movement possible, while ZEISS ARAMIS validates the resulting motion performance after assembly. As this quality loop moves into production, motion performance becomes a core dimension of end-of-line inspection. For X-Humanoid, metrology is becoming the foundation for moving from promising prototypes to consistent, measurable performance in real-world applications.



The new era of metrology

ZEISS TALOS reshapes quality control in production

Manufacturers of medium-sized and large parts have long had to choose between speed, reach, flexibility, and metrological accuracy. Currently available robots move fast and reach far, but fall short when precision matters. Additional trackers, markers, or reference points are necessary, but they also significantly add complexity. ZEISS TALOS resolves the inherent trade-offs: this new metrology robot brings speed, reach, and absolute measurement accuracy together in one system. At the same time, ZEISS TALOS combines full-field measurement of large surfaces with the precise detection of complex features.



> *“ZEISS TALOS could bring about a lasting transformation in metrology.”*
>
> **Christian Besel,**
> Head of Geometric Conformity
> Series Quality, Audi AG



Absolute accuracy – integrated into the robot
While conventional industrial robots excel in repetitive positioning, repeatability alone does not guarantee accurate measurements. Many metrology tasks require an absolute accuracy below 100 µm – far beyond what standard robots achieve. To address this challenge, ZEISS dedicated five years to developing an innovative solution. This new system combines metrology-grade accuracy with flexible robot kinematics and a new optical sensor for both full-field surface and precise feature measurements. It reaches absolute accuracy below 100 µm at a reach of 3.30 meters.

Ready for immediate use and without limitations
ZEISS TALOS determines the robot’s position without external tracking systems or reference markers. This enables measurements in areas that line-of-sight systems find difficult to access and minimizes the hardware that must be installed, maintained, and monitored. The system combines structural mechanics, ZEISS encoder technology, sensors, and algorithms, including temperature compensation. The metrology robot can be used in various industries, such as the automotive and aerospace industries, near production, or offline in a measurement room.

Feature and surface measurement in one system
A key trade-off in optical metrology is choosing between fast surface digitization and precise feature measurement. ZEISS TALOS is designed for both: its compact blue-light sensor quickly digitizes large areas for geometry analysis while also measuring functional and positional features such as holes, edges, and threads – even in hard-to-reach areas behind sheet metal. The feature flashes illuminate details from multiple angles, improving reliable recognition of small and complex features crucial for process monitoring.

The measurement data can be used in the software ZEISS INSPECT for further analysis and process control. The measurement data of car bodies and components such as doors, aerostructures, or large giga-casting parts are displayed in high resolution. Virtual tools can be used to evaluate functional dimensions, gap sizes, and flushness.

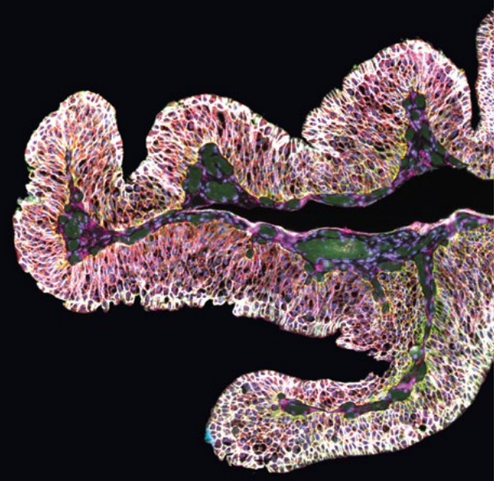


NEW

ZEISS TALOS
Explore the metrology robot for both feature and full-field surface measurements.

→ **Learn more about ZEISS TALOS**





From drug discovery to **patient impact**

Supporting medical innovation from early research to the final delivery system

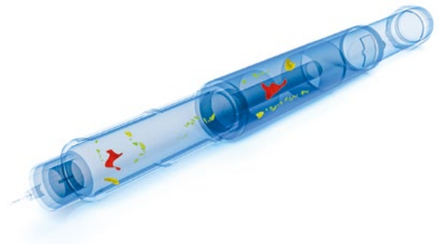
A breakthrough therapy is only valuable if it reaches the patient safely. Developing new treatments is only one part of the challenge. Researchers need to understand disease mechanisms, developers must prove safety and efficacy, and manufacturers have to ensure every product meets strict quality requirements. Across this journey, success depends on one constant: turning reliable insights into trusted outcomes.



> *The real challenge is delivering innovation consistently, reliably and at scale.*



Dr. Claus Hermannstädter,
Head of Customer Segment Medical,
ZEISS Research & Quality Solutions



The journey begins long before a therapy reaches the market. Advanced imaging technologies help scientists explore biological processes, understand cellular interactions, and assess responses to potential treatments. From tumor research to organoid models, reproducible quantitative data supports better decisions throughout drug development. The slide scanning microscope ZEISS Axioscan 7 enables automated imaging of entire tissue sections and larger sample series, turning biological complexity into reliable insights. *"Innovation starts with discovery. Patient trust is earned through quality,"* says Molly McQuilken, PhD, Global Head of Sales Biotech/Pharma at ZEISS.

Discovery is only the first step

Before a therapy reaches the market, promising findings must become robust evidence and scalable processes. Clinical validation, regulatory approval, and manufacturing require consistent results, traceable workflows, and reliable analysis. The focus also expands beyond the drug itself: its container and delivery system must protect the formulation and administer the intended quantity safely.

Pharmaceutical containers and delivery systems, such as vials, cartridges, pre-filled syringes, and inhalers, must be checked for critical dimensions, hidden defects, and correct assembly. With ZEISS METROTOM, computed tomography reveals complete components and internal structures non-destructively. Combined with AI-supported analysis, these insights can also answer highly specific questions about the product itself. In a powder inhaler, for instance, Volume Inspection AI for ZEISS INSPECT X-Ray can segment the powder inside each pocket, compare fill levels, and verify the overall amount present – enabling faster, more reproducible evaluation without dismantling the device.

Together, these technologies support different stages of the same journey. They help scientists understand disease and accelerate therapy development while enabling manufacturers to produce innovations consistently, protect each dose, and deliver it safely to patients. Innovation does not end in the laboratory, and reliable performance does not start on the production line. From the first biological insight to the final container or delivery system, progress depends on transforming knowledge into confidence and scientific breakthroughs into real-world patient outcomes.





AI's energy equation

Computing power as a new stress test for power supply

Artificial intelligence is expanding at a pace that turns computing power into an energy challenge. Every new model, server cluster, and data center raises the same question: how can power be supplied reliably, efficiently, and at scale?

A new scale of energy demand makes hybrid supply essential
The boom in artificial intelligence is rewriting the rules of energy supply. New data centers concentrate enormous computing density, cooling loads, and power demand in single locations. For operators, utilities, and regions, energy is becoming a decisive site factor. Availability, redundancy, and scalability increasingly determine where AI capacity can grow.

But more grid capacity alone will not be enough. AI data centers need hybrid energy architectures: central supply where it is available, decentralized solutions where grid connections are limited, peak loads are critical or downtime is not an option. Backup systems therefore move from the margins to the core. Generators provide proven security for critical facilities like hospitals, while battery storage bridges short-term outages, cushions peak loads and stabilizes operations when grid quality fluctuates.



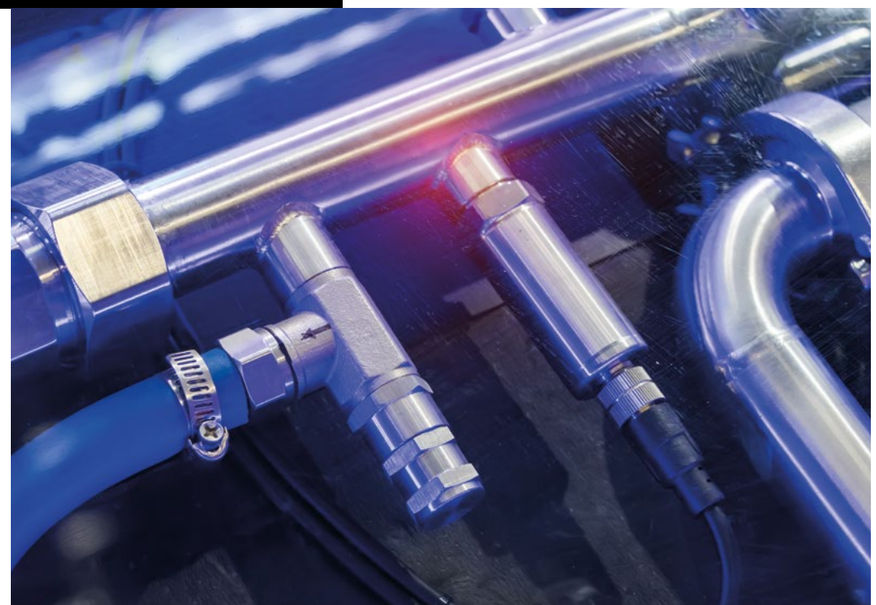
Turbines and waste heat as part of the system
Gas and steam turbines are also moving back into focus. Gas turbines can deliver power quickly and bridge gaps when grid expansion lags behind demand, while steam turbines use energy that would otherwise be lost. In combination with heat exchangers, heat pumps and cooling systems, waste heat becomes a resource. Cooling is no longer just a cost factor; it becomes part of the energy system.

The grid as a critical bottleneck
At the same time, the grid is becoming a bottleneck. Transmission and distribution networks take time to expand, while new data center projects move much faster. Grid connections, substations and key components such as transformers, insulators, and converters cannot be scaled overnight, yet they decide whether power reaches a site in the required quantity, quality, and stability. AI data centers expose a fundamental reality of digitalization: the future of computing depends on industrial hardware, resilient supply chains, and the physical reinforcement of the grid.

Heating and cooling move to the center
Heating and cooling are evolving from supporting functions into strategic disciplines. The higher the computing density, the more important precise heat exchangers, liquid cooling, and heat pumps become. They keep systems stable, reduce energy use, and open paths for heat recovery. In urban or industrial clusters, waste heat can feed local networks — for buildings, processes, or downstream applications. The key is to view cooling not in isolation, but as an interface between IT, energy, and infrastructure.

Planning AI means planning energy
The power appetite of AI data centers is more than a stress test for electricity markets. It is accelerating new supply concepts in which central grids are complemented by decentralized generation, storage, flexible load management, and integrated heating and cooling. Planning AI infrastructure increasingly means planning energy infrastructure: computing power no longer begins in the server rack, but with generators, turbines, grids, transformers, cooling, and heat recovery.

What is emerging is a new industrial equation for the AI era. Computing power, energy availability and thermal management are becoming inseparable. The next wave of digital infrastructure will be defined not only by processing capacity, but by the systems that keep it powered, cooled and resilient. The future of AI will be built as much in energy systems as in server racks.



Wiwynn

Precision for the AI era



Manufacturing reliable hardware for trusted AI infrastructure

As artificial intelligence (AI) reshapes data centers worldwide, server manufacturers face new complexity: higher computing power, tighter thermal management requirements, and rising reliability expectations. For Wiwynn, a leading provider of high-performance cloud and AI server solutions, this means producing complex server systems with reliable cooling, precise rack structures, and consistent high standards. To meet these demands, the company uses ZEISS metrology and inspection technologies to detect deviations early, improve process control, and support trusted AI infrastructure globally.



“By consistently delivering value, responsiveness and cutting-edge solutions, we aim to not only sustain but also expand our partnership with the world-leading cloud service providers.”

Robin Wang,
Vice President, Wiwynn

The rapid growth of artificial intelligence is increasing demand for high-performance AI servers. These systems generate enormous heat, which is why the industry is moving from traditional air cooling to advanced liquid cooling. This makes server operation more stable and efficient, but it also raises production requirements. Even small assembly errors or structural defects can cause leaks, short circuits, or system downtime, with serious consequences for cloud data centers and enterprise users.

Rack structural designs pose challenges

Modern AI servers often feature large chassis and tall rack designs to accommodate more computing modules and cooling components. However, these compact, rigid structures can deform during stamping, assembly, or long-term operation. Even small deviations can compromise structural rack integrity, disrupt the accurate fit of internal components, and ultimately undermine the operational stability and sustained performance of high-load AI servers. To address these industry-wide pain points, leading server manufacturer Wiwynn has adopted cutting-edge metrology from ZEISS.

High-precision inspection technologies enable Wiwynn to conduct full-dimensional, microscopic inspection and data verification throughout the production process. This helps reduce defects, improve yield, and ensure that finished products meet design standards. These technological innovations have laid a solid foundation for the industry to develop more reliable, efficient, and durable hardware solutions for the rapidly evolving AI server ecosystem.

A global framework for consistent quality

Wiwynn’s long-term cooperation with ZEISS focuses on building a unified global quality management framework. Mr. Robin Wang, Vice President of Wiwynn Corporation, emphasizes that standardized global quality systems, real-time production data monitoring, and close supplier collaboration are key to the company’s competitiveness.

By ensuring quality from incoming inspection to final delivery, Wiwynn strengthens its partnerships with global cloud service providers and delivers reliable AI server hardware for the intelligent computing industry.



ArcelorMittal

Smarter **steel**



Development and evaluation of steel with AI-powered software

Mankind has been using steel for about 4,500 years, and its applications are more diverse than ever, from bottle caps to skyscrapers. As one of the few materials that can be fully reused and recycled, steel will play a key role in building a circular economy. Today, ArcelorMittal, the world's leading steel and mining company, is focusing on creating smarter steels that are cleaner, stronger, and more reusable.

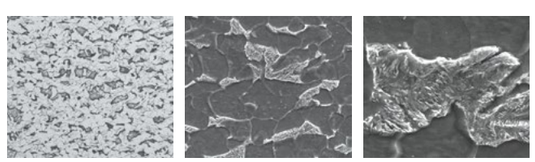


> *"We are using ZEISS ZEN Intellesis for autosegmentation and improved analysis of our second phase constituents in steel. This technology is changing the way we characterize materials, gaining both speed and reliability at the same time."*
>
> **Fernando Generoso,**
> Product Development Specialist,
> ArcelorMittal

At ArcelorMittal in Tubarão, Brazil, Henrique Severiano and Fernando Generoso use connected microscopy and AI-powered software to characterize steels and support product development. Metallurgical knowledge helps define alloys and process parameters for specific customer needs, while quality control ensures that each steel meets its intended application.

