



*Opticline optical systems deliver high-precision results for form, location and dimensional measurements within just a few seconds, and are easy to reprogram for other shaft-like parts.*

# Optical Metrology and Automation – a Natural Fit

*The two work together to improve quality and speed of production*

**Bruce Morey**

Contributing Editor

Automation in manufacturing is more important than ever, reducing costs and improving quality. While it is important in assembling cars, machining engines, or drilling holes in airframes, is it important to metrology operations as well? “Absolutely,” explained Michael Kleemann, engineering manager VRSI (Plymouth, MI). “The evolution of automated measurement is tightly linked with the evolution of automated manufacturing in general. As manufacturing automation becomes more powerful and flexible, it requires more measurement and closed-loop control.”

Kleemann sees continued growth in automated measurement and metrology, which is fortunate since that is the core of his company's offerings. The automotive industry has

historically been a dominant force in the development of industrial automation, including automated measurement. “More recently, the aerospace industry has made large moves in the direction of automation, which has challenged us in the supply base to provide solutions that are more flexible and more adaptable to larger spatial volumes,” said Kleemann. “Tightly integrating measurement and closed-loop control with automated manufacturing processes allows those processes to both tolerate more variation at the input, resulting in more uptime, and produce less variation at the output, resulting in more quality in the product.”



*The 360°SIMS from Hexagon is compatible with commonly used industrial robots, PLCs, automation devices and safety equipment, according to the company.*

### Variety and Uses

Beyond aerospace, automated metrology has found uses in a variety of industries. Among the wide array of metrology devices that are available, Kleemann agrees that most forms of optical or noncontact measurement are best for automation. He listed a number of such systems VRSI has experience in delivering.

Laser trackers are ideal, he said, for global dimensional control of automated assembly processes, especially in the larger volumes typical of aerospace applications. Laser line triangulation sensors or scanners are ideal for robotic feature measurement and guidance of robotic assembly processes. In the automotive industry, they are used on panel-loading robots to optimize the fit of doors and panels. In aerospace, they are often used to measure local features like step/gap, countersinks, and fastener flushness. Structured light or area scanners collect a lot of data at once, and work well in fabrication quality applications where surface geometry is critical or surface defects need to be detected. These include stamping, casting, and machining. Finally, laser radar combines the volume and flexibility of a laser tracker with the automation of a CMM. “Laser radar is ideal for automated dimensional quality measurement on larger parts like body-in-white assemblies or aerospace structures,” he said.

A good example of a company that applies optical principles to mass automation is Jenoptik (Rochester Hills, MI). While providing air gaging as well as optics, optical methods are especially important. “[It] is one of the important megatrends in industry today,” said Andreas Blind, vice president of Jenoptik America. He sees the need for more

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automated metrology, driven by tighter engineering tolerances and more complex situations even in high-volume industries, such as automotive. "If the measuring task is complex and demanding, automation is often the right solution," said Blind. But there is more than tighter tolerances or complexity at work. Especially in automotive, product liability concerns in recent years means OEMs are requiring more commitment from their suppliers. "Globalization is also forcing this commitment, which means [they need] more consistency and uniformity in the parts they deliver," explained Blind.

### Optical and Tactile

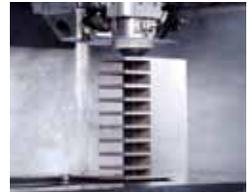
While Jenoptik provides optical, tactile, and air gaging solutions, each of which are delivered in automated systems, Blind stressed that what makes optical solutions especially desirable is their flexibility. They are easier to reprogram for new parts and applications. This need is becoming more important for a simple reason—uncertainty. "The uncertainty of the future is easy to predict," he said. Volumes go up and down, model changes proliferate, making easy reprogramming vital.

A good example of their technology that adapts to uncertainty is the latest generation of the Opticline optical shaft measuring devices released in October 2015. These measure profiles of shaft-like parts (think crankshafts or camshafts), boasting maximum allowable error, or MPE, values of less than 2  $\mu\text{m}$ , according to the company. The new series features an all-new 0.1- $\mu\text{m}$  high-resolution camera for evaluating shaft-like parts up to 150 mm in diameter and 900 mm in length. Measurements include workpiece profiles, diameters and spacing, angle or radii, threads, rotation angles, and form as well as geometric tolerances, or outer contours of high-precision workpieces.

