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Laser measurement and ballbar diagnosis for motion systems

Ballbar

Check machine positioning performance and diagnose machine errors automatically

Laser

The ultimate metrology tool for traceable machine tool and motion system analysis

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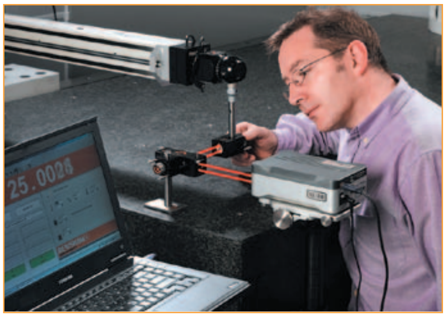


CMM calibration using an XL-80 laser

XL-80 laser and XC-80 environmental compensator

Checking lathe performance with a Renishaw ballbar

QC20-W wireless ballbar system

Metrology is our business

With over 30 years of experience in the field of engineering metrology, Renishaw designs, manufactures and supplies dimensional metrology systems of the highest quality and reliability to enable customers worldwide to carry out dimensional measurements to traceable standards.

Meeting the challenges of modern industry

Modern industry has to meet ever tighter tolerances, customer schedules, and the requirements of international quality standards. Together with the pressure to reduce costs, the performance of manufacturing machinery has never been more important.

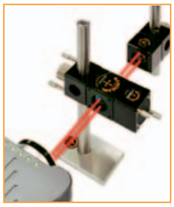
From the touch-trigger probe to the complex Raman imaging microscope, Renishaw brings real solutions to real problems. Renishaw produces products to control processes, improve quality and raise productivity.

Systems normally reserved for research laboratories and standards rooms can now be used directly on the shop-floor without sacrificing accuracy or reliability. Our products combine the best available mechanical, electronic and optical technologies for ease of use, flexibility and portability.

Renishaw's measurement systems are accepted throughout the world as the industry standard for machine performance testing.

Our product offerings enhance quality and productivity, and we strive for total customer satisfaction through superior customer service. When you purchase a laser or ballbar system from Renishaw, you are buying into a worldwide support network that understands machine metrology, machine service and the demands of maintaining accuracy in a production environment.

Encoder
Encoder systems for high accuracy position feedback in linear and rotary applications



Calibration systems
Laser interferometer and automated ballbar systems for performance measurement and calibration of machines

Probe systems for CNC machine tools
Reduce set times by up to 90% and improve your process control

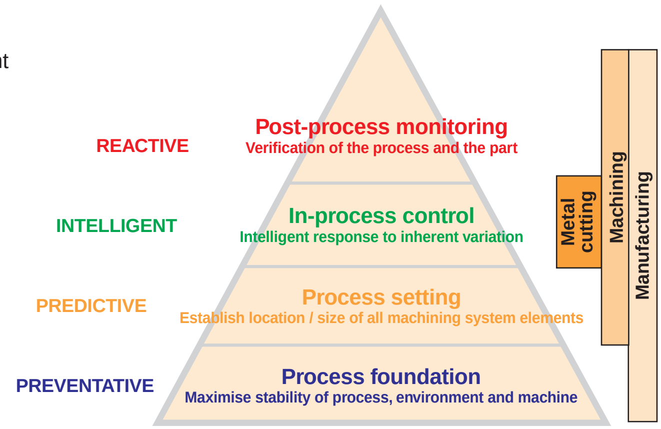
Probe systems for CMMs
Improve your inspection capability and efficiency

Process control and calibration

Calibration is the basis for enhanced process control in manufacturing

If your machines are not in good condition, then no amount of process fault-finding will result in consistently good parts. However, Renishaw is uniquely placed amongst metrology specialists to provide diagnostic and calibration solutions as well as solutions for part and tool setting, tool inspection, on-machine verification and final part ‘off machine’ inspection using its range of probes and sensors (See page 3).

Renishaw products and product support can help you to control your machining processes resulting in less scrap, less rework, less non-conformance, less labour, fewer errors and lower fixture costs.



Machine builders benefit from understanding machine performance to . . .

- **Set up machines and verify specifications:** Fast, accurate measurement of machine performance, quickly allows you to isolate mechanical or electrical problems and then fix them, either by repair or by optimising machine error maps.
- **Reduce build cycle times:** By keeping a record of the performance of each machine you produce, and by closely monitoring the build process, you gain good visibility of any production engineering problems.
- **Demonstrate conformance to specification:** Customers can be reassured that their new machines meet specification as you provide them with traceable calibration results of machine performance. System portability allows you to respond to customer requests for on-site acceptance tests. Machine buy-off test times can be reduced without the need for time consuming cutting tests.

This machine tool OEM checks all production with XL-80 during assembly.

- **Provide a professional maintenance service:** High quality after-sales service is a must. Using the same calibration tools in the customer’s premises is the best way to restore the machine to manufactured specification.
- **Improve machine design:** A detailed analysis of machine accuracy and dynamics helps to identify the impact of new design features on machine performance.

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Machine users benefit from understanding machine performance to . . .

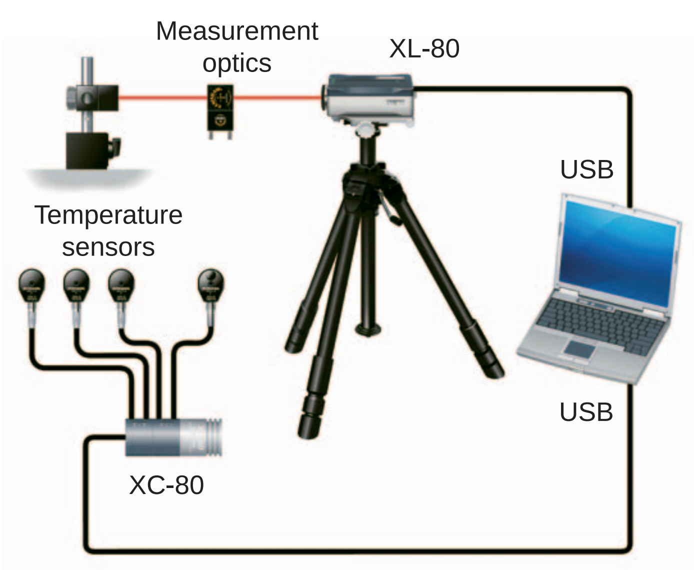
- **Minimise scrap and improve accuracy of cut parts:** By ensuring that a machine is working to specification, the chance of scrap will be minimised. It also enables tighter tolerances to be held on jobs, improving overall accuracy and quality.
- **Minimise machine downtime:** Gain a detailed picture of how each characteristic of a machine's performance is varying over time, predict when maintenance work will be required for a specific machine, and establish contingency plans in advance.
- **Win machining contracts from your competitors:** When customers need confidence in the quality of your machining, calibration graphs and regular performance evaluation results of your machines are excellent proof. These can give you a valuable competitive advantage over other machining contractors, who may not perform such tests.
- **Comply with the ISO 9000 series of standards:** It is a requirement of the ISO 9000 series of quality standards that manufacturing and inspection equipment is calibrated, monitored and controlled.

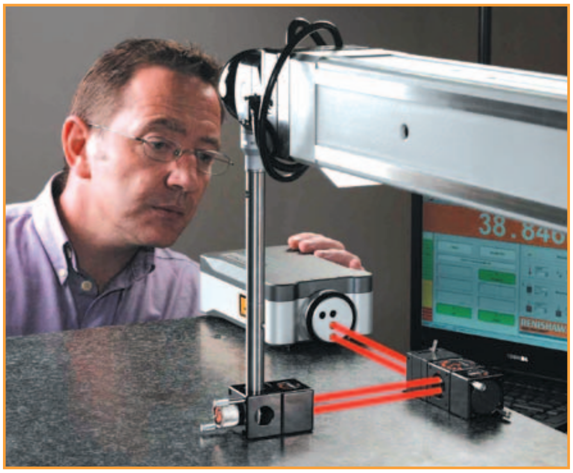
A maintenance and calibration contractor uses XL-80 to verify 5-axis machining centre performance.

- **Grade the performance of all your machines:** By calibrating all your machines, you will be able to grade them according to their relative machining ability. Assigning specific toleranced jobs to machines capable of holding these tolerances, ensures that they are fit for the required purpose and less likely to produce scrap.
- **Extend the life of your machine:** Certain types of machine errors can lead to excessive wear in the drive system and guideways of machines. By pinpointing and eliminating these errors at an early stage, you can improve the working life of a machine.
- **Validate the quality of a new machine upon delivery:** Often shipping and site installation can have a detrimental effect on a machine's accuracy. A performance check on the machine immediately after installation, confirms its readiness to begin work.

