Our Solution Partner

GLM Lasermeßtechnik GmbH

In the field of industrial and engineering measurement, Sokkia NET Series Precision 3D Stations serve our customers of diverse industries in collaboration with our solution partners. SOKKIA AT WORK proudly introduces GLM Lasermeßtechnik GmbH, our first partner in the industrial measurement field, and the bond has been strengthened along the history of NET Series. We interviewed Eberhard Kiesel, Managing Director of the company about his background, strong relationship with Sokkia, and the future directions.

We think our NET Series played important role right after the foundation of GLM in 1991. Can you describe the chemistry at the encounter, and pick up some interesting stories thereafter?

Eberhard Kiesel, Managing Director

Yes, I think it was in 1992, after the first sales of a NET2 and SDR4B datalogger to a railway producer, LHB Salzgitter, now known as GEC Alstom, who used the first system for the production of InterCity trains (IC), we were asked to develop a graphical software running on a PC. This was important to make the measurement results more understandable for the user than having only numerical values. This was the origin of the 3-DIM PC software - at that time under the DOS operating system. This system was widely spread not only to many different workshops within German state railway (DB AG), but also to private suppliers like the Bombardier group.

At the end of the 90's we had a cooperation with leading German shipyards like HDW (Kiel) and the Aker Group (Rostock, Wismar) through collaboration with Sokkia Germany. Background was a funded project from the German Government, called "Shipyard 2000", aiming to increase competitiveness of German shipyards. One major issue was to increase productivity and decrease production costs simultaneously. Along with a complete reorganization of workflows, several shipyards introduced the Sokkia/GLM systems, which lead us to develop new version of the 3-DIM PC Basic software.

In the following years all major German shipyards purchased our systems and GLM began to advertise within the Sokkia European sales network. Many European companies could be convinced about the benefits of the offered turnkey solution.

GLM - Office in Witten, Germany

In 2004 GLM developed the "3-DIM Observer" – data logger software which is now running in 16 different languages. Our decision for in-house development was made in order to guarantee a faster response to requirements of European customers.

From the hardware side, a real breakthrough came along with the NET1200, which was introduced at the end of 2003, equipped with a laser pointer, a white light target illumination and the capability of reflectorless measurements. The high accuracy of these instruments, and also of the motorized 3D stations like NET1, NET05, has been certified by the DKD (German Calibration Service). This was always of great help to win the contracts against competition.

What about unique features of our instruments?

First of all, we think the 'high precision' proven by authorized calibration services must be the most advantageous point. Laser pointer and white target illumination light are very unique as well.

You have to be aware that Sokkia/GLM partnership yields unique turnkey solutions just from one supplier such as instrument, datalogger, PC-software, target sets and training, combined with good after-sales service and support.

Fast action to satisfy customers' new requirements is also our unique feature. We succeeded in contracting with Lufthansa Technik AG recently, because we could offer a software customization on short term basis.

Please talk about your next challenge.

On the hardware side for Industrial applications, we feel that Sokkia instruments exactly meet the technical requirements of today.

The system has been promoted successfully in Europe, but we believe there must be high potential also in other industrialized regions of the world. As we did in Europe in the past, GLM is willing to promote the system worldwide, giving trainings to the dealers, or performing a user conference like "Industrial days" with strong partnership with Sokkia.

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Working on a pollution-free energy source

Sokkia NET05 – Precise nuclear fusion

The global ITER (International Thermonuclear Experimental Reactor) project is one of humanity's most challenging energy-related ventures. Its goal is to harness the power source of stars, i.e., nuclear fusion, to humanity's use. If successful, it would offer a new important, pollution-free source of energy. The ITER development project, spanning several decades, aims to demonstrate the scientific and technical feasibility of fusion energy. A 500-megawatt experimental power plant is already being constructed in France.

Remote operation and virtual technologies are an integral part of the ITER project, as all internal maintenance work of the plant's reactor vessel need to be done by means of remote-controlled robotics. Because of this, the DTP2 (Divertor Test Platform Facility) testing environment has been implemented in Tampere in Finland providing a full-scale model of the bottom part of the fusion.

The testing platform itself is approx. 20 metres long and weighs approx. 65 tons. The development environment is a full-scale model of the bottom of the future reactor vessel in the area of one service gate. The bottom also contains the necessary rails for the reactor components, i.e., the divertor cassette and the maintenance robot. The value of the investments in equipment of the testing environment is approximately EUR 7 Million.