Measuring profiles are easily changed as the part numbers change. It is made for the shop floor, with hermetically sealed optics that keep dust or oil mist from interfering with measurements. However, optical measurements cannot do



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**New Perceptron AutoScan Collaborative RoboGauge showing the operating (green), warning (amber) and protection (red) modes.**

Scott Everling, product manager for Hexagon Manufacturing Intelligence (North Kingstown, RI), agrees there are limitations to optical metrology. The issue is that the carriers and methodologies for the inline measurement of large surfaces are not as accurate as other slower, older technologies such as CMMs. This is combined with shop-floor environmental conditions which limit the accuracy specifications that can be reached. “While it measures the boundaries of holes well,

getting into the hole and measuring angularity or the sides is often too much of a challenge,” he said. Sometimes it is easy to measure one side of a drilled hole, but not the other.

Nevertheless, he sees continued interest and push for optical methods because of the need to measure faster and capture data sets that cover whole surfaces, not just individual data points.

One solution Hexagon offers for area data acquisition over larger parts is attaching the Leica T-Scan 5, to the end of a robot and tracking that via a reflector with an AT960. Another is to automate their Cognitens Structured Light solution with robots or fixed automation. In fact, he noted that since every installation and integration of a system they deliver is to a degree an automated system, Hexagon developed a more standard offering a few years ago. The 360° Smart Inline Measurement Solutions, or 360° SIMS, is a tailorable system built from a standard base for inspection of carbody assemblies, closures, cradles, sheetmetal parts, and finished cars. “All of these are important in a general trend that is moving away from the old-style check fixtures with hard gaging,” said Everling. Laser scanners, structured light systems, even close-range photogrammetry all provide bigger data sets, more than a touch probe can provide and vastly more useful than the go/no-go decisions of hard gaging. “What is pushing people into our technology is the need to look at surfaces carefully, for rooftop dents, for example,” he said.

### Data Collection and Interpretation

While these large data sets are becoming more available, today it is not always easy to evaluate them and understand



**The GOM ScanBox concept is a line of automated, protected measuring cells, available in North America from Capture3D.**

how to guide decisions. “What you are going to see in the next couple of years are engineers learning how to not only capture this data, but take virtual measurements with it,” he said.

He also stressed there is more going on with metrology than automating it. Metrology enables precise robotic automation as well, especially precision material handling. As noted above, laser trackers, such as the Leica Absolute AT960 are ideal for robotic guidance, especially with the large parts and distances typical in aerospace. “Vision-guided systems enable robots to precisely place windshields or doors in a body-in-white, then measure the gap and flush to ensure quality,” explained Everling.

Others note that there are a number of reasons why automation is growing metrology. “There is a general lack of qualified engineers or technicians for quality control applications,” explained Jerome-Alexandre Lavoie, product manager for Creaform (Lévis, Quebec), a brand of the Ultra Precision Technology (UPT) division of Ametek. At the same time, he observed that several industries are trying to move metrology

away from the lab to get it embedded directly into the manufacturing process. “That last change may have a direct impact on the measurement quality, since people building the product may end up measuring it. There are two solutions to these challenges: simplicity and automation,” he said. “[The industry is] looking to purchase accurate, but simple solutions for their employees, solutions that will remove the operator skills from the operation and that can be operated after a short learning program.”

In 2013, Creaform introduced two scanners specifically designed for automating with industrial robots, the MetraSCAN 70-R and the MetraSCAN 210-R. “When we released these, demands for quality control automation was at its beginning for us,” he said. “Since then, reducing cycle time while moving towards 100% inspection has motivated industry to want more automated metrology, especially in the automotive industry.” It became so important, that the company worked with partner AGT to develop its own turnkey scanning solution, released in May 2015.