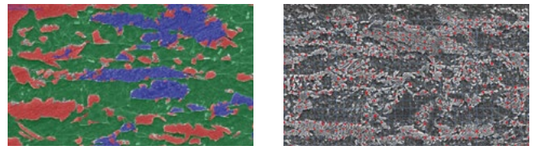
Identify microstructures in second phase constituents

Second phase constituents in steel can be selectively colored by corrosion or thin-film formation using chemical etchants, making them easier to detect and quantify. Combining light microscopy and scanning electron microscopy (SEM) is fundamental for this task, but SEM images can contain artifacts, noise, and subtle texture differences that challenge traditional image analysis. Machine learning-based classification methods are well suited to overcoming traditional image-processing challenges. They enable the bridging of scales, support reliable and rapid automation, and are more tolerant of noise. The biggest advantage is that they can distinguish features that show little difference in the grayscale values of SEM images.



Investigation of microstructure. Ferritic-bainitic steel; etchant: 2% Nital reagent. Light microscopy image, magnification 500× (left). SEM images: magnification 3,000× (center); bainite, magnification 10,000× (right).

Using ZEISS ZEN Intellesis, ArcelorMittal applies machine learning-based segmentation to SEM images. The software assigns false colors to different phases and textures, enabling faster, more reliable analysis of complex microstructures over large areas. This helps improve product development, failure analysis, and process simulation as steel production becomes more advanced.



Bainite, Martensite, and Ferrite segmentation: The dots used in the grid apply two different colors to precisely distinguish the phases within the same microstructure. ZEISS ZEN Intellesis distinguishes the steel phases through these colors. Primary phase: Ferrite (green); secondary phases: Bainite (blue) and Martensite (red).

Future applications and trends in steel development

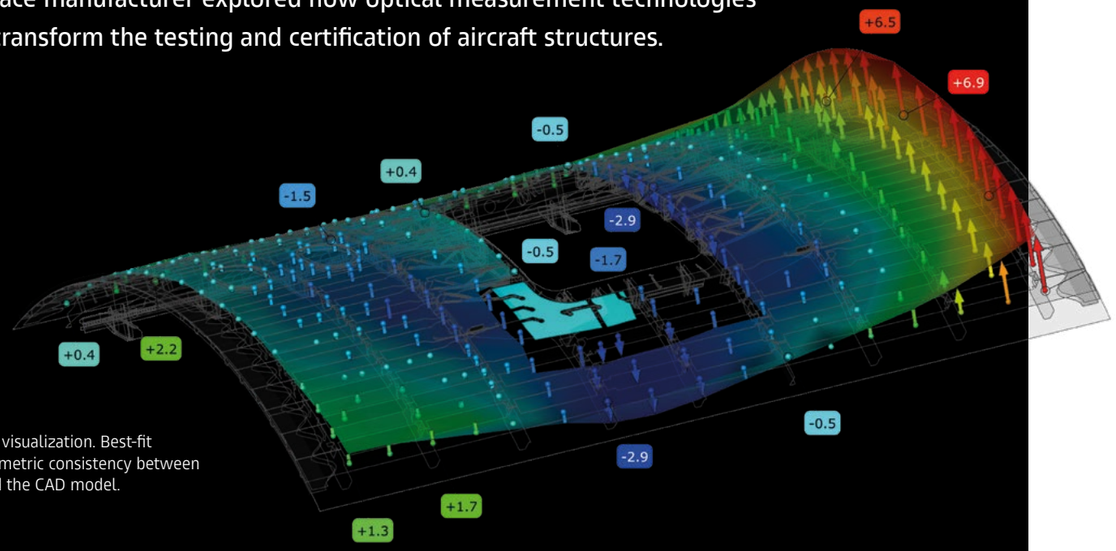
Future steel development will increasingly combine steel with polymers, alloys, and ceramics to enhance performance while reducing environmental impact. ArcelorMittal is also transforming production to support its commitment to net-zero carbon emissions by 2050, including its XCarb™ initiatives.

Applus+ IMA and Airbus

Faster testing, deeper insights

Reduce structural test times while generating richer data for aircraft certification

Can structural testing be made faster, more cost-effective, and more informative at the same time? This question was at the heart of a federally funded research project led by Airbus in Hamburg. Together with testing specialist Applus+ IMA and measurement technology partner ZEISS, the aerospace manufacturer explored how optical measurement technologies could transform the testing and certification of aircraft structures.



Full-field displacement visualization. Best-fit alignment ensures geometric consistency between the measured shell and the CAD model.

Structural testing of a quarter-shell element
The project focused on a quarter-shell fuselage section featuring a door cutout. Door cutouts are a well-known structural weak point in aircraft fuselages and can cause instabilities that must be thoroughly analyzed to verify structural integrity. Traditionally, preparing such tests involves installing large numbers of strain gauges, displacement sensors, and other tactile measuring devices. Depending on the test setup, preparation can take days or even weeks and requires exceptional precision, as even slight sensor positioning errors can lead to inaccurate or unusable data.

High-resolution data in real time
To address these challenges, the project team replaced many traditional tactile sensors with the optical 3D measurement system ZEISS ARAMIS. The camera-based technology captures full-field deformation, displacement, and strain data in real time, providing engineers with a detailed view of structural behavior under load.

Improved insights into failure mechanisms
The benefits extended beyond speed. Because ZEISS ARAMIS captures data across a structure's entire surface, engineers can detect unexpected strain concentrations and deformation patterns that might otherwise go undetected. These insights improve the understanding of structural behavior and help validate simulation models more effectively. Furthermore, combining optical measurement, photogrammetry, and 3D scanning created a reliable spatial reference system that ensured accurate, traceable results throughout the testing process.

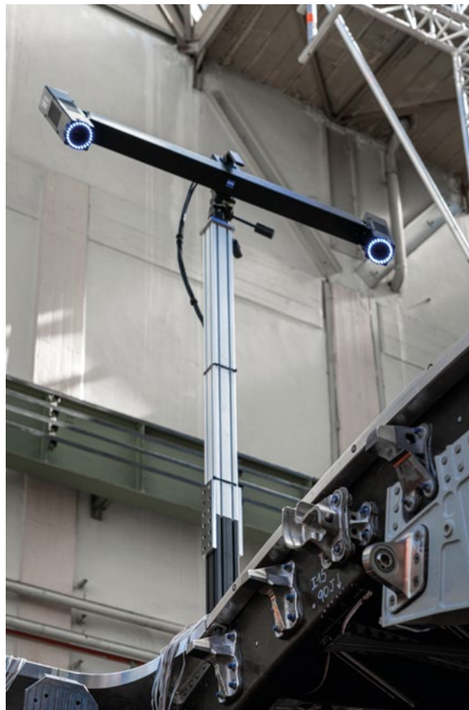
All measurement data were managed within a unified software environment. This streamlined workflow simplified data processing, documentation, and reporting while improving traceability, and supporting the creation of digital twins for future engineering applications.

Deeper insights into structural performance
For Airbus, the project represents an important step toward more efficient testing and certification processes. For Applus+ IMA, the practical benefits are already evident. *"Regardless of the test object, setup time is significantly shorter than that of conventional methods. At the same time, the system delivers a wealth of valuable data,"* says Dr. Silvio Nebel, Head of Aerospace at Applus+ IMA.

As aircraft structures become increasingly complex, access to faster, higher-quality data is becoming a key advantage. This project demonstrates how optical measurement technologies can help aerospace manufacturers accelerate development cycles, streamline certification, and gain deeper insights into structural performance – all while reducing testing effort.

Test bench at Applus+ IMA. The tested shell is made of carbon fiber-reinforced polymer (CFRP), with door cutouts reinforced with aluminum components. The part measures approximately six by four meters.





From AI hype to industrial impact



Picture ©: Nina Stiller

Why manufacturers should redesign their processes around AI

By Dr. Stefan Wamsler,
Head of Metrology Application Software,
ZEISS Research & Quality Solutions

Artificial intelligence dominates headlines, investment strategies, and technology roadmaps. Yet one question remains: How does measurable impact emerge from general-purpose-technologies? History offers an interesting perspective. Steam power, electricity, computers, and now AI all follow a similar pattern. Technology alone doesn't create impact. That happens when companies redesign their processes around it. The difference today is speed. Each generation of technology reaches business impact faster than the one before.

In quality assurance, this means moving beyond rule-based inspection toward integrated intelligence in production. The focus shifts from executing individual quality steps to designing systems that connect data, decisions, and production outcomes, and from traditional rule sets to trusted AI. What does that mean for the people working in metrology? Their role evolves as well: from measuring, documenting, and calibrating toward supervising AI-driven processes, validating results, ensuring traceability, and making risk-based quality decisions.

However, AI alone does not create impact. Success depends on more drivers: AI model (~ 10%), data and infrastructure (~ 20%), and change across processes, people, and priorities (~ 70%).* While general-purpose technology provides the foundation, real value comes from the right context and a willingness to rethink established processes. Reliability remains essential: as a recent survey shows, inaccuracy is still the biggest challenge when applying AI in organizations.** This makes trustworthy AI a core enabler for scale – especially in manufacturing, where predictability, stability, and precision are crucial. Together with customers and partners, ZEISS has shaped quality assurance for more than 100 years through different waves of technological change. Now, we are confident and excited to help shape the future of "autonomous metrology enabled by AI" – and to create trusted AI through reliable solutions.

So, let's have a closer look at how our industrial AI solutions turn this principle into practice, enabling manufacturers to adapt AI to their specific inspection challenges.

* Boston Consulting Group (BCG): The Leader's Guide to Transforming with AI, December 12, 2024. Available at: https://www.bcg.com/featured-insights/the-leaders-guide-to-transforming-with-ai (accessed July 2026)

** McKinsey & Company, The state of AI in 2025: Agents, innovation, and transformation, McKinsey Global Survey on AI, conducted June 25–July 29, 2025, n = 1,993 respondents.

When quality **meets AI**

How ZEISS Quality AI makes inspection intelligent, fast and reliable

- 75%

Using AI models can shorten casting inspection cycle times by up to 75%.*

~ ¼

AI-assisted CT inspection can reduce stator hairpin weld inspection from eight hours to less than two.*

~ 10×

AI-driven analysis can inspect medical implants up to ten times faster than traditional methods.*

Artificial intelligence is becoming an operational reality in quality assurance – but industrial AI needs workflows built for real inspection challenges. ZEISS Quality AI is a software solution for AI-powered data analysis and helps manufacturers transform inspection data into faster and more reliable quality decisions. Integrated into ZEISS INSPECT workflows, it combines cloud-based collaborative AI model training for central optimization, global scaling and continuous improvement with AI-powered inspection running directly within the production environment.

Starting with volume data inspection, ZEISS Quality AI provides a scalable platform for training AI models and extending industrial AI across sensor technologies. Customers can start with ready-to-use models for applications such as batteries, casting, hairpins, or medical implants – or train their own for more specific requirements.

*Referring to specific use cases



NEW

> *As CT specialists, we need solutions that can be adapted to different inspection tasks. ZEISS Quality AI allows us to easily train our own AI models, enabling us to reliably and efficiently detect even complex quality characteristics and process deviations.*



Stefan Tux,
Managing Director,
eTIS-Kassel GmbH

From measurement to integrated intelligence
As inspection moves closer to the production line, cycle times must become shorter while detection becomes more demanding. In X-ray inspection, scatter, noise and beam hardening challenge conventional methods. In visual metrology applications, complex lighting, reflective surfaces, and strong textures add further complexity. AI helps deliver robust recognition where simple gray-value approaches reach their limits.

"This becomes particularly valuable in battery inspection, where inline and at-line processes must detect critical defects quickly and reliably," says Dr. Christian Wojek, Head of AI at ZEISS Research & Quality Solutions. *"By applying AI directly in high-throughput workflows, manufacturers can make faster decisions, achieve more consistent evaluations and strengthen process control at industrial scale."*

From models to measurable results
AI only creates value when it works in real inspection workflows. ZEISS Quality AI connects model development with real inspection workflows, which enables manufacturers to validate performance before deployment. Evaluation metrics reveal accuracy, reliability, and potential failure scenarios early on, helping teams to identify where additional data adds the most value. By linking training, validation, and inspection in one workflow, ZEISS Quality AI turns industrial AI into measurable quality impact.

"Reliable AI starts long before the first production deployment," says Wojek. *"The earlier you understand where a model performs well – and where it does not – the faster you create real value from AI."*

Learn more about ZEISS Quality AI

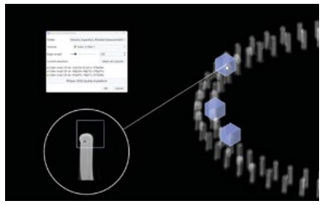
Stronger detection, greater confidence

+48%

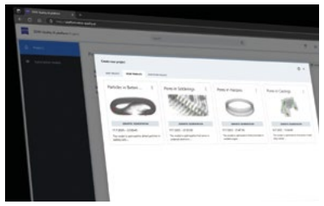
Compared to classical algorithms, advanced AI can improve porosity recognition performance in stator hairpin welds at same false positive rate.*

*Tschechne et al.: An AI-based 450-kV Computed Tomography Solution for Hairpin Welding Inspection, 13th Conference on Industrial Computed Tomography, Wels, Austria (iCT 2024)

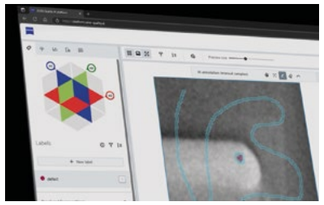
Steps of training an AI model



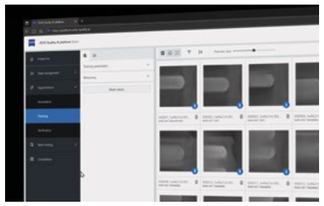
1. Define training data
Visualize data and mark relevant regions.



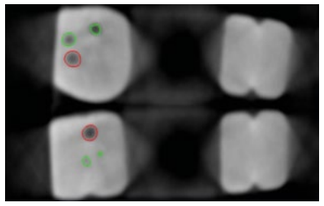
2. Select model
Choose a pre-trained model or start training.