XL-80 laser measurement system

The XL-80 offers the ultimate in high accuracy, repeatable and traceable measurement, using externally mounted interferometers





Renishaw's laser interferometer systems are used for comprehensive accuracy assessment of machine tools, co-ordinate measuring machines (CMMs) and other position-critical systems. The facts speak for themselves....

- **High and consistent accuracy:** System accuracy of ± 0.5 ppm is maintained throughout its operating range of 0 °C – 40 °C (32 °F – 104 °F).
- **Interferometry is traceable:** All Renishaw's laser measurements, including straightness and angular, are interferometric, and therefore based on the internationally traceable standard wavelength of laser light. Other systems which use electronic targets to measure pitch, yaw and straightness errors, appear attractive, but often compromise measurement accuracy and stability.
- **Quick and safe alignments with a tripod mounted laser:** All alignment can be undertaken comfortably and safely outside the machine. No need to lose axis travel or suffer the effects of cable drag on the measurement.
- **Optics designed for the shop user:** All optics housings are made from hard anodised aluminium, resulting in light, durable components that thermally acclimatise to a shop environment 10 times quicker than steel housings. The patented LS350 beam steerer makes alignment simple, even for beginners.
- **Long range measurement:** Linear measurements can be taken on axes up to 80 metres (266 ft) in length, with the option to SIMULTANEOUSLY measure the parallel axes of dual drive machines.
- **Rotary axis calibration:** The combination of the XL-80 laser with XR20-W rotary axis calibrator provides the only FULLY AUTOMATIC method of rotary axis calibration on CMMs and machine tools.
- **Comprehensive software:** Packages that support reporting to international standards for machine verification as well as allowing linear position error correction and dynamic motion analysis.

XL-80 system components

The basis of the new system is a compact laser head (XL-80) and an independent compensator system (XC-80)

XL-80 laser

The XL-80 laser produces an extremely stable laser beam with a wavelength that is traceable back to national and international standards.

The laser frequency stability is specified as ±0.05 ppm over 1 year and ±0.02 ppm over 1 hour. This excellent performance is achieved by dynamic thermal control of the laser tube length to within a few nanometres.

Linear measurement accuracy is an assured ±0.5 ppm over the whole environmental range i.e. from 0 ºC - 40 ºC (32 ºF - 104 ºF) and 650 mbar - 1150 mbar. Readings are taken at 50 kHz, with a maximum linear measurement speed of 4 m/s and a linear resolution of 1 nm; even at maximum speed.

As the XL system uses interferometry as the basis for all its measurement options (not just linear), you can have confidence in the accuracy of all your measurements.

With integrated USB there is no requirement for a separate laser-to-PC interface. The laser also features an auxiliary analogue signal output as standard, with quadrature output a factory option. The same socket also accepts a trigger signal input for data capture synchronisation.

LED status lights, indicating laser status and signal strength, provide back-up to the software's 'on-screen' indicators. Together with a switchable long range mode (40 m - 80 m) and a warm-up time of less than 6 minutes, these features make the XL-80 quick and easy to use.

An external, switch mode power supply ensures 90 V - 264 V flexibility in input voltage.

XL-80 system components

XC-80 compensator and sensors

The XC-80 compensator is a key factor in your XL system's measurement accuracy. Featuring 'intelligent sensors' that process the readings at source, the compensator very accurately measures air temperature, air pressure and relative humidity.

It then modifies the nominal value of the laser wavelength to give a true value, used in displacement calculations, which virtually eliminates any measurement errors resulting from these variations. This can be done automatically, every 7 seconds, as indicated by LED status lights on the XC-80 unit.

Like the XL-80 laser, the compensator is directly connected to your PC via a USB port which, for the XC unit, also supplies power (no separate power supply is required).

Sensor cables are 5 m long and detachable for easy replacement. Multiple cables can be screwed together for extended lengths on longer machines.

The design of the XC-80 and sensors ensures extremely accurate readings over the full range of operating conditions, from units that are built to withstand the daily handling that most systems will receive.

Up to three material temperature sensors can also be attached to the XC-80 compensator to allow linear measurements to be normalised to a standard material temperature of 20 °C.

Both the air and material temperature sensors are 'intelligent'. Integral microprocessors analyse and process the sensors' output before sending digital temperature values to the XC-80 compensator. This offers more secure measurements and is a key reason why the XC-80 is so compact.

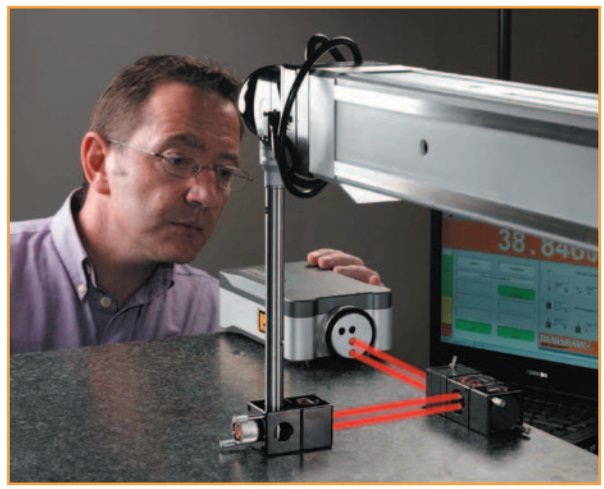
The XC-80 weighs only 490 g and together with the XL-80 weighs just over 3 kg (including connecting cables, XL power supply and sensors).

Sensor performance	Range	Accuracy
Material temperature	0 ºC - 55 ºC	±0.1 ºC
Air temperature	0 ºC - 40 ºC	±0.2 ºC
Air pressure	650 mbar - 1150 mbar	±1 mbar
Relative humidity (%)	0% - 95% non-condensing	±6% RH

Tripod and stage

Unless you are using a dedicated measurement rig, then you are likely to need a tripod and stage to adjust the laser's position relative to the desired measurement axis. A new universal tripod has been extensively tested to provide a stable adjustable base in a compact, lightweight unit.

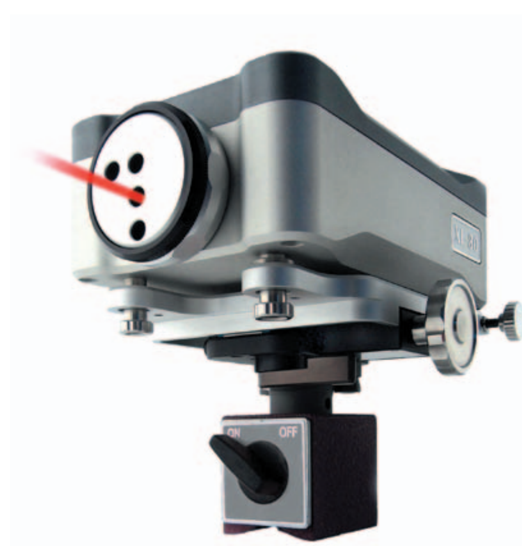
The XL tripod stage allows for precise angular rotation and translation of the XL-80 and is designed to be left attached to the laser unit for easy storage and quick set-up.



A 'quick fit/release' mechanism enables rapid and secure fixing to the tripod. For those applications where tripod mounting is not convenient, e.g. for mounting directly on a machine tool table, the stage and laser can also be mounted on most standard magnetic bases, using an optional adapter with M8 thread.

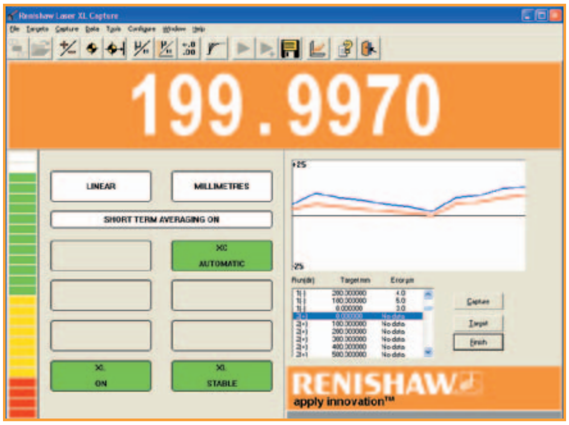
Due to careful design, the XL-80 laser and optics can also be placed directly on a granite table (without tripod stage) for co-ordinate measuring machine (CMM) calibration.