The Department of Intelligent Hydraulics and Automation at the Tampere University of Technology is developing safety-critical remote controlling software to guide the work of the maintenance robot by the use of virtual models and cameras.

Sokkia's NET05 Automated 3D Station is used for creating the coordinate system for the development environment, as well as for calibrating and verifying the motion paths of the divertor cassettes carried by the maintenance robot. Even a small error of the robot in implementing the motion path of the cassette inside the fusion plant would be fatal.

Modelling errors need to be measured, understood, and compensated for

The core of the future reactor will contain altogether 52 so-called divertor cassettes, which among other things collect the helium ash created by glowing plasma and protect the structures of the reactor.

The transport robot needs to replace these cassettes regularly. The cassette carried by the transport robot tested in the first phase is 3.5 metres long and weighs 8.5 tonnes. The reactor component (cassette), which needs to be handled with the accuracy of a few millimetres, weighs approx. 9 tons.

"The robot needs to move very slowly. The modelling errors of the robot model and of each divertor cassette must be measured, understood, and compensated for by correcting the mathematical models. When the robot is brought into operation inside the fusion tunnel, we have to rely on the fact that the models of the robot and each cassette moved by it, verified and validated using the Sokkia NET05, are indeed accurate," explains Jouni Mattila, senior researcher at the Department of Intelligent Hydraulics and Automation.

"It is also essential how the mathematical models of the robot are calibrated in relation to the actual geometry of the future ITER test plant environment. The maintenance robot will be calibrated for this environment," he continues.

The measurements and calibrations carried out using the NET05 are a small but essential part of the ITER project. Using Sokkia's accurate measuring system, the kinematic model of the robot, as well as the model of each cassette, are calibrated as close to reality as possible, and the model is adjusted using mathematical methods.

Large masses handled with the precision of millimetres

Industrial robots and large reactor elements always have certain manufacturing tolerances, which makes each robot and cassette individual. In addition, systems moving objects weighing nearly 10 tons experience mechanical elasticity and deformations, which have a non-linear effect that needs to be taken into account in the mathematical models.

"The NET05 automatically tracks the moving prism, which enables us to also accurately measure the motion cycles of the robot and thus to verify the accuracy of the motion cycles," says Mattila and compares this with the speedometer of a car. "Even if your car's speedometer displays the value 100 km/h, an accurate radar can verify that your speed is actually 95 km/h. Sokkia carries out a similar check on the robot's motion paths, but three-dimensionally."

Challenges of remote modelling

Remote modelling of robots is challenging, even though it has been used for a long time. In the ITER project, the remote modelling of robots is made challenging by the fact that human operators cannot manually access the systems for calibration after operation has started, because the operating environment becomes radioactive.

"Because of this, we need to have sound information on how the robot behaves in a tunnel, as well as full confidence in the model. The spectra and accuracy of Sokkia products have fulfilled the promises made. The price-quality ratio has been highly competitive. In addition, we have received very good service from the importer, Geostar," says Mattila.

"It is great that we have the opportunity to participate in a project that can decrease the adverse effects of climate change. At the same time, we obtain important know-how in highly demanding industrial measuring. It is a joy to participate in this venture as an importer," says Kimmo Jäppinen, CEO of Geostar, a specialized agent of Sokkia brand products in Finland.

All measurements are performed with Sokkia NET05. The NET05 is able to measure directly from a surface, a sticker or a prism. Measured points were processed and analyzed using GLM 3-DIM PC-Basic software. It includes functions for doing various kinds of coordinate transformations and evaluations. These functions can be used to perform all necessary coordinate transformations.

All measurements are performed with a Sokkia NET05 featuring 3-DIM Software from GLM, Germany.

GLM

For more information about GLM, please refer to the back cover.

Automated 3D STATION
NET05
MONMOS
MONo MObile 3D measuring System

Working on automotive production lines

The NET1200 Supports Technological Innov ations of Feeding Systems in Automotive Production Lines

Worldwide recession and the issue of global warming have posed unprecedented challenges to the automotive industry. Today the market demands high-quality, fuel-efficient and low-emission vehicles at even lower costs. The most innovative Japanese automotive companies are focusing efforts on improvement of production processes incorporating the most-advanced manufacturing technologies.
In the automated production lines at front-line factories, all machinery and equipment must be perfectly aligned and positioned to increase production efficiency. In response to this trend, many engineers who build production lines are in need of measurement devices that provide the highest possible precision at affordable costs.