3. Annotate relevant areas
Mark relevant image areas and refine annotations.



4. Train model
Train and download the optimized model.



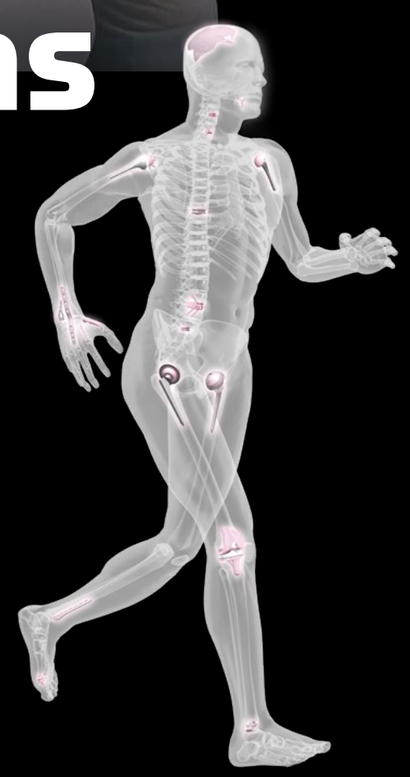
5. Run inspection
Detect defects automatically in local production environment.

CeramTec

From data to decisions

How CeramTec turns complexity into quality

With more than 120 years of experience, CeramTec is one of the world's leading manufacturers of advanced ceramics and innovative high-performance materials. The company develops and produces custom-engineered components that outperform conventional materials in some of the most demanding applications. Operating in both the medical and industrial sectors, the company serves markets with increasing requirements for uncompromising quality. To meet these requirements, CeramTec is driving its digital transformation forward, and Dr. Danny Krautz, Chief Digital Officer, is sharing what they have learned.





Photos: CeramTec

CeramTec's portfolio spans more than 10,000 products and components for medical technology and industrial markets worldwide. In medical technology, the company sets global standards with solutions for hip prostheses, orthopedic implants, dental implants, and medical devices. In industry, leading companies rely on its materials for high-precision parts used in automotive, electronics, and semiconductor applications.

Across these markets, customer expectations are rising. Components must not only meet the highest standards for precision, reliability, and quality; they also increasingly need to be supported by transparent processes, reliable data and clear proof of performance. For a manufacturer operating in highly regulated medical environments as well as complex industrial value chains, digital transformation is becoming essential to manage complexity, ensure traceability, and make better decisions faster.

High-quality data as the foundation for digital transformation

This is the context in which CeramTec is advancing its digital transformation: not by pursuing artificial intelligence as an objective in itself, but by building the data foundation needed to make information accessible, trustworthy, and actionable across the organization. *"Most data-driven projects fail because of the missing foundation,"* says Dr. Danny Krautz. For him, that foundation starts with understanding which data truly matters.

Modern metrology and imaging technologies help generate the high-quality measurement data needed to support this approach. Combined with domain expertise and structured data management, they provide the foundation for AI-driven analyses that help identify patterns, improve processes, and continuously enhance quality.

CeramTec's unique position across both medical and industrial markets creates valuable synergies. While medical applications demand strict validation and traceability, industrial manufacturing emphasizes flexibility and efficiency. Together, these perspectives strengthen the company's approach to quality management.

AI as an efficiency booster for experts

But digital transformation starts with people. CeramTec sees AI as a tool that supports experts rather than replacing them. By making information easier to access and interpret, teams can spend less time searching for data and more time applying their expertise where it creates value. Collaboration – both internally and with partners – becomes a critical driver in turning data into real customer value.

For CeramTec, digital transformation is ultimately about more than data, algorithms, or technology. It is about creating trust. Trust in processes, trust in decisions, and trust in products that are used in some of the world's most demanding applications.



"At the end of the day, it's all about the customer."

Dr. Danny Krautz,
Chief Digital Officer, CeramTec

Watch the full interview here



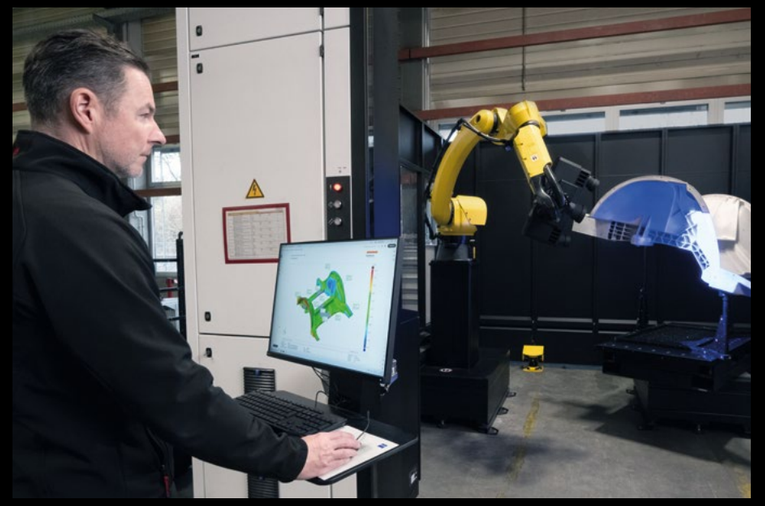
Handtmann

Champions league quality in megacasting

Structural components from a single cast



As one of the first foundries in Europe to invest in megacasting, Handtmann has positioned itself at the forefront of automotive manufacturing. The technology enables large, highly integrated aluminum components to be produced in a single shot, creating new opportunities for part design and production. At the same time, it brings entirely new quality assurance challenges. To ensure precision throughout the process, the German company combines optical, tactile, and X-ray measurement technologies.



> *When it comes to megacasting, we are playing in the Champions League, also in terms of requirements – and for that we need ZEISS as our partner.*

Sandro Langer,
Head of Quality Control,
Handtmann

One cast, many benefits

Instead of casting and machining many small components and then assembling them in several stages, megacasting produces a complex structural component in a single shot. This results in significant advantages. The production time is significantly shortened, as a complete module is now made in a single step instead of many parts being produced, temporarily stored, and welded. Additionally, the technology enables significant weight savings by eliminating joining points, reinforcements, and overlapping material zones. Less mass means more range for electric vehicles and thus a tangible competitive advantage.

At the same time, megacasting also brings new challenges. Large, highly integrated components are more sensitive to process fluctuations. Even in the casting process itself, temperature distribution, filling behavior, and solidification have a greater impact on the result. Whereas a smaller component can compensate for certain fluctuations, large castings immediately run the risk of warping, unevenness, or dimensional deviations.

From hidden defects to functional precision: Quality strategy in megacasting

The transition to megacastings also pushes inspection technology into new territory, as established processes and equipment reach their physical and technical limits once components span several meters. Sandro Langer, head of quality control, explains: *"For megacasting, we need larger devices, new processes, and a quality logic that is designed for fast, understandable feedback."* In the foundry's measuring room, the company uses several quality solutions from ZEISS.

The 2D X-ray system ZEISS OMNIA GC enables a complete internal inspection of large castings without having to destroy them. The system detects porosity, shrinkages, and other defects throughout the entire component volume. This supports early decisions on further processing. The automated 3D measurement system ZEISS ScanBox captures the full component surface and compares actual 3D coordinates with CAD data, making warping and dimensional deviations immediately visible. Automated robot-based operation ensures fast, reproducible results – ideal for quick feedback loops. Finally, the coordinate measuring machine ZEISS PRISMO enables high-precision tactile measurements even on stationary, large megacastings. For high-precision tactile inspection, ZEISS PRISMO verifies critical functional dimensions and machining tolerances on large megacastings, supporting OEM approvals and subsequent machining processes.

Ultimately, it was also crucial that most automotive manufacturers themselves work with ZEISS. As a benefit, measurement coordination becomes easier, results more comparable, and approvals faster. Sandro Langer sums it up as follows: *"When it comes to megacasting, we are playing in the Champions League, also in terms of requirements – and for that we need ZEISS as our partner."*

Watch the video:
Our visit to Handtmann

Makers
around the world

#**HandsOn**Metrology
across the product lifecycle

At #**HandsOn**Metrology, we know that makers face tough quality challenges every day. That's why we've brought together a unique portfolio of easy-to-use solutions to address these diverse demands: From handheld laser scanners for quick on-site troubleshooting to compact fringe projection systems for accurate part inspection, X-ray solutions for deep insights into hidden manufacturing errors, and automated systems for repeatable measurement results – all running on ZEISS INSPECT metrology software.

With the latest addition of ZEISS Smartzoom 100, makers gain access to a smart, all-in-one digital microscope for fast visual inspection.

Follow us around the globe to meet makers from different industries. See how they tackle various challenges of each product lifecycle stage by choosing the right 3D metrology solution.

→ **Experience #HandsOnMetrology**

Andreas Bruns
Zerspanungstechnik

Advancing aerospace development **with 3D scanning**



Our journey along the manufacturing process begins with Andreas Bruns Zerspanungstechnik, a traditional German contract manufacturer that has grown from a small garage into a trusted manufacturer of precision components for industries like aerospace. The company works closely with universities in R&D, transitioning complex parts from CAD designs to cutting tools under rigorous oversight. 3D scanning, powered by the semi-automated ZEISS ScanPort with ZEISS ATOS Q, plays a key role in validating prototypes, comparing designs to reality, and streamlining iterations. This advanced solution has become a cornerstone of their process, enabling faster production and high-quality results.



Maped

Empowering the **makers of the future**

A couple of thousand kilometers across the Atlantic Ocean, the global manufacturer of school supplies, Maped, transforms everyday items into engineering excellence. The Mexico-based branch specializes in high-volume production under strict safety and cost requirements. To meet these demands, prototypes and molded parts are digitized, inspected, and refined quickly. Their go-to for quality control is the semi-automated fringe projection technology with ZEISS ScanPort with ZEISS GOM Scan 1. With the ability to measure multiple parts simultaneously, the system accelerates defect detection in parts, processes, and molds, ensuring students receive safe, reliable, and high-quality scissors, sharpeners, and more.



SEW-EURODRIVE

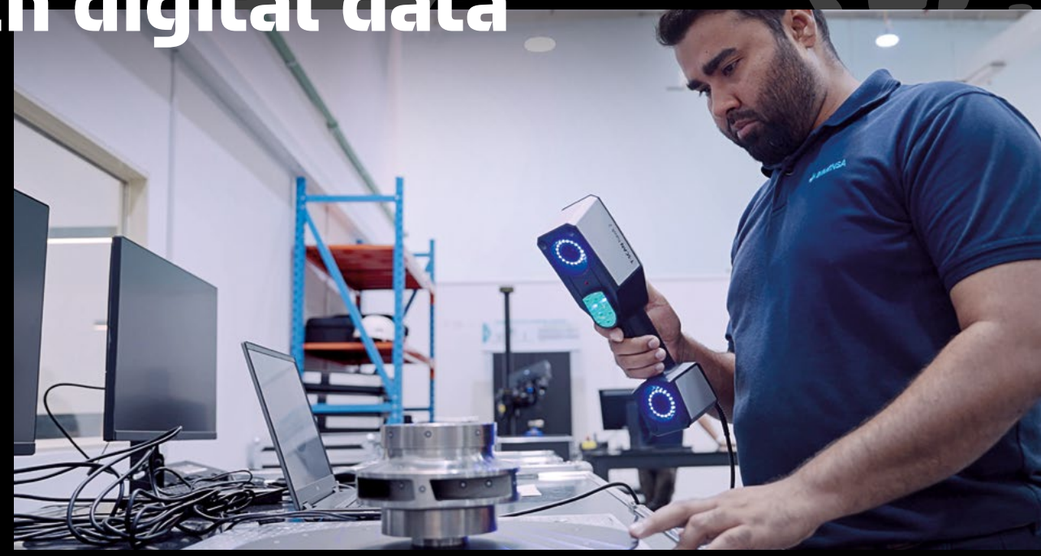
Driving innovation through **reverse engineering**

SEW-EURODRIVE stands for reliable drive technology in countless factories worldwide – from modular gearmotors to intelligent automation solutions. In this environment, every mechanical component must fit, function, and integrate seamlessly, even when machines are customized, upgraded or repaired under time pressure. Within its industrial gear unit operations, SEW-EURODRIVE uses ZEISS T-SCAN hawk 2 in service and incoming goods inspection. The handheld 3D scanner captures component geometries precisely and generates reliable 3D data for reverse engineering and quality checks.

For the company's R&D and service teams, this technology closes critical gaps in the product lifecycle. It supports the development of new drive solutions tailored to real-world constraints, ensures transparency in retrofit projects, and enables confident replication of worn parts. The result: faster engineering decisions, reduced downtime, and seamless operations across all company branches.

Immensa

Transforming supply chains **with digital data**



Lastly, we visit Immensa, a company transforming industrial supply chains in the Middle East by shifting traditional spare-part logistics to digital, on-demand manufacturing. Instead of warehousing thousands of components, customers from the power and energy sectors receive certified 3D-printed parts exactly when and where they are needed.

Using 3D scanners ZEISS T-SCAN hawk 2 and ZEISS ATOS Q, engineers digitize legacy parts and complex geometries that often exist only physically, without complete drawings or CAD data. The resulting 3D models form the foundation for design validation, process optimization, and quality assurance of additively manufactured components.

Across the product lifecycle, from first digitization of a spare part to serial on-demand production, metrology becomes a central enabler. Immensa verifies incoming reference parts, ensures printed components meet specifications, and documents every step for industrial customers in energy, utilities, and heavy industry.

By integrating 3D scanning solutions into their digital supply chain, physical inventories are transformed into reliable, data-driven manufacturing capacity, reducing downtime and cutting logistics costs.

Flexible 3D scanning transforms everyday workflows into powerful, data-driven solutions. From product development to high-volume inspection, reverse engineering, and on-demand manufacturing, #**HandsOn**Metrology empowers makers to tackle challenges with precision, efficiency, and innovation.

Whatever the challenge, let's do this together.



LYXQL

Keeping the **turbines turning**

Measurement confidence for reliable wind power

As wind turbines become larger and more powerful, the quality of critical components becomes decisive for long-term performance and reliability. With ZEISS metrology, LYXQL verifies critical slewing bearings with the precision required for long-term turbine operation.



Where wind power raises the bar

Wind energy's rapid growth is reshaping the industrial value chain behind it. According to the Global Wind Energy Council, 117 gigawatts of new capacity were installed worldwide in 2024, evidence of the sector's momentum and the rising demands on turbine manufacturers. As turbines grow larger and more powerful, quality must be engineered, verified, and documented at component level.