The tripod and tripod case together weigh just 6.2 kg, to complement the portability of the rest of the laser system.



LaserXL™ software maximises your XL system performance and flexibility

Powerful software and clear and extensive support documentation are key to releasing the potential of the XL-80 system



LaserXL™ software

LaserXL™ software includes modules for linear, angular, rotary axis, flatness, straightness and squareness measurements, as well as dynamic measurement capability (see below). Users can select from English or a choice of several main languages* for LaserXL™, QuickViewXL™ and system manual.

Standard report options conform to many international machine performance checking standards, such as ISO, ASME, VDI, JIS and GB, and include a comprehensive Renishaw analysis.

The standard analysis software includes an option to generate compensation values for use in the CNC machine's controller, significantly improving the machine's positioning accuracy. Optional 'stand alone' linear error compensation packages include additional capability to read and write to the machine's controller, enabling existing error compensation parameters to be read and new ones to be uploaded. For further details see page 17.

Dynamic measurement

LaserXL™ dynamic measurement facility allows the collection of data at rates of 10 Hz to 50 kHz (at 12 preset values) and provides displacement, velocity and acceleration data. There's even an integrated FFT package for frequency analysis.

For real-time 'oscilloscope style' display of live position velocity or acceleration data refer to QuickViewXL™ software.

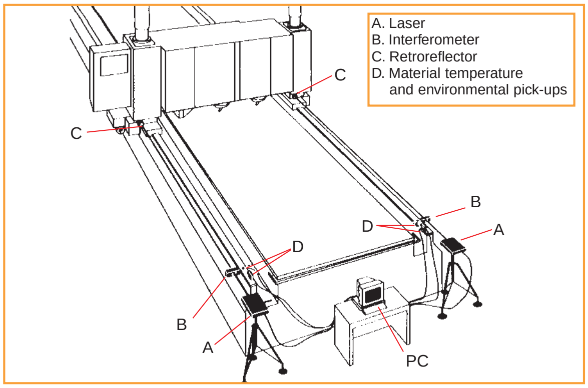
These dynamic measurements allow certain machine error characteristics to be highlighted and quantified. For example:

- Pre-load and hysteresis of ballscrew and nut mechanisms
- Positional stability and encoder performance
- Resonance characterisation of drive motors, spindles and other systems
- Feedrate accuracy, stability and interpolation accuracy
- Control-loop optimisation

Dual axis measurement

In some installations, one axis is controlled by two drives and two feedback systems (eg Spar mills, lathes and large dual beam type CMMs). In this instance, a second laser and optics, coupled with dual axis software, provides the capability to automatically capture data of parallel axes simultaneously.

Dual axis measurement software is included as standard with LaserXL™ software.



Typical dual axis set-up

* Software is supplied on CD in the following languages: English, German, French, Italian, Spanish, Japanese, Chinese, Russian and Korean.

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QuickViewXL™ software for live dynamic analysis

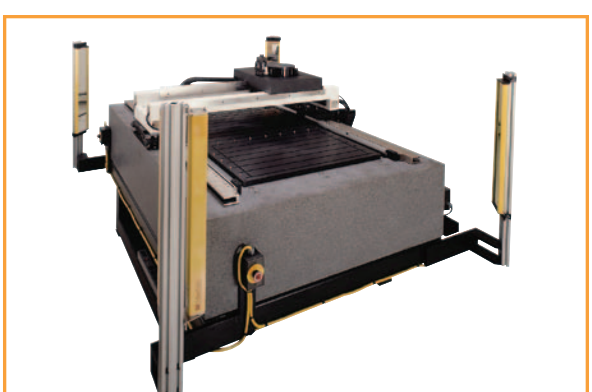
Live, real-time display of laser measurement data for linear displacement, velocity and acceleration analysis

QuickViewXL™ is a simple to use, intuitive software package to capture, review and save dynamic data acquired via the XL-80 laser measurement system.

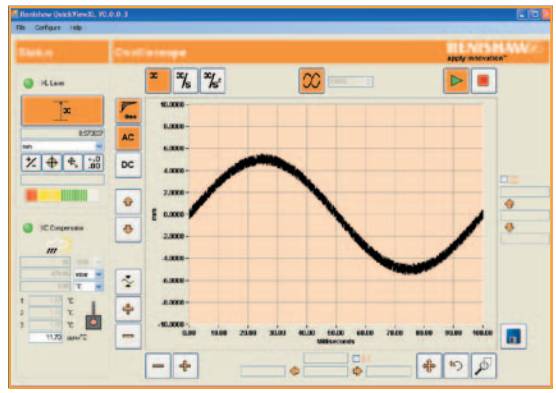
Knowledge of a position sensitive machine's dynamic characteristics - acceleration, velocity, vibration, settle time, resonance and damping - is critical in many applications. These characteristics will influence operational capabilities such as positional accuracy, repeatability, surface finish, throughput and wear.

QuickViewXL™ provides the ideal tool for R&D, as it enables quick and easy investigation, review and characterisation of motion systems. It provides users with the following functionality:

- Live data display in an oscilloscope style format
- Data capture rate of 50 kHz
- Supports measurement with linear, angular or straightness measurement optics
- Three modes of data capture: free running, single shot trigger and multi-shot trigger



X-Y stage (photo courtesy of Danaher Precision Systems)



QuickViewXL™ software

- Distance, velocity and acceleration display modes
- Selectable filters of 1, 2, 5, 10, 20, 50 and 100 ms response
- Cursors for measurement of amplitude, time and frequency
- Manual scale, pan and zoom functions allowing 'close up' analysis of selected data
- Auto scale option

Captured data can easily be loaded into supporting applications such as MathCAD, Mathmatica and Excel for further analysis using CSV file format. It can also be loaded into Renishaw's LaserXL™ software allowing FFT analysis.

PC minimum requirements (Laser XL™ and QuickViewXL™)

Correct PC specification is vital for system performance. Please check with Renishaw for latest details.

- Processor - 1 GHz Pentium, 512 MB RAM
- Drives - CD-ROM for software installation
- Minimum screen resolution 1024 x 768, SVGA
- Hard Disk - 100 MB drive space needed for software installation
- Peripherals - Keyboard and Microsoft mouse or compatible pointing device
- Operating system - Windows® XP SP2/SP3, Windows Vista™ or Windows® 7 (32 and 64 bit versions of these operating systems supported)
- Interface - Recommended 3 free USB, 2 ports for XL laser, XC compensator and USB mouse. More USB ports may be required if an XR20-C, error compensation or dual functionality is required. Note: a USB hub can be used to increase the number of available USB ports.

System performance

Without reliable and accurate wavelength compensation errors of 20 ppm - 30 ppm would be common

±0.5 ppm	**certified linear measurement accuracy over the full range of environmental operating conditions**
1 nm	**linear resolution (even at max. velocity)**
4 m/s	**maximum travel velocity**
7 seconds	**between each automatically updated environmental compensation**
50 kHz	**dynamic capture rate**
80 m	**linear range as standard**

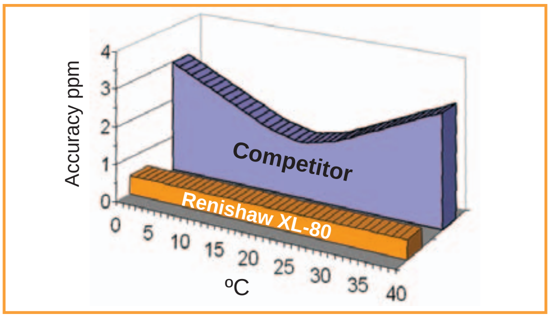
The greatest uncertainty in most laser measurements arises from variations in environmental conditions (air temperature, air pressure, humidity) compared to nominal values. Even small variations in conditions will alter the laser wavelength and the resulting measurement reading. For example, the following changes will increase laser wavelength by 0.25 ppm (parts per million):

- 0.26° C air temperature increase
- 0.93 mbar air pressure decrease

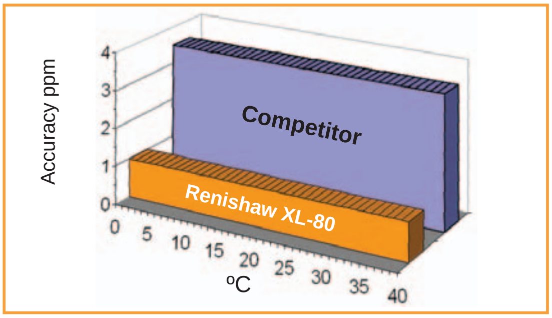
When variations of temperature, humidity and pressure from nominal values are combined they can cause 20-30 ppm uncertainty in measurement (even if the test conditions remain stable).