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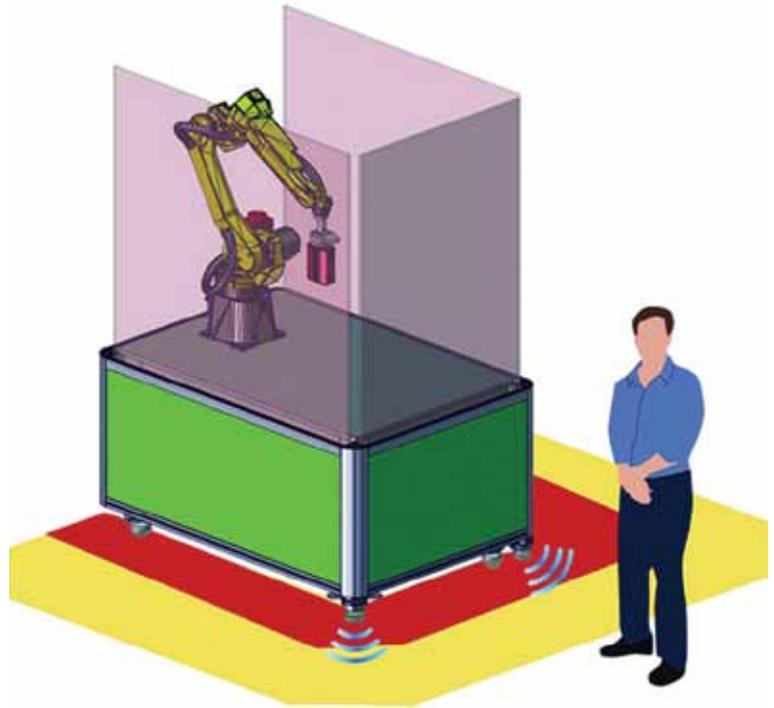
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### Automation as a Product Line

Automation is so important to the manufacturer GOM, producer of the ATOS structured light system, that it created a comprehensive line of Scanbox inspection cells. These combine movements and their ATOS sensors in a protected enclosure. They range from the small 4105 for individual parts up to a double robot cell on rails for whole bodies-in-white or aerospace parts. "Automated metrology is very important to our customers because it allows them to inspect parts faster with higher repeatability and throughput," said Marc Demarest, sales engineer for Capture 3D (Farmington Hills, MI), the North American reseller of GOM equipment. "The best applications are in those environments where either 100% of the parts need to be inspected or a sampling of the produced parts require inspection."



Warning field and protective field configuration in the new Perceptron RoboGauge cell.

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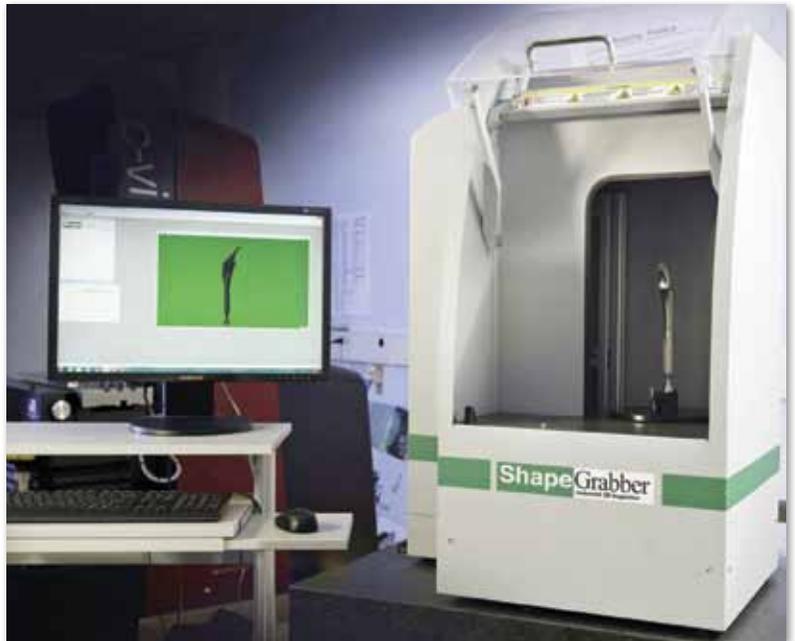
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He said that structured light systems like the ATOS are particularly good for automating because they measure large patches of data from a single viewing perspective. They also achieve their accuracy independent of the motion control equipment's accuracy and repeatability. The device needs to be durable as well, also making structured light systems ideal. "When a metrology device is integrated with a robot, it must be able to endure [that robot's high] velocity and accelerations/decelerations," he explained.