The company Luoyang Xinqianglian Slewing Bearing Co., Ltd. (LYXQL) manufactures high-precision slewing bearings, which are essential for the operation and performance of wind turbines. They enable movement, absorb heavy loads, and support efficient operation over long service lives. Their role is decisive at the turbine's dynamic interfaces: yaw bearings align the nacelle with the wind, pitch bearings adjust the rotor blades, and main shaft bearings support stable power transmission. Across these applications, precision directly influences efficiency, uptime, and service life.

From bearing quality to turbine reliability

Even small deviations in critical components can have consequences beyond manufacturing. Component failures can reduce energy output, increase operating costs, and affect supply reliability. Precise measurement data helps reduce these risks early in production, turning metrology into a business-critical factor. *"The measurements and data obtained enabled us to optimize our production further and thus minimize the risk of subsequent failures and increased maintenance requirements for the bearings during operation,"* summarizes Gaoqiang Xiao, CEO of LYXQL.

Measuring complexity with confidence

Individual components of wind turbines – including slewing bearings – undergo rigorous certification processes. The challenge: how to measure these large, solid components in a way that is traceable and replicable. To meet the high-quality requirements, LYXQL inspects the slewing bearings before they are installed in wind turbines. *"Our largest coordinate measuring machine, the ZEISS MMZ G, is in daily use at our company. It offers an outstanding combination of performance, precision and reproducibility that meets our requirements for high-quality metrology technology,"* emphasizes Wu Jinghui, CMM application engineer at LYXQL.

By using the new system, LYXQL has reduced measuring time by 20 percent while improving transparency and consistency across inspection. For components exposed to harsh conditions after installation, this measurement confidence is essential. It turns inspection data into process stability, product reliability, and long-term trust.



Jian Sun, Head of Greater North Regional Sales at ZEISS Research & Quality Solutions China, underlines metrology's broader role in wind energy: *"ZEISS Research & Quality Solutions develops high-precision metrology technologies that are essential for quality assurance in the wind industry. What motivates me is the fact that we can contribute actively to the energy transition and global climate protection through our innovations."*

In wind energy, precision is more than a quality metric. It is a foundation for reliable power generation, long service life, and the confidence to scale renewable energy efficiently.

Watch the video: Our visit to LYXQL





Germanlitho

Next-gen vision

Inside the production and quality assurance of AI glasses



AI and AR glasses promise to bring digital intelligence directly into our field of view. Making them light, bright, and ready for everyday use depends on one thing in particular: extremely precise optical structures. Germanlitho, a Chinese specialist in nanoimprint innovation, is scaling this technology for industrial production – supported by ZEISS metrology.

Smart glasses are moving closer to everyday life. As AI becomes better at interpreting images, voice, and context in real time, glasses could become the interface large models need to interpret surroundings, support interaction, and deliver useful information directly in the user's field of view. But the devices can only become truly wearable if their optical systems remain compact, bright, and efficient. This places high demands on optical waveguides, extremely thin glass structures in the lenses that embed the light path into the glasses, making them better suited for lightweight devices that could one day replace conventional eyewear.

This is where nanoimprint lithography comes in: A prefabricated template is pressed into a coated substrate, transferring micro- and nanoscale patterns into the material. The method is cost-efficient and scalable, but only if the resulting structures can be measured and controlled with high precision.

Yet the same tiny structures that enable compact AI glasses also make production demanding. Gratings are the core components of diffractive waveguides: their shape determines how light travels through the waveguide and how efficiently images are displayed. Even small deviations in period, residual layer thickness, or depth can affect brightness, color performance, and image quality. For manufacturers, precise metrology is therefore not a final check but a prerequisite for stable, repeatable mass production.

Specialist in nanoimprint innovations

Based in Qingdao, Germanlitho develops nanoimprint solutions for applications such as optical waveguides, AR glasses, displays, medical diagnostics, and flexible electronics. For the company, reliable characterization has become a key enabler of innovation — from early development to industrial scale-up.

To secure nanoimprint quality across this process, Germanlitho uses a connected ZEISS metrology workflow. The confocal microscope ZEISS LSM 900 enables inspection from the millimeter to the nanometer scale, while ZEISS Crossbeam adds focused ion beam technology for precise cross-section analysis. Together, the systems help validate grating structures faster, reduce process risks, and prepare nanoimprint technology for scalable production. Instead of two weeks, the process now takes less than two hours.

The benefit goes beyond speed. Faster access to reliable data helps Germanlitho accelerate process development, support customer validation, and move toward standardized, automated characterization and future in-line solutions. For a fast-growing field that depends on precision at scale, this creates the confidence to turn nanoimprint innovation into industrial reality.

ZEISS Innovations

NEW



ZEISS Crossbeam 750 FIB-SEM

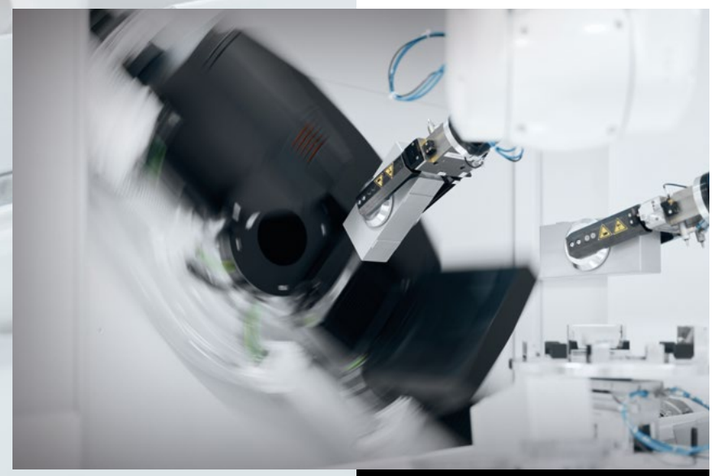
High-precision quality analysis at nanoscale

ZEISS Crossbeam 750 FIB-SEM combines focused ion beam and scanning electron microscopy to characterize materials and components at the nanoscale. With applications ranging from defect and failure analysis to 3D tomography, TEM sample preparation, and nanofabrication, it supports reliable quality assurance and process optimization across semiconductor, electronics, automotive, and advanced materials industries. The "See While You Mill" technology from ZEISS enables live imaging during material removal, improving endpoint detection, reducing sample damage, and ensuring reproducible results.

→ **Learn more about ZEISS Crossbeam 750 FIB-SEM**

In-line, **on time**





Automated computed tomography for complex quality decisions

The challenge of in-line computed tomography (CT) has always been time pressure. It must deliver highly precise three-dimensional information without slowing down the production line's cycle time. This conflict between speed and precision has long been the limit of the technology as traditional CT took minutes to hours to finish the analysis. A limit that is now being pushed back with ZEISS INRADIA 3D.

ZEISS INRADIA 3D integrates complex quality decisions into the pace of high-volume productions and combines speed, automation, and AI-based evaluation into a single technological ecosystem. Dr. Valentina Aloisi, Head of Product Management X-Ray, explains what this means for modern production.





Dr. Valentina Aloisi
Head of Product Management X-Ray, ZEISS Research & Quality Solutions

What had to change for CT to become relevant for complex in-line quality applications?
Dr. Valentina Aloisi: During the development of ZEISS INRADIA 3D, the challenge was to tailor CT to the pace of production. In a laboratory, you can optimize for maximum quality and accept longer inspection times. In in-line manufacturing, the question is different: how do we generate exactly the information needed to make a decision within the available cycle time?

A key component here is the system design, specifically, the path that a part follows within the system. The loading concept allows us to feed the components to be inspected into the system and unload them without having to turn the X-rays off. This allows us to make the best use of the X-ray time, which we improve even further by using a rotating "X-ray beam". Unlike traditional CT solutions, we do not move the part through the X-ray source and detector; instead, we move the "X-ray beam" continuously around the region of interest and use alternating robots to minimize the waiting time.

For which applications is this type of solution relevant?
Dr. Valentina Aloisi: Battery cells are an example because they combine high complexity, short cycle times, and strict quality requirements in production. In overhang inspection, for example, the relative positioning of the electrodes inside the cell is checked with tight tolerances in the order of tens of microns. In this case, the internal geometry is very critical, and 3D data ensures the conformity of the entire part.

In this application, quality data must be generated directly on the production line, automatically evaluated, and linked to a clear decision-making logic within seconds. Only in this way can manufacturers achieve a more solid foundation for process control, scrap reduction, and real-time traceability. This applies to any parts where internal features are critical to function, safety or performance.

Learn more about ZEISS INRADIA 3D

We know that CT data volumes can be enormous. How does AI help us to use this data efficiently?
Dr. Valentina Aloisi: In-line CT adds value when data is turned into decisions, which is why AI-based evaluation is essential. With our software solutions ZEISS INSPECT X-Ray and Volume Inspection AI, we integrate data acquisition, processing, analysis, reporting, and decision-making into a seamless workflow tailored to the customer's application.

We create individual AI models which are not generic black boxes. They can be trained for specific applications, defect patterns, and customer requirements and can process enormous data sets within seconds. Hardware and software thus work in synergy to provide our customers with a customized and reliable ecosystem for in-line CT inspection.

SOFTWARE

Beyond **measurement**

A scenario of a day in modern manufacturing



Alex, responsible for quality operations across several production sites, starts the day with the shift handover. His job now goes beyond verifying quality. It is to ensure that the right decisions are made at the right time. A few years ago, this meant paper reports, spreadsheets and lengthy discussions between shifts. Today, production indicators, machine status, inspection results and supplier information are available in a shared quality dashboard before the first meeting begins. Having all information in a single view enables up to 90% higher efficiency in accessing and analyzing quality data.

One item immediately catches his attention. Overnight, a supplier on another continent detected a subtle process shift. Everything remains within specification. No defects are found. No shipment is blocked. Yet the right people already know. Inspection results, process and supplier data are connected across the quality network. Before production even starts, teams are already evaluating impacts.

Production and quality as a joint process

Later that morning, Alex joins a global optimization meeting. For years, sites developed their own inspection programs and evaluation methods. Expertise existed everywhere, but much of it remained local. Today, approved inspection strategies and workflows are managed centrally and reused globally. Teams spend less time recreating solutions and more time improving processes, reducing engineering effort while ensuring consistent quality standards.

Shortly afterwards, a dashboard highlights a potential bottleneck. Not in production, but in the metrology process. Through standardized OPC UA connectivity, machine status, utilization and inspection capacity are visible alongside manufacturing KPIs. Production and quality are managed as one process. Inspection strategies adapt dynamically to process behavior. Stable characteristics require less attention, while critical changes trigger additional inspection activities. Resources are focused on where they create the greatest value.

From detection to prediction

Back at the desk, Alex opens the company's quality data platform. Measurement results, inspection reports, machine information and production data from multiple sites appear instantly in one view. AI-powered applications continuously analyze incoming information, identify anomalies and uncover relationships. What once required hours of manual analysis is now available in seconds. In selected applications, AI-supported inspection can dramatically accelerate evaluation cycles. As data collection, documentation and routine inspections become increasingly automated, quality specialists spend less time generating data and more time validating insights, assessing risks and ensuring traceability. Quality is moving from detection to prediction.

The true value of quality

As Alex leaves the plant, he reflects on how much his role has changed in recent years. Quality is no longer defined by the number of inspections performed or reports created. Its value lies in helping people make better decisions, earlier and with greater confidence. Across suppliers, production lines and quality teams, connected data turns complexity into clarity and insight into action.

The future of quality lies in connecting data, understanding what matters, and turning insight into impact.

Measurable impact across the quality value chain

Up to **90%** higher efficiency*

through centralized access to quality data and automated analysis.

25% reduction in work effort*

Digital task allocation and systematic analysis workflows reduce manual work effort.

Up to **75%** faster inspection cycles*

in selected AI-supported inspection scenarios.

* Referring to specific use cases

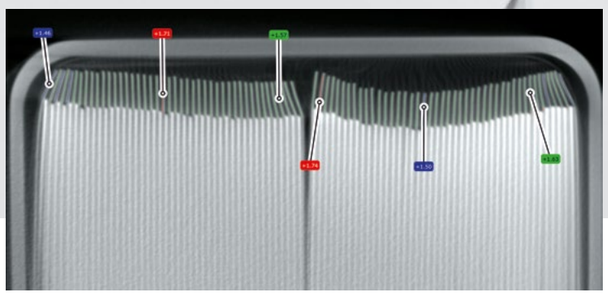
Get to know our ZEISS Quality Software Portfolio

EVE Energy

Inside **battery quality**

Why hidden defects decide performance

The battery determines a vehicle's range, performance, and reliability. But whether a cell delivers on its promise isn't visible from the outside. The critical errors occur on the inside. That is precisely what makes quality assurance in battery production so challenging today. Particles between layers, defects on tabs, or deviations in the cell structure often remain invisible. Their consequences are not. They cost material, time, and energy. Ultimately, they jeopardize the quality of the entire product.



For a long time, one thing above all else took center stage in the battery industry: capacity. Factories had to ramp up production, output had to increase, and delivery capabilities had to be secured. Today, the focus is shifting. As industrial scale expands, so does the pressure for consistent quality. Anyone manufacturing millions of cells cannot afford any blind spots.

The importance of finding defects early

Market dynamics show the scale of the challenge. According to the battery manufacturer EVE Energy, battery shipments in China rose from 158 GWh in 2020 to more than 700 GWh in 2024, with far higher volumes expected in the years ahead. As automation increases and process chains become more condensed, every undetected deviation becomes more costly. In high-speed production, defects escalate with each subsequent step: if they are found too late, value, energy, and machine time have already been invested. Quality assurance therefore needs to move closer to where defects originate.

From the lab to the line

A key trend is therefore the shift of quality assurance from the laboratory to the line. High-resolution CT technology initially helps to understand critical defect patterns and failure mechanisms. Today, real progress lies in transferring this knowledge to mass production.

Rather than a simple transition from 2D to 3D inspection, the key is choosing the right technology for the right task. 2D X-ray remains highly valuable where speed, cost efficiency, and straightforward inspection geometries are decisive, for example, in foreign-particle detection in simple structures. Its limitations become apparent when internal structures overlap, defect location matters, or higher measurement accuracy is required. This is where 3D inline CT adds a layer of information. By capturing the cell volume rather than a projected image, complex internal relationships become visible and measurable, such as overhang, layer alignment, and foreign particles in challenging geometries. And particle detection is key: EVE Energy estimates that approximately 50% of cell defects are attributable to dust and foreign particles.