Renishaw uses it's XC-80 environmental compensation unit and very accurate environmental sensors to compensate for the effects on the laser wavelength.

Great effort has been taken to ensure Renishaw's XC-80 compensation system and sensors are accurate across the entire operating range of the system. It is this that maintains ±0.5 ppm linear measurement accuracy from 0 ºC - 40 ºC (32ºF - 104 ºF) and over the full air pressure range (see graph comparisons with competitor system).



System linear measurement accuracy vs. environmental temperature



Material normalisation accuracy @ 10 ppm/ºC

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Other factors for accuracy

- **Laser frequency stabilisation –** ± 0.05 ppm over 1 year, ± 0.02 ppm over 1 hr is achieved by thermal control of the laser tubes length to within nanometres.
- **Separate interferometer –** Renishaw uses a remote interferometer rather than one mounted on or inside the laser head, to avoid thermal drift.
- **Accuracy for all measurements -** Laser linear measurement accuracy is only part of the metrology solution. You can also capture and analyse linear, angular, straightness, squareness, flatness and rotary axis motion with your XL-80 system, all using traceable linear measurement as a basis.

Measurement normalisation

To compensate for a machine's thermal expansion, the XC-80 unit can also receive data from up to three material temperature sensors. Placed in appropriate positions on the machine under test these normalise all readings to a reference temperature of 20 °C (68 °F). Thermal compensation is particularly important when performing linear measurements, especially on large machines or machines made of high expansion materials.

Accuracy by design

We believe that you should understand the background to our performance claims, to give you the confidence that the XL-80 delivers real accuracy where it counts, in day to day use.

Renishaw's accuracy specification is derived in accordance with recognised procedures for the calculation of measurement uncertainty (EA - 4/02) for laser stability, sensor output, and all key parameters and calculations affecting the final measurement. A summary of the error budget that is the basis of the published specification is available.

Overall system accuracy is quoted to the internationally recognised 95% confidence level (k=2) and includes allowance for drift in service.

Proven field performance

With an installed base of thousands of units worldwide operating over 18 years, our track record shows that Renishaw's laser systems continue to meet specifications day-in day-out, under a wide variety of conditions. This level of performance has been repeatedly verified by third party testing (including national laboratories).

Ease of use and set-up

Easy to transport, quick to set-up and use, the XL-80 allows users to reduce waiting time and increase available measurement time.

- Short preheat time (below six minutes)
- Laser and stage designed for combined storage
- Stage features quick release tripod mounting

- Reduced components and connections. Both laser and compensator connect to your PC via USB; no separate interface, and no complicated set-ups are required
- The XC-80 compensator is powered via its USB connection, so no external power supply is needed

Flexibility and ease of operation

- 'Switchable' between standard (40 m) and long (80 m) range modes
- An analogue I/O port allows for analogue and quadrature signal outputs (factory specified option) and a trigger signal input
- Easy to read LEDs for status and signal strength indication
- Uses standard or cordless mouse as trigger for remote manual data capture

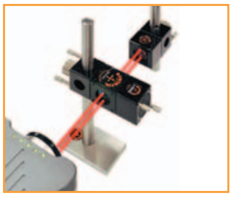
The small size of the XL-80 laser and XC-80 compensator means that the whole system (less tripod) can now be packed into a truly portable 'wheelie-case'. A complete linear system in its case weighs around 12 kg. Even with the optional angular optics and accessories it weighs just over 15 kg; a highly portable system that others just can't match.

Base system case takes full linear and angular system*

System 'wheelie-case' and additional tripod case are truly portable

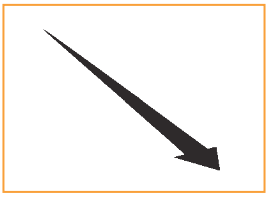
* Optional larger case available for comprehensive optics and accessories storage

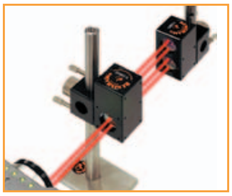
Measurement options



Linear positioning accuracy and repeatability of an axis

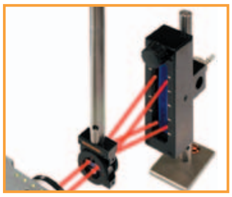
The laser can measure the actual displacement moved along an axis and compare it against the displacement shown by the machine's axis encoders. The basis for error compensation of machine tool CNCs.





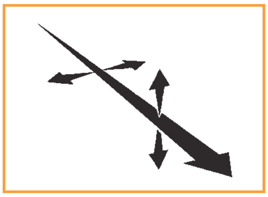
Angular pitch and yaw of an axis

These are common causes of positioning errors. Even a small error at the spindle can cause a significant effect at the tool tip. Interferometric measurement is fully traceable to national standards



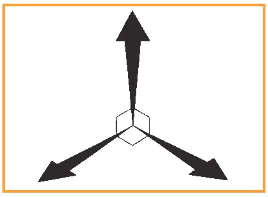
Straightness of an axis

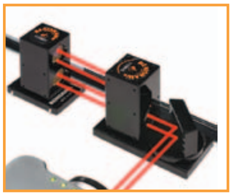
Both horizontal and vertical straightness of motion along an axis can be measured. Straightness errors have a direct influence on machine path accuracy and are unlikely to be uniform along an axis of a machine.



Squareness between axes

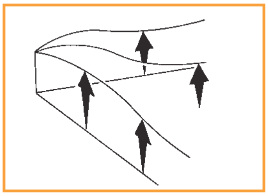
Axes need to be square to each other as well as accurate along their length. By using a calibrated optical square and combining two straightness measurements the squareness of two axes can be calculated precisely.

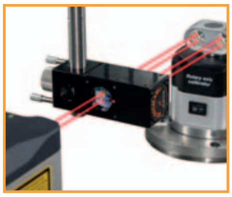




Flatness of a surface

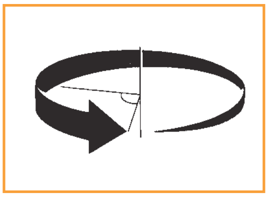
Flatness of reference tables can be critical. This measurement enables a 3D picture of the surface form to be built up.





Rotary axis/table angular positioning

Rotary axes are increasingly common on machine tools.
The XR20-W provides for automatic data collection when used with a Renishaw laser and angular optics.



Laser measurement system - linear measurement

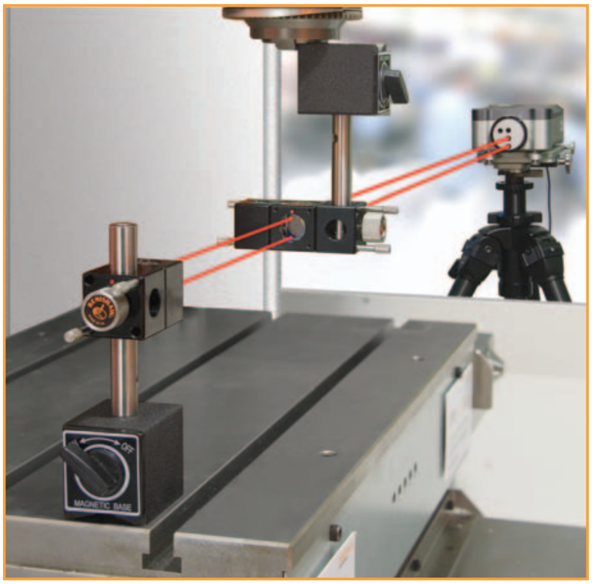
Linear measurement is the most common form of measurement performed on machines.

The system measures linear positioning accuracy and repeatability by comparing the position given on a machine's controller display with the true position measured by the laser. These values can then be viewed, printed and statistically analysed by the system's software to national and international standards.
On many of today's machine tools, it is also possible to take this process one step further and automatically download the error data to a compensation table in the machine's controller. In this way, a machine's positioning accuracy can be verified and significantly improved, quickly and easily.