Employing the NET1200 for Precise Installation of Machine Pressing Lines

Taiho Seiki Company Limited (TSK) in Toyota-city, Aichi, recently introduced the Sokkia NET1200 3D Station to provide the best possible precision in the automation process. TSK has special expertise and years of experience in machine pressing and welding automation in automotive manufacturing plants.

Yoichi Okamoto, TSK chief of the Facility Manufacturing Division, said, “We used to take measurements with auto-levels and visible cross-line lasers when we worked on assembly and installation of automated feeding systems in machine pressing lines. About a year ago, one of our clients asked us if we could make the process even more precise so they could further increase productivity.”

“Until recently,” he said, “increased precision was accomplished with re-adjustment of feeding robots. That method, however, could not satisfy the newly requested specifications. This was not just a simple adjustment; we needed to improve installation accuracy of entire machine pressing lines.”

The answer to the problem was around-the-corner precise surveying technology.

In automated machine pressing lines, feeding robots serve to transfer work metals from one place to another. All machinery and equipment, including pressing machines, feeding robots and intermediate tables for work metals, must be precisely aligned and installed at the designed locations using established baselines.

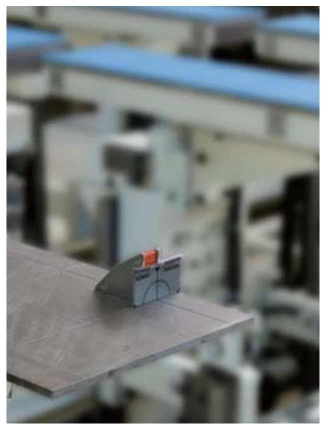
Pursuing maximum measurement precision and work efficiency, TSK introduced the Sokkia NET1200 – 1-arcsecond precision 3D Station. In combination with a handheld computer, the NET1200 system provides a non-contact measurement capability that obtains 0.1mm 3D coordinate values of large objects in a distance range of up to 200m.

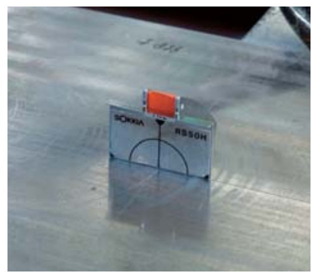
Okamoto said, “With an auto-level, it’s very difficult to read 0.1mm because a slight tilt of a staff can change readings and we also had to count human error in reading graduations. But with the NET1200, it is a breeze. One single measurement instantly gives us xyz 3D coordinates.”

Special Jigs and Measurement Criteria Solved Problems due to the Variation of Operators’ Skill Levels

The company “made special jigs so that anyone could set the reflective targets precisely at the pre-determined measuring points,” he said, “which eliminated variations in operators. Then we made our measurement criteria using the NET1200 that enabled us to obtain highly accurate, reliable data with incredible ease and speed irrespective of operators.”

Okamoto said, “In any factory, there are constant vibrations that lower the measurement accuracy and reliability. But with the NET1200, we can take a complete measurement in a very short period of non-operating time. This is another advantage of this system.”





“Half-type” reflective sheet target with TSK’s special jigs

Superior Portability Accelerated Use in Foreign Countries

To obtain the new tolerance standard, TSK initially purchased two NET1200 systems. Along with their expanding business working with automotive factories outside Japan, the company later added an additional system.

Today, TSK has about 10 operators of this system to simultaneously carry out a number of projects in different countries. One of these operators, Kotaro Iwasa, working with the Facility Manufacturing Division, said, “There was no difficulty at all in learning the NET1200 operation. We can take much more reliable data in a far shorter time, compared to auto-levels and cross-line lasers that we previously used.”

Okamoto said, “We can take the NET1200 as carry-on luggage on flights. This portability is a very important feature for long-distance transportation to foreign countries because we can keep the instrument away from temperature changes and vibrations in the cargo bay.”

Leveraging full advantages of the NET1200 high-precision 3D Station, TSK continues supporting innovations of automotive manufacturing facilities.