A reliable assessment of the internal condition of a battery is only possible by combining deeper inspection, automation, and data intelligence. Since 2021, EVE Energy has been working with ZEISS to develop inline X-ray technology capable of scanning batteries directly in production. The collaboration has enabled a more precise defect model and laid the foundation for AI-supported defect detection at industrial scale. Based on a training dataset of more than six million cells, the cutting-edge AI model that ZEISS developed in-house can achieve an accuracy of more than 99%.

Learn more about our new inline CT solution ZEISS INRADIA 3D on page 38



"Quality is the lifeblood of a company."



Felix Gong,
Vice President, EVE Energy



Czech Airlines Technics

Modern **MRO**

Where digital inspection meets human expertise

In aircraft maintenance, quality depends on precision, compliance, and confidence. For maintenance, repair, and overhaul (MRO) providers, every inspection must meet approved procedures and airworthiness requirements. At Czech Airlines Technics, a leading aircraft MRO provider based in Prague, digital inspection technologies support maintenance teams assess components, make engineering decisions, and return aircraft to service safely. Yet the foundation remains human expertise: technicians who ask the right questions, verify their judgment, and understand the responsibility behind every release to service.





When conventional measurement reaches its limits
Accurate measurement is fundamental to aircraft maintenance. Technicians rely on established manual procedures to assess dents, wear, corrosion, and structural damage. But complex geometries, tight tolerances, curved surfaces, and difficult-to-access areas can limit how much reliable data conventional methods provide. Digital inspection technologies such as 3D scanning help close this gap by capturing complete component geometry and creating a detailed digital representation for analysis. They do not replace established inspection methods; instead, they complement them with additional measurement data, giving engineering teams a stronger basis for decision-making.

Digital inspection in action
A recent repair at Czech Airlines Technics shows how digital measurement data can support maintenance decisions. When a damaged landing gear torsion link required evaluation, replacing the part would have been the standard route, involving removal and the risk of uncovering further issues. Instead, the technicians used the handheld optical scanner ZEISS T-SCAN hawk 2 to scan the damaged area before and after a blend repair. The resulting 3D data captured the repaired geometry precisely and was shared with the manufacturer for assessment.

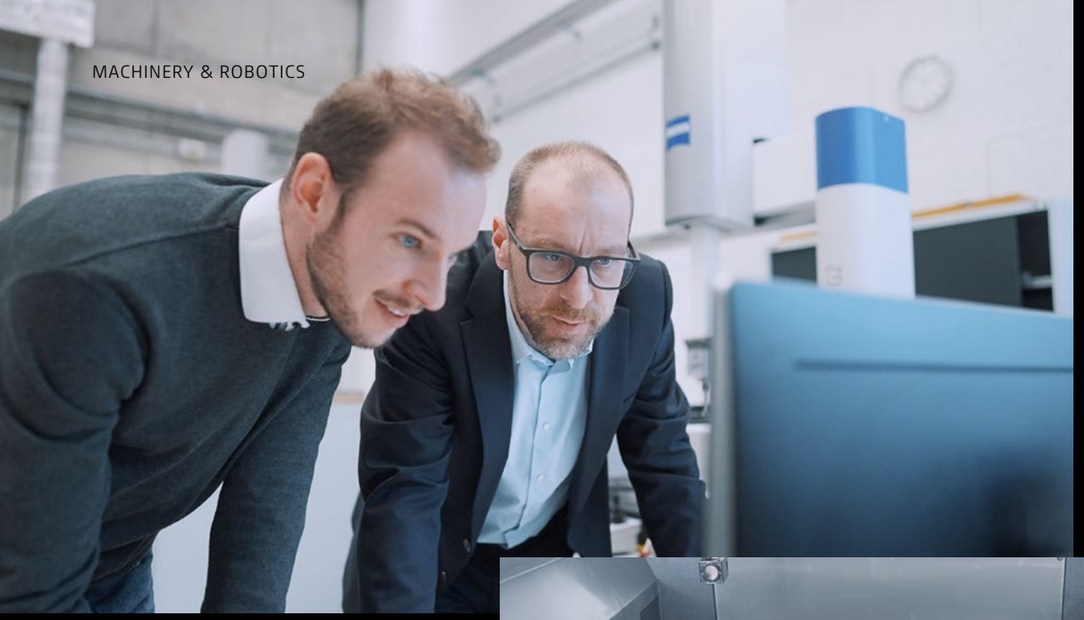
> *“Aircraft maintenance will always rely first and foremost on human experience and technical skill.”*
>
> **Vladimír Müller,**
> Vice-Chairman of the Board of Directors at Czech Airlines Technics

Based on the component’s verified condition, the repair was approved, and the part remained in service. The example highlights a broader shift in aviation maintenance: precise digital data is increasingly helping teams assess damage, communicate with manufacturers, and make informed technical decisions while staying fully aligned with approved engineering procedures.

The next chapter in aircraft maintenance
As aviation becomes more digital, future workflows are likely to connect inspection technologies more closely with engineering data. Maintenance teams may increasingly compare measured aircraft structures directly with original design models, helping them assess deviations faster and more accurately.

For Vladimír Müller, Vice-Chairman of the Board of Directors at Czech Airlines Technics, digital tools should strengthen, not replace, human expertise.



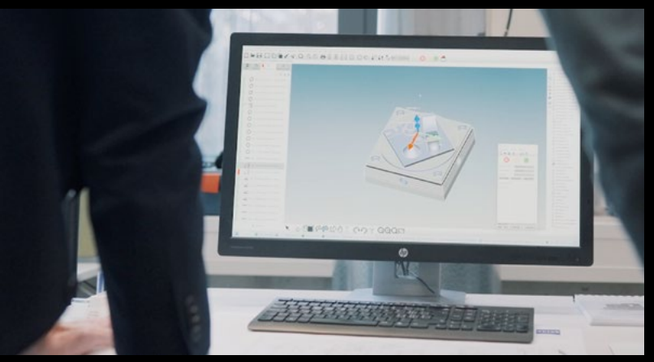




UNITED MACHINING

Closing the loop on quality

How measurement data and digital twins enable smarter decisions across the machine lifecycle



In high-precision machine tool manufacturing, quality is not confirmed at the end of the process. It is built into every stage, from concept and assembly to measurement and reporting. At MIKRON MILL in Switzerland, a member of UNITED MACHINING, this principle has evolved into a closed loop connecting engineering, production, and metrology.

Precision from the very first part

UNITED MACHINING develops milling, EDM, laser, and automation solutions for precision-critical industries such as aerospace, medical technology, energy, and motorsport. Across brands like MIKRON MILL, Liechti, and AgieCharmilles, its machines produce complex parts with tight tolerances. For many customers, confidence in a machine begins with the first component, making metrology essential from the start. *"Our machines produce highly accurate components, often with tolerances below two microns,"* says Yvan Meyer, CTO of UNITED MACHINING. *"To assess the performance of the machine, we need to measure the part correctly."*

Connecting digital twins with real production data

MIKRON MILL relies on digital twins across the machine lifecycle. In development, digital models simulate statics, dynamics, and thermal behavior, while supporting software testing and automation planning before production systems are installed. Today, this approach is moving into production, where measurement data from ZEISS PRISMO and ZEISS CONTURA machines is fed back into the process. Validation parts are measured, tolerances inspected, and results linked with machine data. This gives production teams deeper insight into machine performance and helps them identify the root causes of deviations more quickly.

From measurement to manufacturing intelligence

The value of this connection becomes clear in the complexity behind micron-level precision. As Meyer explains: *"Everything needs to run at exactly the right speed and the right time. We are talking about micron accuracy and surfaces that can look like polished mirrors. To achieve that, all elements have to work together."*

In such environments even small deviations matter. A minor misalignment in axes, spindles or drives can affect the finished part, while the root cause remains difficult to isolate. By connecting measurement data with the digital twin, MIKRON MILL can detect issues earlier and address them more precisely. This way, first-pass yield has increased from 50 percent to more than 70 percent.

From faster diagnosis to less downtime

The benefits extend beyond production into service. By comparing a machine's factory baseline with test data from the customer site, service teams can quickly identify deviations. In one aerospace application, a digital twin-based drivetrain test traced a quality issue to the A-axis. After replacement and validation, the machine returned to production in less than a week, reducing downtime and supporting the transition toward predictive maintenance.

For UNITED MACHINING, metrology is where quality becomes visible – and improvement begins. Combined with digital twins, ZEISS measurement technology turns production data into actionable insights across engineering, manufacturing, and service. In an industry where every micron matters, this approach transforms precision into a repeatable, data-driven process.

ZEISS Innovations



ZEISS mass automated

Automated sensor changes for maximum throughput, speed and flexibility

With ZEISS mass automated, manufacturers can unlock even more flexibility from their ZEISS PRISMO by combining different ZEISS probe and sensor technologies in one automated CNC workflow. The system changes sensors automatically, so the measuring routine can adapt to the component instead of stopping for manual intervention. This is especially valuable for complex parts that require different measurement approaches – from high-precision tactile scanning and flexible measurements from different angles to optical inspection and roughness measurement. The result is a more complete measurement process that brings greater flexibility, consistency and efficiency to demanding metrology tasks, all combined in a single measurement protocol.

Learn more about ZEISS mass automated



Automated processes, **measurable efficiency**

From individual measurement systems to connected quality assurance

Rising costs, shorter delivery times, and a growing shortage of expertise are increasing the pressure on quality assurance teams. At the same time, manufacturers need reliable results, higher throughput, and maximum flexibility. By integrating automation into production processes, manufacturers can achieve higher efficiency, greater reliability, and reduced operator workloads. It also ensures seamless operation, increased throughput, and smooth production during breaks or off-peak hours. The question is no longer whether to use automated systems, but how to integrate them into existing production and quality processes in a meaningful and cost-effective way.

Automate all your systems
Automation requirements vary from one production environment to another. Some manufacturers want to automate a single measurement step, while others aim to integrate their entire quality assurance process. ZEISS Integration Series enables automation across the whole ZEISS portfolio, regardless of the technology, including coordinate measuring machines, optical systems, X-ray and CT solutions, and industrial microscopes. It can control workpiece loading, for example via a robot, as well as inspection plan execution, measurement result feedback, machine status, and system peripherals. This makes it possible to automate individual systems or connect multiple technologies within one customized quality assurance process. For example, a workpiece can be transferred automatically from full-surface optical inspection to tactile measurement, supporting a seamless and efficient workflow.

Automating ZEISS DuraMax 8/5/5
The new ZEISS DuraMax 8/5/5 offers significant automation potential as a robust, scalable, and future-proof solution. Designed for the shopfloor, it combines precision and durability with modular automation options. Manufacturers can start with a simple solution and expand automation as requirements grow.

A barcode scanner provides an easy entry point. This tool automatically selects the measurement program based on the workpiece or production order. Operators scan the relevant code, and the appropriate measurement program loads instantly. This reduces input errors, simplifies operation, and increases process reliability. For manufacturers handling diverse part types or batches, barcode identification is a cost-effective way to streamline operations while laying the foundation for more advanced automation.

The next step is to optimize workpiece loading with the ZEISS Duplex system. With this manual system, operators can prepare the next workpiece on one pallet while measuring another on the second pallet. Once the measurement is complete, the pallet is moved out, and the next job begins immediately. This reduces downtime and improves machine utilization without requiring complex automation technology. For manufacturers seeking even greater efficiency, the ZEISS Duplex system can be upgraded to an automatic pallet-changing system. Pallet changes then take place without operator involvement, enabling productive use of breaks, shift changes, or off-peak hours.

For manufacturers aiming to fully integrate ZEISS DuraMax 8/5/5 into an automated production line, the ZEISS Automation Interface can connect it to robots and other automation equipment. This standardized interface enables automated workpiece feeding, identification, measurement, and transfer to the next production step. This way, the system supports continuous material flow and consistent quality assurance.

With this modular concept, manufacturers can implement automation step by step, scaling their investment as production requirements evolve. Whether you start with a barcode scanner or integrate a fully automated production line, ZEISS DuraMax 8/5/5 grows with your needs, making it the ideal solution for both small operations and highly automated environments.



ZEISS Innovations

ZEISS DuraMax 8/5/5

The choice for expanded shop floor precision

More space, same trusted performance: ZEISS DuraMax 8/5/5 delivers the ideal balance of footprint, performance, and scalability for those seeking greater flexibility on the shop floor. The latest member of the ZEISS DuraMax family offers a larger measuring volume that significantly increases flexibility for measurements.

Learn more about ZEISS DuraMax 8/5/5

Automated workpiece change with ZEISS ShuttleLoad
ZEISS ShuttleLoad automates the loading and unloading of coordinate measuring machines using pre-loaded pallets. This keeps measurements running continuously, reduces downtime, and increases throughput with minimal operator involvement. It also supports unattended operation during breaks, shift changes, and unmanned shifts.