Set-up

The components used in this measurement comprise:

- Linear beam-splitter
- Retro-reflectors (2)
- Targets (for easy optical alignment)

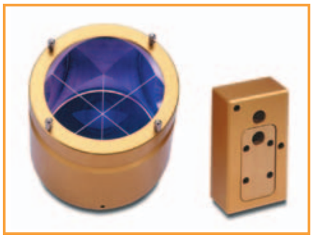


X axis linear positioning measurement on a VMC

In linear measurement, one retro-reflector is secured to the beam-splitter, to form the fixed length reference arm of the interferometer. The other retro-reflector moves relative to the beam-splitter and forms the variable length measurement arm. The laser system tracks any change in the separation between the measurement arm retro-reflector and beam-splitter.

Linear optics

The XL-80 incorporates a 'high gain' signal switch that can be used to allow linear measurements of up to 80 m. However the laser beam diverges over long distances and outgoing and incoming laser beams can interfere with one another.



Long range retro-reflector and periscope

The linear long range accessory kit provides a periscope to separate the output beam and a large retro-reflector to maintain separation and make alignment easier (kit has to be used in conjunction with standard linear measurement optics).

For measurement of dual or tandem drive machines, connect two laser systems together with the DUAL AXIS SOFTWARE.
Refer to page 10.

For easier set-up and alignment refer to page 28.

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System advantages

- **Highly durable optics –** the aluminium optics housings, including threads, are all hard-anodised, corrosion proofed and shock resistant.
- **Improved dynamic response –** with less than half the weight of steel optics housings, machine loading is reduced.
- **Quick thermal acclimatisation –** aluminium optics acclimatise 10 times quicker than steel optics.
- **No thermal drift problems –** the interferometer is remote from the heat of the laser head, with the laser heat source remaining away from the machine.
- **Easier set-up –** the remote interferometer can be fitted to specific areas of interest on a machine, without loss of axis travel. This also allows for multiple axis measurements to be made from one position.
- **External laser alignment –** tripod mounted laser makes for easy alignment outside the machine.
- **Easier long-range alignment –** the larger retro-reflector gives an easy target to hit and returns more laser light, even in turbulent air.

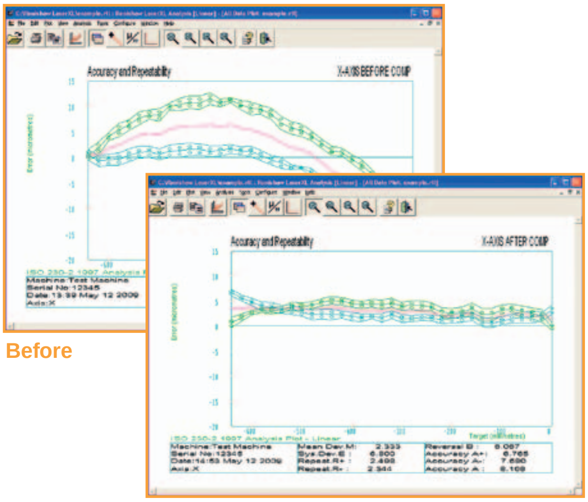
Linear error compensation

Software is available for the following controllers which, in conjunction with Laser10 and LaserXL, gives additional functionality to make axis compensation even easier. Note that error compensation software may not work with all variations of the following listed controllers including those with 'customised' controller specifications. Functionality may also vary from package to package. Contact your local Renishaw product support for details of latest controllers covered and full details of functionality.

Once the compensation has been completed, a final laser check ensures that a machine's positioning accuracy has been significantly improved.

Compensation packages are available to interface with many of today's machine controllers including:

- Fanuc OM and OT
- Fanuc 10 - 12, 15, 16, 18, 20 & 21
- NUM 750, 760, 1060.
- Mazak M2, M32, M PLUS
- Siemens 810, 810D, 820, 840, 840C, 840D, 850, 880
- Acramatic 2100
- Cincinnati A850, A850SX, A950
- Combination package (includes all the above)



Before

After

For users with PCB drilling and routing machines.
Sieb & Meyer error compensation software (V8.66J or later) can accept data output files directly from Laser10's generic error compensation facility.

Specification	Metric	Imperial
Linear measurement range *	0 m – 80 m	0 in – 3200 in
Measurement accuracy (with XC-80 compensator)	±0.5 ppm (parts per million)	
Resolution	0.001 µm	0.1 µin
* 0 m - 40 m standard. Performance specifications for linear (above) and other measurement modes are quoted to 95% confidence level (k = 2), and are valid across the full environmental operating range.		

Laser measurement system - angular measurement

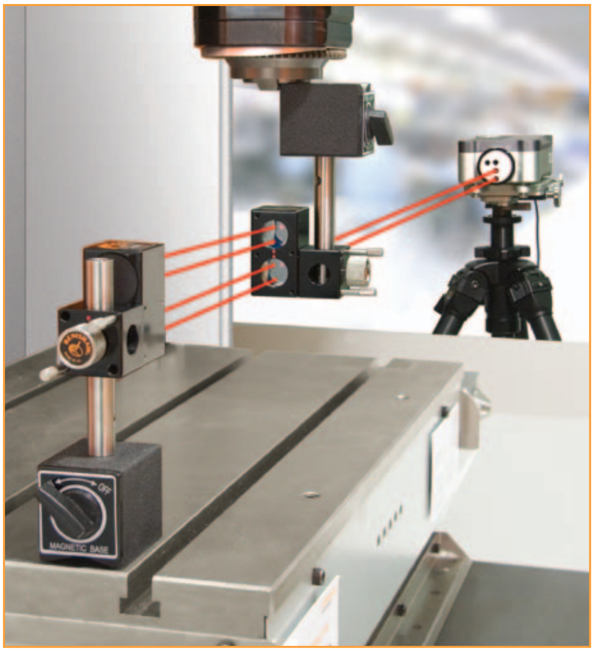
Pitch and yaw angular errors are among the largest contributory factors to positioning inaccuracy in machine tools and measurement errors on CMMs.

Set-up

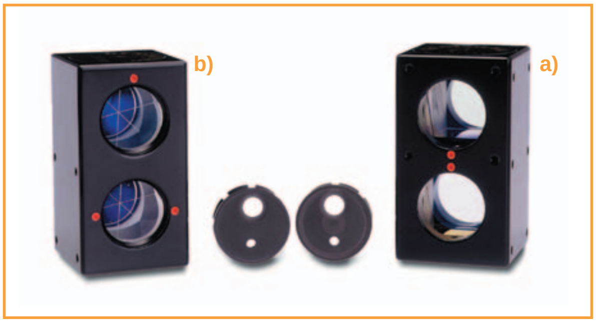
The components used in this measurement comprise:

- Angular beam-splitter
- Angular retro-reflector
- Targets (for easy optical alignment)

For measurement set-up, the angular beam-splitter optic is best mounted in a fixed position on a machine, for example, the spindle on a moving bed machine tool or granite table on a CMM. The retro-reflector optic is then mounted to the moving part of the machine, for example, the moving bed of a machine tool or probe head of a CMM. The measurements are made by monitoring the change in relative angle between the beam-splitter optic and the reflector optic.



X-axis pitch measurement on a moving bed VMC



Angular optics. Includes: a) Angular interferometer, b) Angular retroreflector and plastic alignment targets

For single set-up of both linear and angular measurements, contact us to find out more about our special ‘combination optics’ kits.

System advantages

All the advantages of linear measurement plus . . .

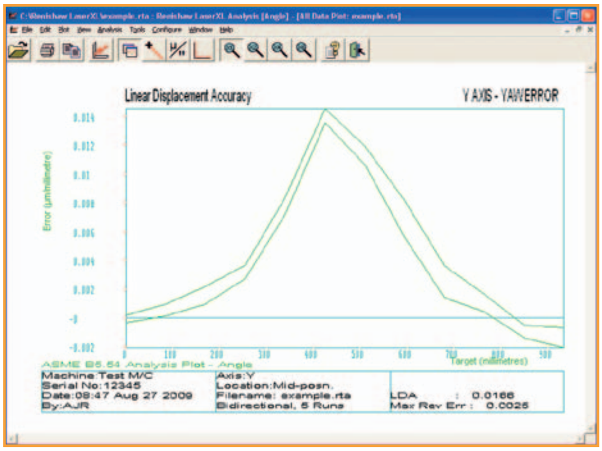
- **Traceability –** interferometry directly benefits from the traceability of the laser wavelength. PSD/CCD/Quad cell based systems do not.
- **Accuracy –** interferometry offers more accuracy and linearity with less sensitivity to air turbulence noise, compared to PSD/CCD/Quad cell based systems.
- **Easier set-up –** the remote interferometer can be fitted to specific areas of interest on a machine, without loss of axis travel. This also allows for multiple axis measurements to be made from one position.