3D STATION
NET1200
Bluetooth®

Quest for the Ultimate in Precision

Many manufacturers have long believed that achieving 0.5" precise positioning accuracy was unattainable. The highest accuracy comes not only with a single technological breakthrough, but with a series of discoveries in key technologies, production technologies, and -- most important of all -- shared enthusiasm among all persons involved. This article is the first in a series that will illustrate the principles and development of diverse technologies implemented by Sokkia in its products.
Experience our journey—"Quest for the Ultimate in Precision."

Chapter 1 Angle Measurement Technology

Introduction

The "angle" is one of the primary information elements used to determine the coordinates of measuring points in surveying applications. Technological innovation has seen instruments for angle measurement evolve from the relatively basic optical transits/theodolites to the electronic theodolites and total stations of today, the majority of which incorporate advanced technical features such as absolute rotary encoders and microprocessors.

Over the past decade, Sokkia Topcon has developed a number of innovative technologies in order to achieve higher precision and reliability in angle measurement. These technologies include not only improved mechanics and optics, but also electronic processing algorithms that utilize information theory and communication theory.

Development of Absolute Rotary Encoders

Optical theodolites and transits measured angle by optically reading the graduations along the circumference of a built-in glass circle. Early electronic theodolites read angles using incremental rotary encoders with single patterned codes in consistent pitch. Codes are mostly rectangular in shape. These incremental encoders are still widely used today. One limitation of this technology is that it provides only a relative angle counted from the previous position, requiring users to rotate the instrument after powering on and read the zero-index before starting measurement.

We started development of our original absolute rotary encoders based on our patented RAB code (RAndom Bi-directional code) technology with linear image sensors previously developed for Sokkia SDL30 digital level and its staffs. The absolute encoders have code patterns with which the angle values can be determined irrespective of previously read position. Our goal was to design an encoder with a precision of 1 arcsecond or better while reducing time and cost for assembly and adjustment at both the manufacturing and maintenance stages. Our new encoder satisfied all these demands. Its advanced coding technology not only detects misreading, but can also automatically correct such errors.
Its extremely simplified structure eliminated the need for optical parts, making assembly and adjustment significantly easier compared to its predecessors. The first production model DT510S, a 5" electronic theodolite implementing the new absolute encoders, was released in the Japanese market in 2001. One year later the new Series10 total stations were released in all markets. Absolute encoders render zero indexing unnecessary meaning users no longer have to rotate the instrument after powering on. The Series10 was well received all over the world due to its convenience of use as well as its precision and reliability. The Series10 became a long-selling product and its encoder technology is still being used for current models such as Series20, 20K, 30R and 30RK.

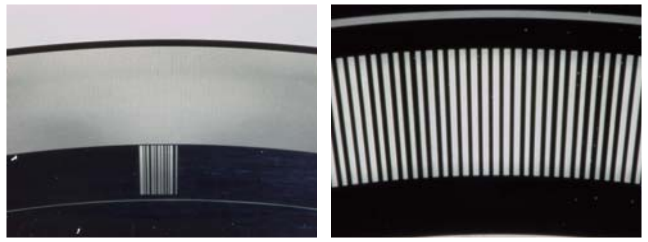

Incremental Encoder Pattern   Absolute Encoder Pattern

FIG.1: Encoder Patterns

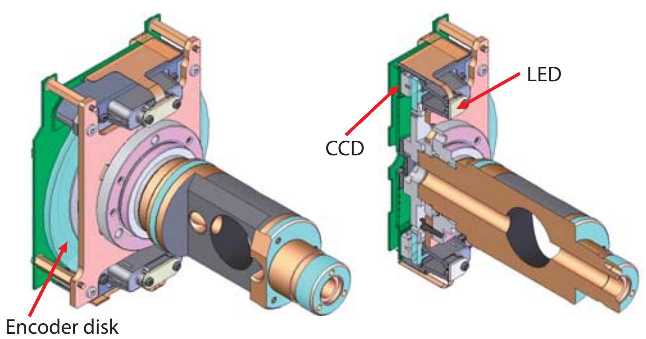


FIG.2: Configuration of Absolute Rotary Encoder System

Function Parameter

We have been continuously pursuing innovation of measurement technologies to obtain higher accuracy and improve product quality. Our target of development was an angle measurement accuracy of 1" or better. There are several approaches for increasing accuracy. One is to improve precision of hardware used, for example, using encoders with more precise code layout or with finer code patterns, or manufacturing more precise rotating axes and bearings. This approach, however, requires a considerably longer lead time and generates a higher production cost.