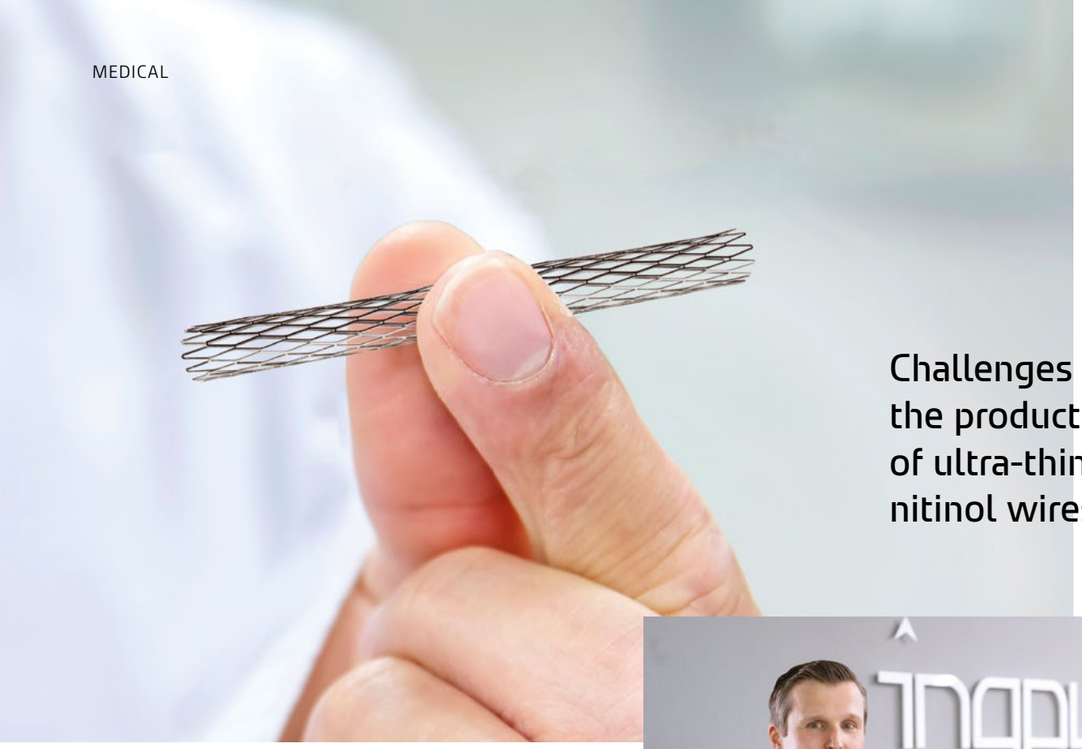
The system is controlled via the ZEISS Automation Interface and requires no training. By identifying workpieces with a handheld scanner, it loads the correct measurement programs and prioritizes workpieces at the push of a button. A visual presentation of the pallet status quickly shows whether the workpieces are within tolerance. Its modular design enables integration with the coordinate measuring machine and expands as production demands grow. ZEISS ShuttleLoad is compatible with ZEISS PRISMO, ZEISS SPECTRUM, ZEISS CONTURA, ZEISS MICURA, and can be extended to other machines and technologies on request.

Automation that scales with your production
Automation is transforming manufacturing by helping companies address rising costs, skills shortages, and increasing productivity demands. With ZEISS automation solutions, manufacturers can automate individual measurement steps, connect different technologies, or create fully automated, robot-assisted processes.

From barcode identification to automated pallet changes and fully integrated production cells, ZEISS offers scalable solutions for different requirements. The result is higher machine utilization, improved process reliability, greater throughput, and higher efficiency.







Challenges of the production of ultra-thin nitinol wires



Ingpuls

High-performance wires for stents

Ingpuls GmbH, based in Bochum, is transferring its expertise in shape memory alloys from the automotive industry to the field of medical technology. Since 2022, the company has been manufacturing ultra-thin nitinol wires for stents. In quality assurance and process development, the ZEISS EVO scanning electron microscope supports these efforts with precise material analyses and makes the finest surface and microstructures visible.

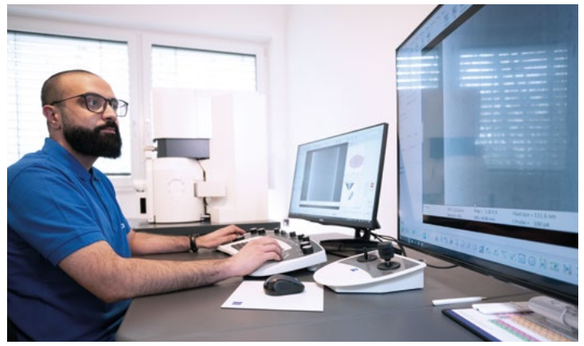
Nitinol combines flexibility and shape memory
Nitinol is a nickel-titanium alloy with superelasticity and thermal shape memory. In stents, the material ensures reliable expansion and a constant force on the vessel wall. Its biocompatibility, corrosion resistance and resilience make it particularly suitable for medical applications. Ingpuls draws on many years of research experience: The three founders earned their doctorates at Ruhr University Bochum, where they studied shape memory alloys. *"We have extensive fundamental and process knowledge, as well as many ideas for products made from shape memory alloys,"* says Dr. André Kortmann, co-founder and managing director of Ingpuls. These include wires with diameters of 20 micrometers.

From Automotive Engineering to Medical Technology
Initially, Ingpuls focused on the automotive industry. In this field, shape memory alloys must function reliably even under wide temperature fluctuations – which means the alloy and the manufacturing process must be precisely coordinated. The company's entry into medical technology began with a customer inquiry: A stent made of Ingpuls material achieved particularly good results in a lifespan test. Today, in addition to wires, the company also manufactures stent tubes and nickel-titanium products for the dental market.

More than 100 steps to produce the finished wire
The precise ratio of nickel to titanium, as well as forming and heat treatment, are critical for the wire's properties. Even the smallest deviations or impurities can cause the material to become brittle, alter its shape memory properties, or impair the function of the later stent. From the cast raw material to the 75-micrometer-thin wire, the material undergoes more than 100 processing steps over a period of two to four weeks. Regular samples are inspected using the ZEISS EVO.

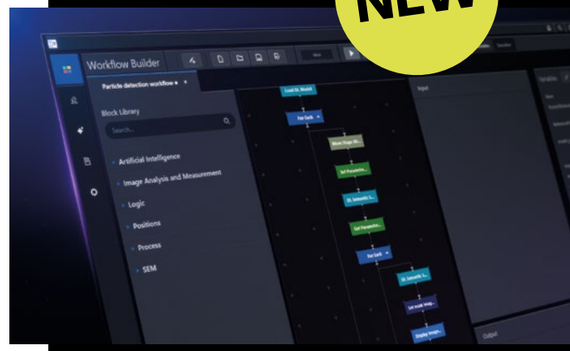
Reliably detect microcracks and impurities
The scanning electron microscope visualizes microstructures, reveals microcracks, and helps identify impurities – which can affect the material's service life – using energy-dispersive X-ray spectroscopy. *"At a magnification of 1,000 to 2,000 times, we can detect even the smallest irregularities,"* says quality engineer Ali El-Toufaili.
The analyses also support process optimization: Engineers examine how heat treatments, forming processes, tools, and surface treatments influence the material structure. *"Without the ZEISS EVO, we'd be groping in the dark and wouldn't be able to act as quickly and effectively,"* explains Kortmann.

Quality assurance for further growth
Ingpuls uses the device for quality assurance, development, and failure analysis. Each week, specimens from more than 10,000 meters of wire production are inspected. The intuitive user interface and configurable Workflows make it easier to perform recurring analyses. For the company, which has 75 employees, the system is also an investment in growth: *"The ZEISS scanning electron microscope saves us valuable time and strengthens our customers' trust,"* Kortmann summarizes.



ZEISS Innovations

NEW

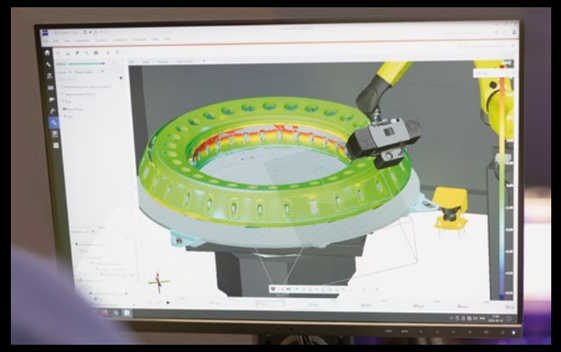


ZEISS Blockwise

Automated SEM workflows for standardized quality analyses

ZEISS Blockwise makes complex SEM analyses easier, faster, and more reproducible. The software transforms recurring tasks into clearly structured workflows that can be created intuitively using drag-and-drop and executed with the click of a button. ZEISS Blockwise enables the automation of microscope control, navigation, image acquisition, AI-powered image analysis, and measurement functions within an end-to-end workflow. This makes expert knowledge more accessible, reduces operator-dependent variability, and allows quality checks to be integrated more efficiently into industrial processes – from electronics manufacturing to medical technology.

Learn more about ZEISS Blockwise



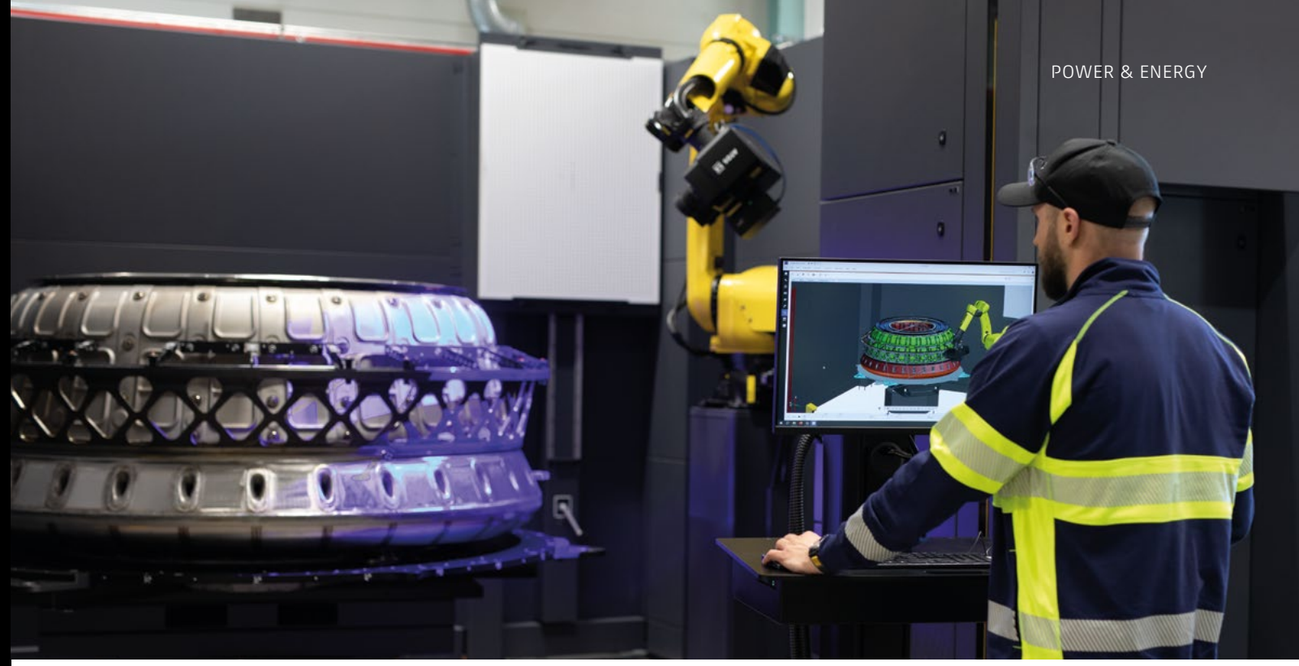
Siemens Energy

The **hidden chamber** of gas turbines

From final verification to smarter production

As AI-driven data centers push electricity demand higher, fast-starting gas turbines are taking on a more prominent role in stabilizing modern power grids. For Siemens Energy, this makes the quality of every combustion chamber critical. At its Trollhättan site, ZEISS solutions turn 3D inspection into faster decisions, higher confidence and continuous process improvement.





Precision under extreme conditions
As one of the most demanding parts of a gas turbine, the combustion chamber controls the fuel-air mix and directly affects efficiency, emissions and reliability. At Trollhättan, Siemens Energy manufactures these complex components largely in-house, maintaining tight control over quality. Some chambers exceed two meters in diameter, which makes accurate inspection essential before delivery.

"Every combustion chamber is inspected before it leaves our site," says Jonas Göthberg, Metrology Technician at Siemens Energy. *"We verify dimensions, GD&T characteristics, surfaces and freeform geometries to ensure each part meets specification."*

A digital twin for every part
With the optical 3D measuring machine ZEISS ScanBox, Siemens Energy has turned a technically demanding inspection task into a highly structured digital workflow. Large, complex components with freeform surfaces and tight tolerances are captured as full-field 3D data and transformed into precise digital twins. Dedicated fixtures, standardized programs and virtual preparation in the Virtual Measuring Room (VMR) make the process faster, repeatable and scalable.

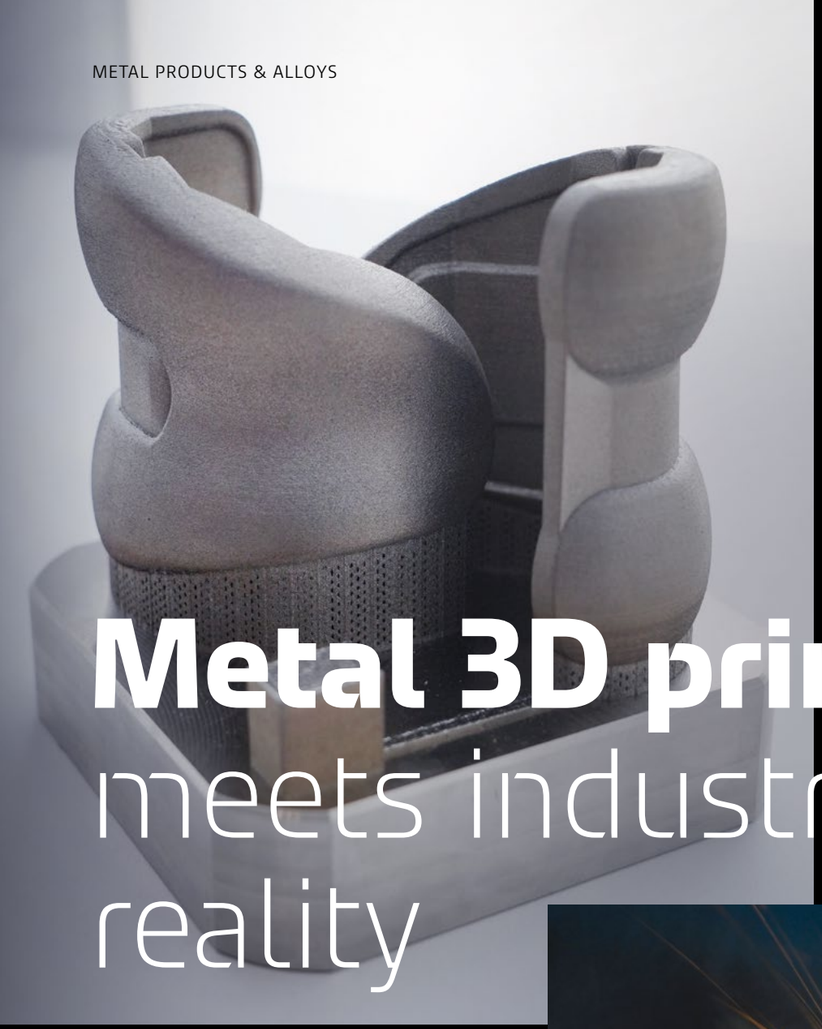
From data to decisions
Capturing 3D data is only the beginning. With ZEISS INSPECT, production and engineering teams share a common visual basis for analysis and decision-making. The software supports CAD comparison, detailed evaluation and collaboration across departments. The impact is measurable.