For easier angular alignment set-up use the LS350 beamsteerer.
Refer to page 28

Angular optics can also be used to measure the flatness of CMM table and surface plates.
Refer to page 24

Rotary axes can also be calibrated using angular optics in combination with the XR20-W rotary axis calibrator.
Refer to page 26

The unique design of linear, angular and straightness optics enables easy interchange for different measurements without having to re-align the laser.



A typical plot captured when performing an angular measurement.

Specification	Metric	Imperial
Axial range	0 m - 15 m	0 in - 49 ft
Angular measurement range	±175 m rad	±10º
Angular accuracy	±0.002A* ±0.5 ±0.1M µ rad	±0.002A* ±0.1 ±0.007F arc sec
Resolution	0.1 µm/m	0.01 arc sec

* A = displayed angular reading.
±0.002A is the term for optional high accuracy angular optics (±0.006A with standard optics)
M = measurement distance in metres; F = measurement distance in feet

Laser measurement system - straightness measurement

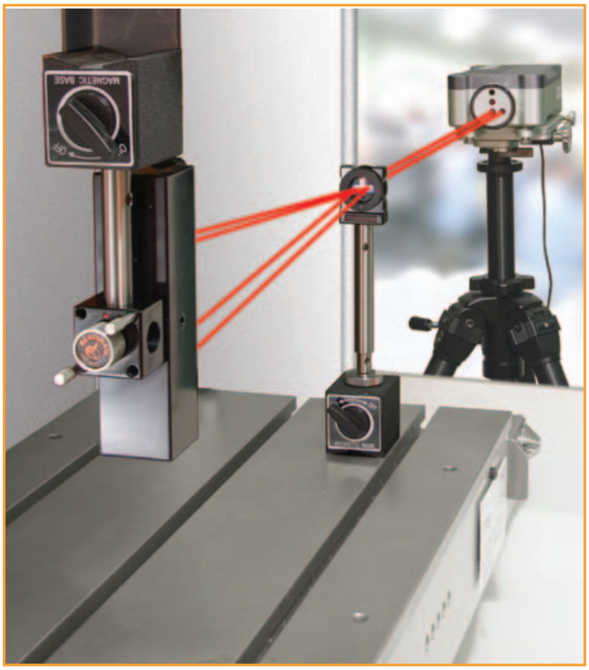
Straightness measurements highlight any bending component or overall misalignment in the guideways of a machine.

This could be the result of wear in these guideways, an accident which may have damaged them in some way, or poor machine foundations that are causing a bowing effect on the whole machine. Straightness error will have a direct effect on the positioning and contouring accuracy of a machine.

Set-up

The components used in this measurement comprise:

- Straightness beam-splitter (Wollaston prism)
- Straightness reflector

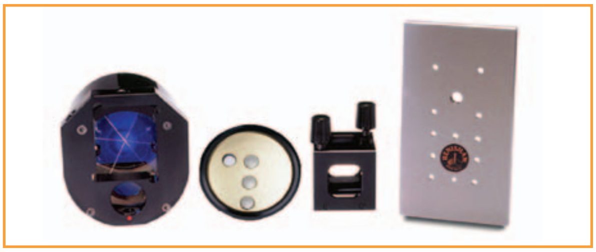


X-axis straightness measurement on a moving bed VMC

For measurement set-up, the straightness reflector is mounted to a fixed position on the table even if it moves. The straightness beam-splitter should then be mounted in the spindle. There are two kits available for measuring shorter axes (0.1 – 4.0 m) and longer axes (1 – 30 m).

Short range straightness optics

When measuring vertical straightness in a horizontal axis, or straightness in a vertical axis of a machine, a straightness accessory kit is required for set-up.



Straightness accessory kit

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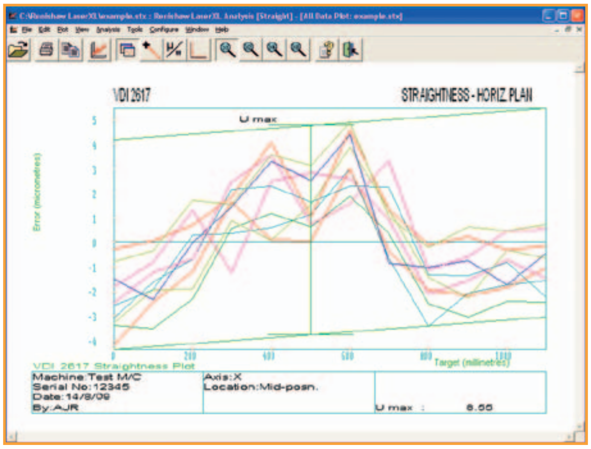
System advantages

- **Easier set-up –** geometry of the patented straightness retro-reflector gives non-overlapping output and return laser beams, making alignment far easier than with other systems.
- **Best long-range performance –** PSD/CCD/Quad cell based systems can suffer from noise and accuracy problems, particularly on long range measurement.
- **Convenience –** moving optics have no cables to drag or snag, for best accuracy and convenience.



This is a typical plot captured when performing a straightness measurement.

If straightness measurements are taken on two axes, it is possible to assess parallelism. It is also possible to measure squareness errors between these axes. Refer to page 22

Specification	Metric	Imperial
Axial range (short range)	0.1 m - 4.0 m	4 in - 160 in
(long range)	1 m - 30 m	40 in - 1200 in
Straightness measurement range	±2.5 mm	±0.1 in
Accuracy (short range)	±0.005A ±0.5 ±0.15 M^2 µm	±0.005A ± 20 ±0.5 F^2 µin
(long range)‡	±0.025A ±5 ±0.015 M^2 µm	±0.025A ±200 ±0.05 F^2 µin
Resolution (short range)	0.01 µm	1 µin
(long range)	0.1 µm	10 µin
A = displayed straightness reading M = measurement distance in metres; F = measurement distance in feet; ‡ subject to environmental conditions		

Laser measurement system - squareness measurement

Squareness measurement determines the out-of-squareness of two nominally orthogonal axes, by comparing their straightness values.

Squareness errors could be the result of wear in machine guideways, an accident which may have caused damage, poor machine foundations or misaligned home position sensors on gantry machines. Squareness error will have a direct effect on the positioning accuracy and contouring ability of a machine.

Set-up

The specific component required for this measurement is:

- Optical square and bracket
- Straightness optics

To measure squareness of horizontal to vertical axes will also require a straightness accessory kit. Other set-up accessories may also be required, depending on what axes are being measured and the configuration of the machine.

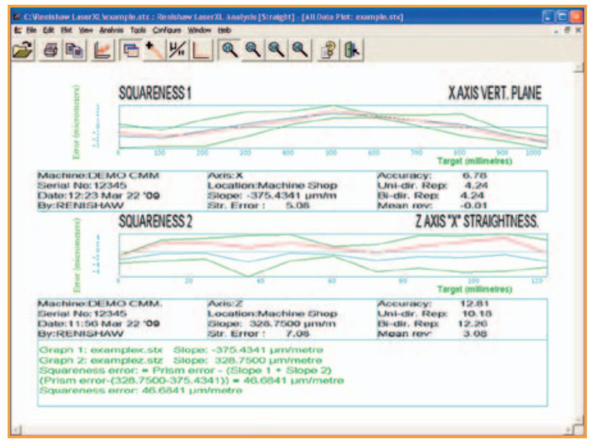
X-Z axis squareness measurement on a VMC

Optical square

As a quick alternative for measuring squareness on machine tools, why not use the QC20-W ballbar? Although not a fully traceable measurement, the squareness diagnosis given by the QC20-W is very quick and simple to achieve and indicate whether a more in-depth analysis using the XL-80 laser is appropriate. Refer to page 30

System advantages

- **Easier set-up –** geometry of the patented straightness retro-reflector gives non-overlapping output and return laser beams, making alignment far easier than with other systems.
- **Best accuracy –** the optical square provides better accuracy than other systems due to the premium grade optics used (± 0.5 arc sec).



This is a typical plot captured when performing a squareness measurement.