He has seen automated metrology grow as a market. While their automated ATOS systems are used in many different industries, the two largest industries up to now have been automotive and aerospace. In automotive, many of these systems are used for inspecting sheetmetal parts and assemblies, while in aerospace, the most common inspection



*ShapeGrabber Ai series of 3D scanners includes the Ai310 for inspection of smaller parts and the Ai810 (not shown) for larger parts up to 1250 x 800 x 700 mm.*

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is turbine engine airfoils. "In each of the industries we have seen tremendous growth," he said. "In 2011 we experienced 28% of our business in automated solutions, which grew to 60% in 2015."

What about optical metrology in general? "Noncontact systems will continue to grab more and more market share because they are able to provide more complete part information than tactile systems," he said, and along with that will be even more automated installations. "This will lower the cost of entry for automated solutions," he stated.

Pierre Aubrey, CEO of ShapeGrabber (Ottawa) agrees that optical systems like his company's ShapeGrabber 3D laser scanners are ideal for automation. "They reduce the need for the operator to know intimate details of the part or metrology. With 3D scanning you capture all of the data, not just the metrologically significant information," he explained. Since less knowledge is needed at the data capture stage, it is easier to automate.

The ShapeGrabber Ai series of automated laser scanners are ideal where high accuracy coupled with repeatability of results is vital for the job. The ShapeGrabber scanner is designed so that no special fixturing or physical registration of the part is needed. An operator simply places the part in the cabinet then lets it digitally capture the detailed part shape in a series of scans. Alignment, registration and measure-

ment are handled automatically in software. Aubrey notes that while some ShapeGrabber systems can be robotically fed, the majority are used in quality rooms because they get measurement data faster than a CMM. There are also a few installations in near-line applications as well. "You would still want reasonably good temperature and vibration control for ShapeGrabber," he said.

Aubrey pointed out that their systems report baseline accuracies in the 15 to 30- $\mu$ m range. He also noted that a new 3D laser scanhead will have the best accuracy and resolution the company has produced to date. "This will open up new applications for us in which our scanners can measure smaller parts with more intricate details," he said. "It will have under 2  $\mu$ m of resolution."

### Processes and Adaptation

The ideal applications for laser scanners are parts with complex surfaces, such as injection molded plastics, stampings, or castings such as turbine blades. Aubrey notes a

growing business in orthopedic implants, such as knee and hip replacements. "The challenge in that field is getting the manufacturer to change their measurement processes," he said. Their QC methods have been developed over a long period of time assuming measurements would be made with older, often 2D technologies. And in the highly regulated medical industry, change is a challenge all its own.

An important trend in the field of robotics is safe collaboration with human workers, a trend that Perceptron (Plymouth, MI) is adapting to with its AutoScan Collaborative RoboGauge. "Metrology is having an increasing role in assembly and manufacturing," said Keith Mills, vice president of global marketing of Perceptron. He believes people are looking to automate the metrology process for a number of reasons. "It has been too remote from manufacturing, with a feedback loop that is too long," he said. "With metrology becoming an integral part of the assembly process, the assembly process is becoming adaptively controlled based on that data."

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Providing an adaptive solution, RoboGauge brings automated 3D scanning to the plant floor, by combining one of its Helix scanners with a FANUC robot, integrated with a collaborative robot safety solution. The important point of the RoboGauge is it eliminates the need for a safety enclosure—precisely what collaborative robotics is all about. The RoboGauge perimeter is monitored using laser scanners that use diffused reflections of emitted infrared lasers to create a two-dimensional programmable detection safety field. The RoboGauge Cell includes a rigid machine base for holding both robot and part fixture with translucent side panels that light up to provide visual color status indication. It handles and measures a variety of parts including sheetmetal, fabrications, molded parts and castings, and can be used in comparative or absolute inspection mode. The Helix 3D laser scanner incorporates a MEMS sensor. This means laser line quantity, density, length and orientation are programmable and eliminates the need for the robot to physically move the Helix sensor.

“This [affordable] solution means even smaller companies can look at in-line or near-line measurements robotic metrology automation,” said Mills. Although called a gage, Mills stressed that the measurement is an absolute inspection, programmed from a CAD description of the part. ➤

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