"Today, we trust the results," says Idha Wiklund, Head of Quality Management at Siemens Energy in Trollhättan. *"That gives us greater confidence in quality decisions and allows us to move faster."* For the largest combustion chambers, inspection time has been cut from about four hours to two.

The value of the data extends beyond the inspection station. With the data management software ZEISS PiWeb, quality information is connected across manufacturing, assembly and service, making insights available throughout the component lifecycle. Over time, individual inspections become a broader source of manufacturing insight, helping teams identify improvement opportunities earlier, respond faster to deviations and continuously optimize production processes.

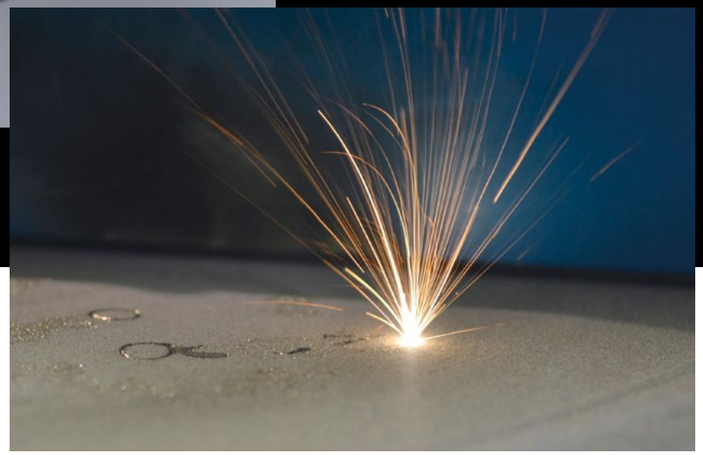
Beyond final inspection
For Jonas Göthberg, this marks the shift from verifying parts to understanding processes. *"We originally invested in ZEISS ScanBox for final inspection. Today, we use it much more broadly. The data helps us understand production, component performance over time and the condition of parts returning from operation,"* explains Göthberg.

This broader role for quality data is now shaping the next phase of Siemens Energy's metrology strategy. *"We are increasing inspections with ZEISS ScanBox, exploring additional metrology solutions, and making greater use of ZEISS PiWeb to improve quality, efficiency and transparency,"* adds Idha Wiklund.



Why quality matters along the entire process chain

Metal 3D printing meets industrial reality



In many industries, additive manufacturing of metal components has long moved beyond pure prototyping. With the shift to industrial use, the focus changes: it is no longer basic feasibility that counts, but long-term process stability, reproducibility, and part quality. In industrial environments, additive manufacturing is not viewed as an isolated printing process, but as an interconnected process chain. Wherever complex geometries, demanding performance requirements, and efficiency pressures converge, additive manufacturing enables faster innovation. Throughout the process, quality assurance is essential.

From powder to part quality
Every single step of the additive manufacturing process influences the quality of the components: from design and engineering through the actual printing process and final inspection. In the first step, the properties of the powder particles, such as particle size distribution, shape, density, or added micro-satellite particles, can influence the part's attributes and may cause defects that are often only visible at a later stage. This detail makes automated and thorough characterization of powder quality using microscopy solutions indispensable. Additionally, effects of heat treatment are analyzed, for example with coordinate measuring machines and optical scanners. High-resolution X-ray imaging reveals internal defects, enabling voids and material impurities to be detected at an early stage. This inspection method is complemented by optical metrology, which captures dimensional accuracy and surface characteristics, resulting in the foundation for a proper assembly across multiple components.

Additive manufacturing for regulated industries
Especially in regulated or safety-critical applications, dimensional accuracy, internal integrity, microstructure, surface quality, and documented reproducibility are essential for scaling additive processes. Quality assurance processes thus play a central role throughout the value chain and are a key driver of the industrial adoption of additive manufacturing.

Data-driven quality assurance is particularly important in this context. Clear visualization and correlation of results across all stages of the process help companies develop printing strategies and increase throughput. Such an approach links material characterization, dimensional accuracy, surface effects, and defect analysis results. This makes it possible not only to safeguard quality but also to drive continuous improvement through feedback on process parameters, machine strategies, and part design. The transition from one-off production to series-ready manufacturing processes, as well as the qualification of new materials, can thus be significantly accelerated.

Quality as part of the entire process
However, quality assessment does not end at the build platform: heat treatment, part removal, removal of support structures, surface finishing, and final geometric inspection are integral elements of a qualified end-to-end process. Only the interplay of all these steps produces a component that is industrially robust and exhibits traceable properties. Companies seeking to scale additive manufacturing economically need more than machine capacity — they require end-to-end inspection strategies, standardized workflows, and a deep understanding of the interdependencies across the entire process chain.

That's why the greatest value can be achieved when quality is embedded throughout the entire additive manufacturing workflow, rather than being treated as a final inspection step. ZEISS enables this approach by linking measurement systems, software, and process data across every stage of production, providing end-to-end transparency and accelerating process optimization. For example, at Materials Solutions, a Siemens Energy company, the automated optical 3D metrology system ZEISS ScanBox inspects multiple fuel swirlers in a single run, accelerating inspection workflows while ensuring geometric conformity for series-ready production. ZEISS also offers efficient quality assurance solutions from raw material to the finished medical device. The company Armbruster GmbH lays a special focus on optical 3D scanning, verifying medical components produced using both additive and subtractive manufacturing processes.



Additively manufactured components can achieve mechanical properties that match or even exceed those of traditional manufacturing methods through optimized process control, performance-optimized material qualification, and post-processing steps. Those who make quality measurable across the process chain lay the foundation for trust, from development and production teams to customers and partners.

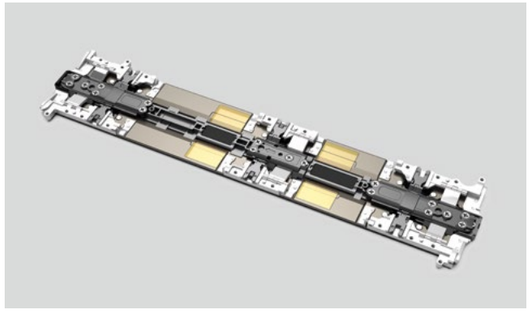
Perfecting **the fold**

Meeting the quality challenge of foldables

The foldable smartphone market stands on the cusp of explosive growth. Foldables are reshaping how we think about smartphones: bigger displays when you need them, but a compact device when you don't. This dual promise is driving rapid innovation in hinges, displays, batteries, and thermal management. The trend isn't just about clever engineering; it's about new user experiences – multitasking, flexible cameras, and seamless phone-to-tablet transitions. To make these experiences reliable day after day, engineers and manufacturers must focus on three core components: hinges, battery steel housing, and vapor chambers. Learn how these quiet engines make foldables genuinely durable for mainstream audiences.



ELECTRONICS & SEMICONDUCTOR



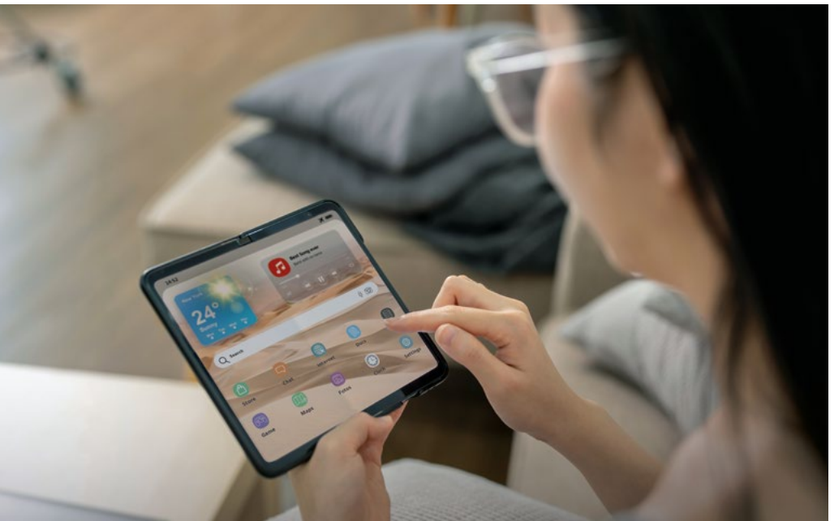
Hinges
To deliver superior crease suppression, slimmer form factors and enhanced durability for foldable smartphones, breakthroughs in hinge technology are essential. This drives upgrades in precision and material strength for hinge components, while raising industry quality control benchmarks: the mainstream 0.01 mm precision standard is set to tighten to an exacting 0.005 mm, imposing stricter manufacturing and inspection requirements for core parts. Key inspection scenarios include reverse engineering and non-destructive defect analysis of hinges, 3D reconstruction of nested mechanical assemblies, accelerated design iteration validation, and non-destructive detection of assembly flaws.

ZEISS industrial computed tomography (CT) systems deliver accurate 3D reconstruction of nested mechanical structures, fully recreating the intricate internal transmission mechanisms of hinges. Boasting exceptional capability to capture micro-features, the equipment detects minute surface wear, assembly clearances and other critical details. Its non-destructive testing modality preserves sample integrity, allowing specimens to be reused for subsequent validation tests. This accelerates iterative design verification, shortens R&D cycles and cuts trial-and-error costs.

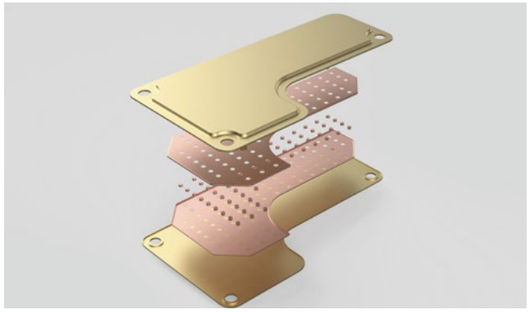


Battery steel housing
The flatness of the battery steel housing is critical for efficient heat dissipation and seamless assembly. The housing must fit tightly against smartphone mainboards, thermal modules and other components. Surface protrusions or indentations create gaps that impede thermal conduction, introducing thermal resistance and trapping operational heat. This compromises battery life stability and accelerates cell degradation. Accordingly, housing flatness must be controlled within micrometer-level tolerances to ensure full surface contact and maximum thermal efficiency.

Multi-sensor coordinate measuring machines (CMMs) feature intelligent auto-calibration for fast active scanning of unknown profiles. Equipped with red and blue light technology compatible with all surfaces and materials, the systems automatically switch between tactile scanning probes to capture hidden geometries inaccessible to optical sensors. Optional white light probes are ideal for thin-walled and transparent workpieces such as lenses and glass. Non-contact measurement delivers outstanding throughput while eliminating workpiece deformation to guarantee consistent measuring accuracy.



Amid continuous technological iteration, three core components, namely hinges, battery steel housing, and vapor chambers (VCs) serve as pivotal enablers for technological maturity, alongside rigorous quality inspection systems that bolster core product competitiveness.



Vapor chamber (VC)
The design and manufacturing of vapor chambers demand stringent checks over copper pillar diameter and height, wick structure thickness and pore size, as well as surface defects including dents and bulges to guarantee reliable performance. The dimensional design of internal copper pillars and wick structures represents a balancing act of conflicting performance priorities. Copper pillars must deliver structural rigidity, yet oversized pillars obstruct vapor diffusion and condensate backflow, raising flow resistance. Modern designs therefore adopt micro copper pillar arrays to resist collapse while minimizing disruption to phase-change heat transfer. As the driving force for liquid recirculation, wick geometry directly defines performance limits: overly thin, narrow pores generate strong capillary force but drastically increase fluid flow and thermal resistance; excessively thick, wide pores weaken capillary force and risk dry-out at the evaporator section. Optimal engineering selects an ideal range of wick thickness and pore size to maximize the comprehensive performance index, striking a balance between capillary force and permeability.

The X-ray microscope ZEISS VersaXRM offers a complete solution for internal structure characterization and defect analysis of vapor chambers via non-destructive 3D imaging. Unmatched multi-scale imaging enables rapid overview scanning of full internal architectures at low magnification, with switching to high-resolution 3D analysis of micro-features including wick structures, copper pillars, and surface irregularities. Paired with dedicated 3D visualization and analysis software, the system supports virtual sectioning and stereoscopic rendering at any viewing angle to generate high-fidelity colored 3D models. These precisely reveal spatial internal geometries and defect distribution, delivering critical insights and data to guide process optimization and reliability assessment.

The foldable revolution is moving from an exciting novelty to a new standard in mobile computing. By weaving trend-driven design with rigorous, transparent quality assurance processes, manufacturers can deliver foldables that delight users today and endure for years to come. With this holistic approach, the industry can turn ambitious ideas into reliable everyday tools, reshaping how we work, create, and connect on the go.

ZEISS Innovations

NEW



ZEISS ViScan

Optical precision for the tiniest details

Compact electronic components demand reliable inspection of tiny features, edges and geometries. The optical CMM sensor ZEISS ViScan combines a large field of view, high-resolution imaging and versatile illumination to make even challenging structures clearly visible. Advanced optical technology helps capture recessed features, improve contrast and reveal critical details with confidence. Measure more in a single image, reduce repositioning and CNC cycle time to increase inspection efficiency across a wide range of applications. Discover a new dimension of optical measurement.

Learn more about ZEISS ViScan



Auburn University

Carbon **sequestration**

A method for CO_2 storage

To reduce atmospheric carbon dioxide and limit its environmental impact, geologic carbon sequestration offers a promising route. CO_2 captured from industrial sources like power plants and factories is transported to storage sites and injected into deep porous rock formations. There, pore spaces and mineral surfaces help retain the gas and keep it away from the atmosphere for long periods of time. To better understand the whole process of geologic carbon sequestration, researchers use multi-scale imaging.