Straightness optics

Straightness accessory kit

Specification		Metric	Imperial
Range		±3/M m rad	±2000/F arc sec
Accuracy	(short range)	±0.005A ±2.5 ±0.8 M µrad	±0.005A ±0.5 ±0.05 F arc sec
	(long range)	±0.025A ±2.5 ±0.08 M µrad	±0.025A ±0.5 ±0.005 F arc sec
Resolution		0.01 µrad	0.01 arc sec
A = displayed squareness reading M = measurement distance in metres of the longest axis; F = measurement distance in feet			

Laser measurement system - flatness measurement

Flatness measurement is performed to check the form of CMM tables and all types of surface plate.

It determines whether any significant errors in form exist and, in turn, quantifies them. If these errors are significant to the application of the flat surface, then remedial work, such as further lapping, may be required.

Angular measurement optics are also required to attach to the top of the flatness bases. These are available separately and are shown in the angular measurement section. Refer to page 18.

The angular retro-reflector is mounted on one of three lengths of flatness foot-spacing base. The size of base used depends on the size of surface to be tested and the required number of points to be taken. The angular beam-splitter is mounted on the flatness mirror base.

Set-up

The specific components used in this measurement comprise:

- Base (50 mm)
- Base (100 mm)
- Base (150 mm)
- Flatness mirrors

Flatness mirrors and bases

Angular optics

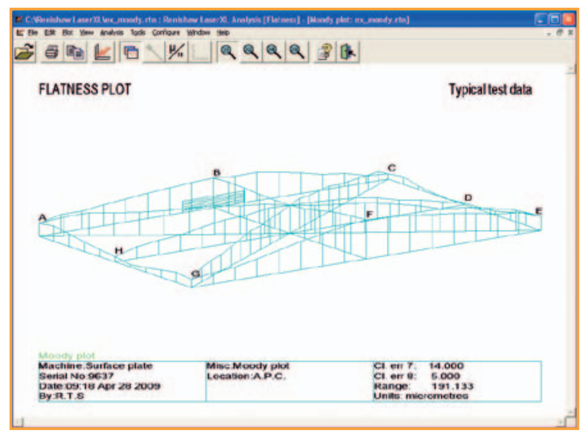
Before making any measurements, a 'map' of the measurement lines should be marked out on the surface. The length of each line should be an integer multiple of the foot-spacing base selected. There are two standard methods of conducting flatness measurements:

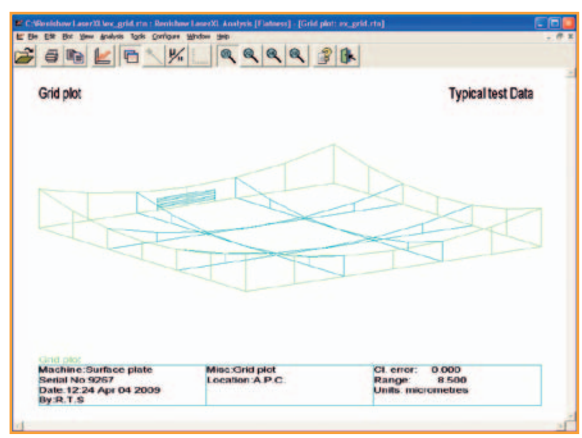
a) Moody method – in which measurement is restricted to eight stipulated lines.

b) Grid method – in which any number of lines may be taken in two orthogonal directions across the surface.

System advantages

- **Reduced thermal drift –** the interferometer is remote from the warmth of the laser head.
- **Traceability –** interferometry directly benefits from the accuracy and traceability of the laser wavelength. PSD/ CCD/Quad cell based systems do not.
- **Easier set-up –** the flatness mirrors are non-slip and fully adjustable for both pitch and yaw for simple, quick alignment.
- **Flexibility –** the software supports flatness measurement using electronic levels. It can also support both Grid and Moody plot techniques.
- **Single laser positioning –** all measurement lines can be achieved from a single laser position.





These are the typical plots obtained from a flatness measurement. The top graph shows a Moody plot type whilst the bottom shows a typical Grid plot type.

Specification	Metric	Imperial
Axial range	0 m - 15 m	0 in - 590 in
Flatness measurement range	±1.5 mm	±0.06 in
Accuracy	±0.006A ±0.02 M^2 µm	±0.006A ±0.08 F^2 µin
Resolution	0.01 µm	1 µin
Foot spacing	50 mm, 100 mm and 150 mm	2 in, 4 in and 6 in (approx)
A = displayed flatness reading M = length of the diagonal in metres; F = length of the diagonal in feet		

Laser measurement system - rotary measurement

Rotary axes are increasingly common on machine tools and their accuracy is vitally important to overall machine accuracy

The fundamental importance of rotary axis accuracy is recognised in many national and international standards. These include strong provision for rotary axis measurement. Many CMMs also have rotary tables fitted. With the XR20-W, Renishaw offers a compact, lightweight, wireless device (Bluetooth® wireless technology) that enables much easier and quicker testing of rotary axis angular performance than has been possible until now.

Set-up

The components used in this measurement comprise:

- XR20-W rotary axis calibrator
- Angular interferometer optics. Users may already have these as part of their angular measurement optics (see page 18) or they can be purchased separately.

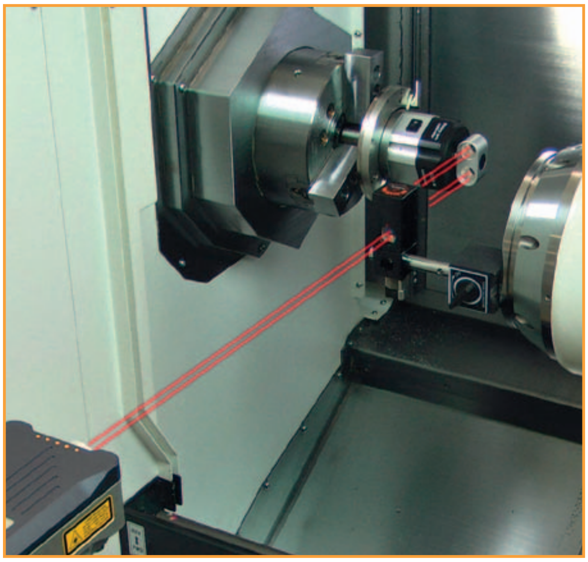
Recent international standards state that a rotary axis should be calibrated in a number of ways, which include:

- 0.1° increments through 5°.
- 3° intervals through 360°.
- At 0°, 90°, 180° and 270° positions and nine further random angular positions through 360°.

It is extremely difficult to complete these measurements using auto collimators and optical polygons.

Automated testing with XR20-W enables rotary axes to be checked at any angular position and far more quickly than with any other methods.

With its integrated target and alignment optics and pre-test calibration routine, repeatable, high accuracy measurements are ensured. The system will operate horizontally, vertically or even upside-down for easy calibration of different orientations of rotary axis.



XR20-W rotary axis calibrator

XR20-W showing fixing to table and angular reflector

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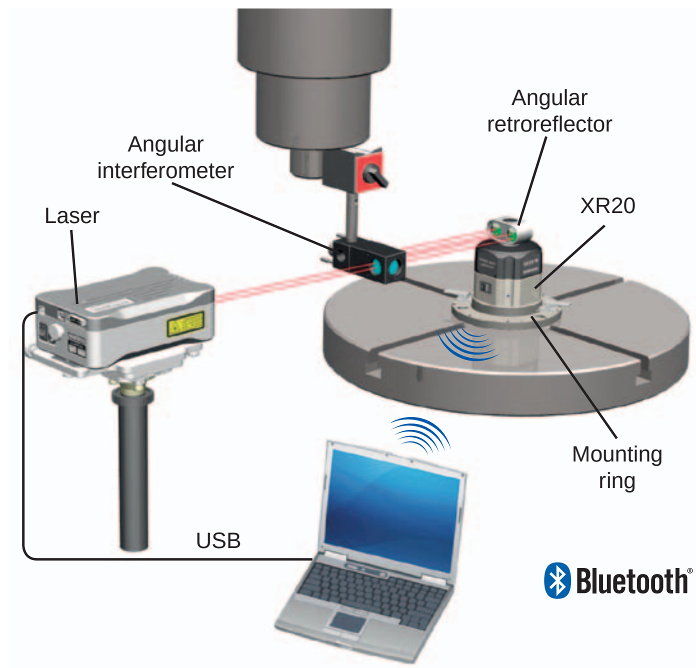
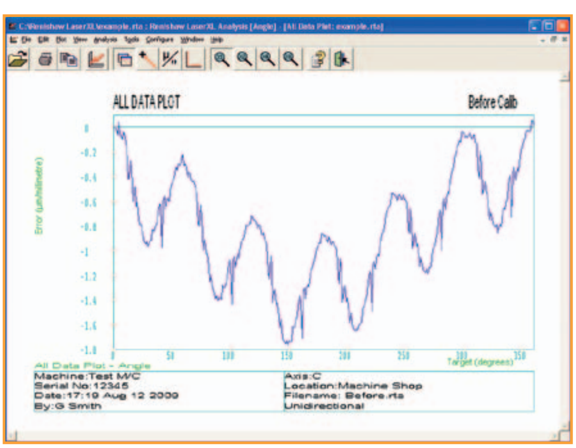
Testing an axis

A typical test (5° step size) is performed as follows:

1. The XR20-W is located on the axis under test and the laser system aligned (as shown in the diagram opposite).
2. The laser is datumed at the axis start position, data capture is started on the PC and the CNC program run.
3. After overrun the axis reaches the initial target position (laser reading equals zero) and a laser reading is triggered.
4. The axis under test then moves 5° to the 2nd target and the XR20-W rotates 5° in the opposite direction.
5. The system records the positional error in the axis under test by combining the XL-80 and XR20-W readings.
6. By driving the rotary axis to a series of points it is possible to build up a picture of the overall accuracy of the axis.