A common characteristic of angle measurement systems leveraging rotary encoders is that a rotation of the encoder through a full 360° returns measurement error to its original value, and said error changes continuously in relation to rotation. These cyclic and sequence error characteristics allows error patterns to be figured in mathematical schemes as error functions, by using a theory of trigonometrical function.

$$fE(\theta) = AE \cdot \sin(\theta + \phi E)$$

$fE(\theta)$: Error function
AE: Amplitude
ϕE: Initial phase
(Fourier series omitted for simplification)

The error functions of each theodolite or total station can be measured by using external references, and can be memorized within instruments. By subtracting the error calculated with the error function above from measured angle values, theodolites and total stations can provide corrected angle values which are closer to true values.

$$\text{Displayed angle value} = \text{Measured value}(\theta i) - fE(\theta i)$$

This method described above enables us to consistently manufacture high-precision products with 1" or 2" horizontal angle accuracy without any adjustment of hardware.

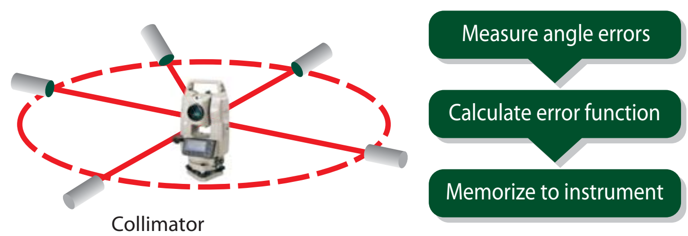


FIG.3: Determining Function Parameters

IACS (Independent Angle Calibration System)

Collimators or other external references are necessary when enhancing accuracy using function parameters as per the method described above. Setting up such references is often costly. Measurement of angle errors is time-consuming and somewhat dependent on operators' skill levels. In order to eliminate these drawbacks, we developed a new, revolutionary technology that does not require external references or measurement by operators at all.

We set a certain angle by calculating a geometric relationship with the angle detection component and have the instrument measure this angle with its own absolute encoders. The measurements should be taken using the full circumference of the encoders so that this angle can be determined accurately enough to be used as the reference. We compare the measured angle values with this reference to determine the error functions of each encoder. These error functions are used for function parameters as explained in a previous paragraph.

Since this technology allows the instrument to calibrate its own angle measurement system by itself, we named it the Independent Angle Calibration System – IACS. At our evaluations during the development stage, we confirmed that by implementing IACS on total stations with a pre-IACS accuracy of up to 3", we could achieve an angle accuracy within 0.5" on all units. IACS requires neither external references nor operator observation, eliminating loss in accuracy due to the problems of external references and variations in operator ability.

IACS was first implemented in 1" and 2" models of the SRX Auto-Tracking total stations in 2006. Currently all high precision Sokkia total stations and electronic theodolites incorporate this technology to provide the highest possible precision and reliability in angle measurement.

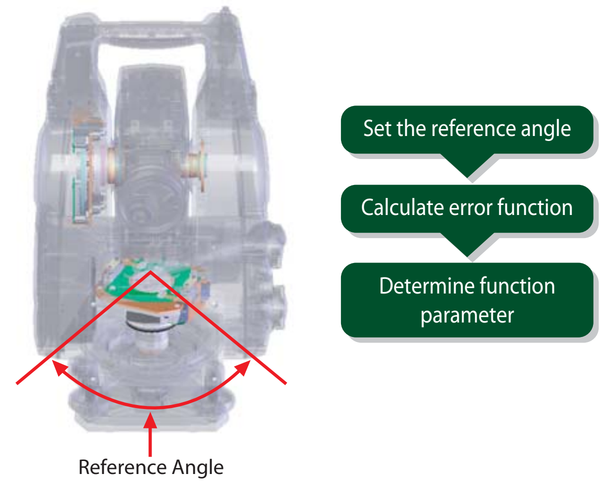


FIG.4: Principles of IACS

Conclusion

We have systematically built up our current angle measurement technologies centered around our original absolute encoders, forever in pursuit of ever higher precision and reliability. These technological innovations not only improved performance in angle measurement, but also reaped efficiency gains in terms of manufacturing and maintenance. We intend to continue our research and development in these fields to realize further innovation to the profit of our users.