Dr. Lauren Beckingham, Associate Professor in Civil & Environmental Engineering at Auburn University, Alabama, leads a group studying geochemical reactions in subsurface energy systems. Her team investigates how injected CO_2 interacts with brine, minerals and pore networks – knowledge essential for safe, effective carbon storage.

How CO_2 is trapped underground

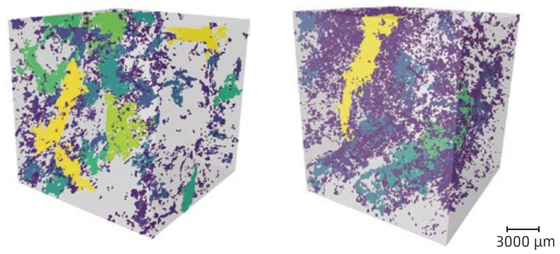
Geologic carbon sequestration involves the injection of CO_2 into deep geological formations for permanent storage. After injection, CO_2 dissolves into formation brine, lowers the pH and reacts with minerals in the rock. Some minerals dissolve and release ions; others may precipitate as carbonate minerals that incorporate CO_2. This so-called mineral trapping process can provide stable, long-term storage. Because natural rocks are complex, Beckingham's group studies which minerals react, how fast they change and how these reactions affect storage capacity, injectivity and site security.

Multi-scale imaging – an enabler for CO_2 storage security

Mineral dissolution and precipitation reactions occurring after CO_2 injection affect formation, storage capacity, and injectivity. Accurate prediction of these reactions is therefore critical to assess a potential storage site. Multi-scale imaging enables the understanding of CO_2 sequestration as it connects mineral chemistry with pore structure. Using 2D scanning electron microscopy imaging, the team creates mineral maps that show the distribution of minerals relative to each other and to the pore space. This helps to understand the mineral phases that may interact with reactive fluids.

Combined with 3D X-ray microscopy, these maps help reveal how fluids move through the formation. This way, researchers can better predict how injected CO_2 will behave underground and how secure a storage site may remain over time.

Pore structures and carbonate precipitation



Segmented carbonate samples reveal connected pore regions that are relevant for carbon storage and help researchers assess how formations may evolve after CO_2 injection.

ZEISS Innovations

NEW



ZEISS VersaXRM 5 Insight

Hybrid system for non-destructive 3D X-ray analysis of complex components

ZEISS VersaXRM 5 Insight combines micro-computed tomography with high-resolution X-ray microscopy for non-destructive 3D X-ray analysis of complex components, advanced materials, and internal structures across multiple length scales. Its seamless multi-scale workflow enables fast, reliable inspection of complete parts, identification of critical regions, and analysis of hidden details without damaging the sample. The system supports defect detection, root cause analysis, process optimization, and material or design validation in industries such as electronics and semiconductors, battery production and e-mobility, automotive, materials research, and industrial manufacturing.

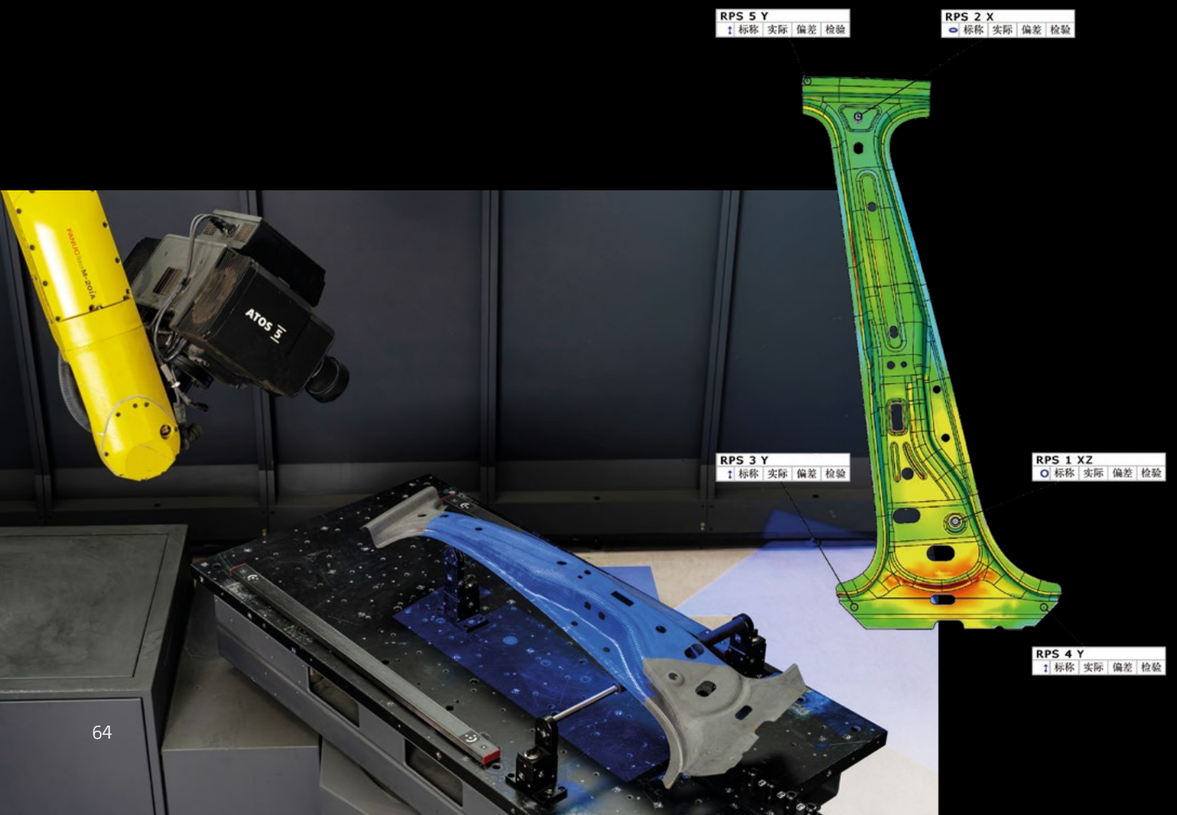
Learn more about ZEISS VersaXRM 5 Insight

BENTELER

From physical fixtures to **Virtual Clamping**

A smarter way to inspect automotive sheet metal parts

In vehicle production, cold-stamped and hot-formed sheet metal parts are widely used. Traditionally, each structural part requires its own dedicated measuring fixture. At its Wuhu plant, global automotive supplier BENTELER uses Virtual Clamping to address these challenges by reducing dependence on part-specific fixtures while enabling reliable measurement results under defined and reproducible clamping conditions.





Three challenges posed by physical fixtures

Before adopting Virtual Clamping, BENTELER relied mainly on physical fixtures to hold parts in place during the measurement. Jiang Pengfei, Plant Quality Manager at BENTELER, summarized three key challenges with this conventional approach: *"Fixture changeovers cost time, physical fixtures can obstruct critical mating areas of the workpiece, and require ongoing resources."*

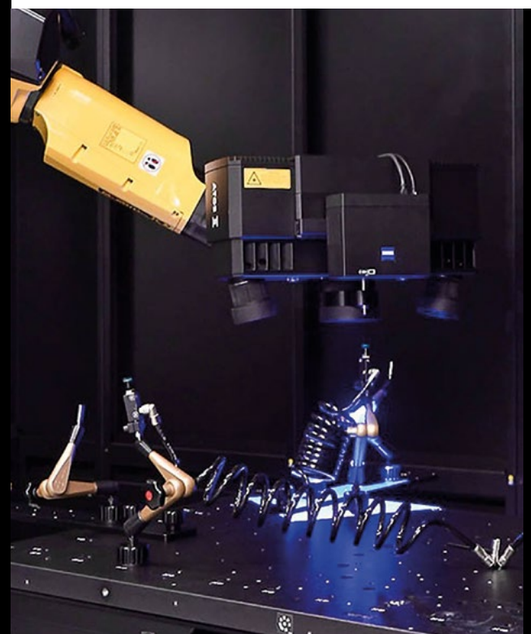
Moving parts into the digital space

Virtual Clamping is fully integrated into the software ZEISS INSPECT. Unlike dedicated measuring fixtures designed and manufactured for individual parts, it uses a more universal support concept. The workpiece is measured in an unclamped state and under low-stress support to capture its actual geometry. Based on the measurement data, the component can be analyzed under the defined stress conditions and assembly configuration.

For automotive body sheet metal structural parts, this approach captures the part's actual measured geometry and enables dimensional evaluation in the specified clamped state. The Virtual Clamping project at BENTELER's Wuhu plant commenced in April 2025 and currently provides support for all components produced through laser cutting. The inspection workflow has become simpler: Operators place the part on the flexible support used for Virtual Clamping, open the measurement program, and start the measurement to obtain the required results.

Nearly 100 traditional fixtures replaced

Now that the solution has rolled out, the cost and space savings from Virtual Clamping have become increasingly tangible. To date, the plant has used Virtual Clamping to replace nearly 100 custom-built traditional fixtures for typical sheet metal components, including hot-formed A-, B-, and C-pillars, rocker panels and side members. According to plant statistics, the eliminated fixtures represented design costs of several million RMB and freed up more than 100 square meters of storage space.



NEW

ZEISS Innovations

Guided Holding Kit

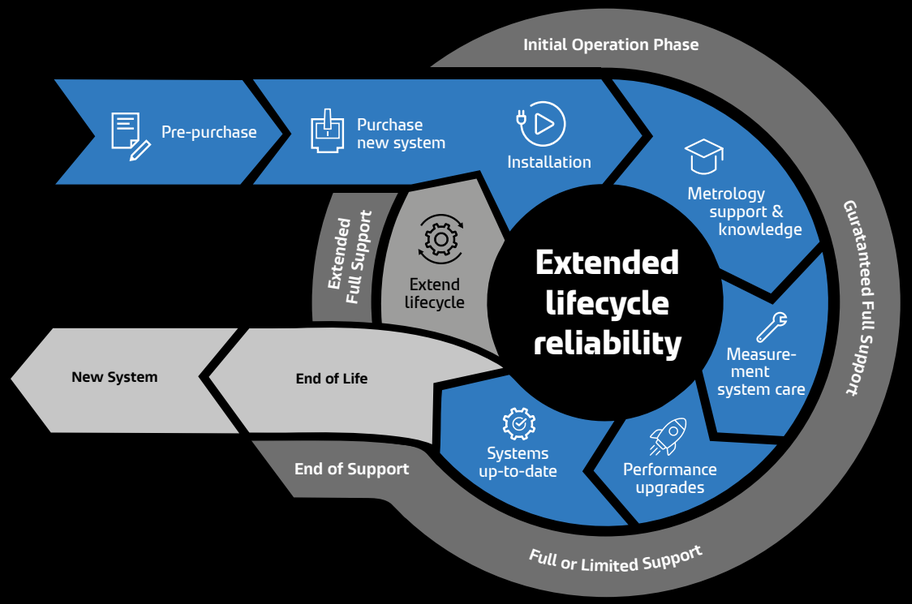
Precise part positioning and measurement

The Guided Holding Kit is designed for mounting parts without stress. The fixture includes up to four contact points, and ZEISS INSPECT software automatically adds extensions to the measuring plate and collision bodies in the Virtual Measuring Room, to support as wide a range of parts as possible.

→ **Learn more about Virtual Clamping**

SERVICES

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ZEISS Metrology Services help ensure that your metrology solutions deliver reliable results and maximum availability throughout their entire life cycle. From installation and user training to preventive maintenance, optimization, and retrofit, we support you at every step. Our global service organization combines standardized concepts with local expertise. Around the world, more than 3,000 metrology specialists use state-of-the-art tools and digital services to keep your systems productive. We help stabilize your processes and protect your investment – today and in the future.



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Strong metrology performance starts with skilled users. ZEISS Academy Metrology offers tailored training programs for every level of experience. These programs combine practical, hands-on sessions with real parts and flexible formats, including online, onsite, and classroom training, so users can apply what they learn directly in their daily work. Industry-recognized certifications, such as AUKOM, further strengthen your team's expertise and credibility.

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Keeping systems up to date highlights software as a key performance driver. ZEISS Software Maintenance Agreements ensure regular updates, new features, performance enhancements, and security upgrades. They also support better cost planning while improving system security with the latest software versions. The Smart Service Dashboard provides intuitive monitoring tools that help keep systems optimized and reliable.

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Become a #measuringhero

with ZEISS Metrology Expert Tips Season 2



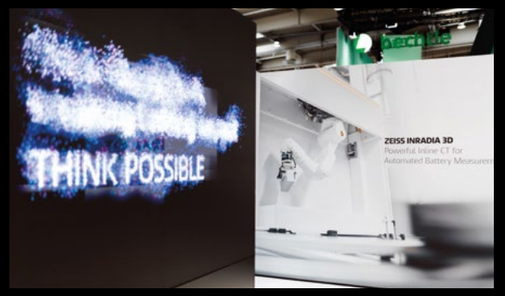
Often, it is the small tips and tricks that make the decisive difference in metrology: greater efficiency, higher process reliability, and improved precision. This is exactly where Season 2 of ZEISS Metrology Expert Tips comes in. In this video series, ZEISS experts, together with Jay Elepano from the ZEISS #measuring-hero vlogs, show how to get even more out of your coordinate measuring machine, optical system, or X-Ray system using smart application tips for ZEISS Original Accessories.

At the same time, Jay Elepano takes you behind the scenes of the metrology world in his #measuringhero vlog on YouTube: short, entertaining episodes with fascinating insights, real success stories, the latest trends, forward-looking events, and the people behind precision.

Explore the tips in the ZEISS Metrology Shop and put them into practice. Or subscribe to the ZEISS YouTube channel and discover the #measuringhero vlogs.

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Events

Join us at various trade shows and our own in-house events to experience how ZEISS solutions are designed to meet the requirements of your unique quality inspection challenges.

Upcoming Events









Your partner for **innovative research** and **quality solutions**

ZEISS Research & Quality Solutions is the leading provider of innovative research and quality solutions for engineering applications. Serving customers across automotive and aerospace, electronics and semiconductor, metal products, machinery and robotics, power and energy, medical technology, chemical and raw materials, academic materials science as well as natural resources, ZEISS provides innovative solutions. With cutting-edge technologies, high-performance software solutions, and comprehensive process expertise, ZEISS enables customers to gain valuable insights and turn them into measurable business success.

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