System advantages

- **Accuracy and flexibility –** ±1 arc second verification of rotary axes in any orientation. Multiple mounting options.
- **Simple operation –** Wireless technology, self calibration and simple test setup and data capture.
- **Rapid testing –** Quick system and test setup and our fastest ever data capture.

Specification	Metric	Imperial
Angular target range	up to 25 revolutions	
Measurement accuracy (zero at 0°)	±5 µm/m	±1 arc sec
Max axis rotation speed (<5° axis rotation)	Unlimited	
Max axis rotation speed (>5° axis rotation)	10 rpm	
Bluetooth range	Typically 5 - 10 metres	
Orientation	Any	

Laser measurement system - system accessories

LS350 beam steerer

This unique patented optic provides easy angular adjustment of the laser beam in both horizontal and vertical planes, making laser alignment a simple one step process. The beam steerer speeds up linear, angular and straightness measurements, whether in-line or at 90°. The optic is also compatible with the linear/angular combination kit and swivel/fixed turning mirrors. Clamping screws allow the beam steerer to be easily attached to measurement optics.

Specification	Metric	Imperial
Steering angle range	± 35 m rad	± 2°
Steering linear range	0 - 10 m	0 - 33 ft

Swivel mirror

This mirror can be used as an alignment aid for ANSI B5.54 diagonal measurements. It is also useful when measuring slant-bed lathes. Clamping screws allow the mirror to be easily attached to measurement optics.

Fixed turning mirror

This mirror reflects the laser beam through 90^{o}. Like the swivel mirror, it can be attached to the measurement optics to aid optical set-up and is used primarily when there is restricted access to the required axis of measurement.

Optics mounting kit

This kit provides the essential elements required to mount the Renishaw optics to a machine. Optics can be easily interchanged without the need to re-align the laser. It comes with hard anodised aluminium mounting blocks, stainless steel pillars and bases for the optimum combination of portability and durability. They also incorporate M8 threads for attachment to standard magnetic bases or Renishaw's CMM probe heads.

TB10 quadrature trigger box

This device monitors the position feedback signals between a machine's encoders and its controller, and feeds trigger signals to the Renishaw laser system. This allows synchronisation of data capture from the XL-80 laser head to encoder position or movement.

It is primarily used in applications such as 'on-the-fly data capture' or for monitoring encoder errors, so a machine can be driven along an axis without stopping to collect data for position, angle, straightness etc. This mains-powered unit works with RS422 quadrature or analogue current loop encoders and triggers the laser measurement at regular user-defined intervals.

TB10 quadrature trigger box

QC20-W wireless ballbar and ballbar kit

The most widely accepted system for machine tool performance evaluation

Renishaw's QC20-W ballbar offers you the perfect solution. It's the quickest, easiest and most effective way to monitor machine tool condition.

The heart of the system is the ballbar itself, a very high accuracy, telescoping linear sensor with precision balls at each end. In use the balls are kinematically located between precision magnetic cups, one attached to the machine table and the other to the machine spindle or spindle housing.

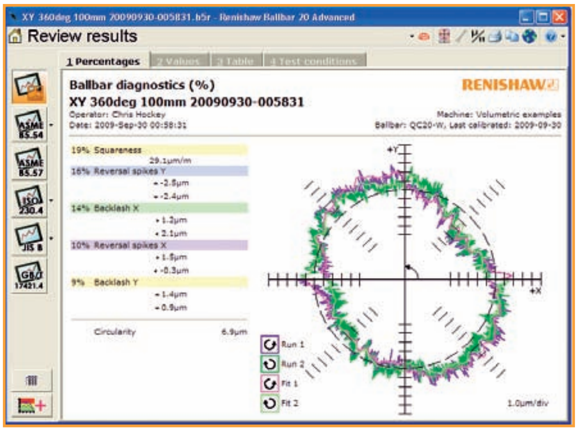
This arrangement enables the ballbar to measure minute variations in radius as the machine follows a programmed circular path.

The data collected is used to calculate overall measures of positioning accuracy (circularity, circular deviation) in accordance with international standards such as ISO 230-4 or Renishaw's own analysis reports. Data is displayed graphically as well as in numeric format to aid and support diagnosis.

Signal processing is carried out within the ballbar and data transmitted to a suitable PC using a Bluetooth® Class 2 module. A standard (non rechargeable) CR2 lithium ion battery is supplied with each unit. An LED status indicator built into the housing shows battery, communications and fault status.

Analysis reports

Test data can be analysed and displayed in accordance with the latest ISO 230-4, JIS B 6190-4, ASME B5.54 and B5.57 and GB17421.4 standards. These reports give a value for a single overall indicator of machine positioning performance, e.g. circular deviation. The separate Renishaw analysis format uses unique maths algorithms to derive values for up to 15 contributory machine errors. It can even rank these according to their contribution to the overall positioning performance. In short it is a true 'expert' system that can deliver an in depth diagnosis of a machine's errors; all from a single test. Renishaw analysis can even be used with 'partial arc' test data.



The *Bluetooth* word mark and logos are owned by Bluetooth SIG, Inc. and any use of such marks by Renishaw plc is under license.
Other trademarks and trade names are those of their respective owners.

Testing capability

The standard QC20-W ballbar kit includes a 100 mm long ballbar assembly and 50, 150 and 300 mm long extension bars. By assembling the ballbar with different combinations of extension bars it is possible to carry out ballbar tests with 100, 150, 250, 300, 400, 450, 550 or 600 mm radii. With additional extensions it is possible to perform tests up to 1350 mm in a horizontal plane.

The optional small circle kit allows tests with a 50 mm radius, and testing can also be carried out on two-axis machines and lathes using optional accessories.

Partial arc testing

Redesigned ball mounts (including new centre pivot and tool cup extension) allow the QC20-W to carry out a 220° arc test in planes through the centre pivot axis.

This means that you can carry out ballbar tests in three orthogonal planes without the need to reposition the centre pivot, so speeding up testing.

The results can also be used in the new ‘volumetric analysis’ report function (see software section) with the assurance that all data has been gathered around the same reference point.

QC20-W ballbar kit

Supplied as a complete kit-in-a-case, the ballbar kit provides a powerful and portable solution – just add a PC and you’re ready to start testing.

Kit contents

- QC20-W wireless ballbar
- Centre pivot
- Tool cup
- 50, 150 and 300 mm extension bars
- System software (including manuals)
- Zerodur® calibrator
- Offset setting ball
- Machine validation cards
- Calibration certificates
- System carry case (includes cut-outs for the optional small circle and VTL adaptors)

System specification

Sensor resolution	0.1 µm	4 µin
Ballbar measurement accuracy (at 20 °C / 68 °F)	±1.00 µm	±40 µin
Ballbar measuring range	±1.0 mm	±0.04 in
Sensor stroke	-1.25 mm to +1.75 mm	-0.05 in to +0.07 in
Maximum sample rate	1000 Hz	1000 Hz
Data transmission *Bluetooth*, Class 2	10 m typical	33 ft typical
Operating range	0 °C - 40 °C	32 °F - 104 °F
System case dimensions	395 x 300 x 105 mm	15.5 x 11.8 x 4.1 in
System case weight incl. kit contents	3.75 kg (approx)	8 lb 4 oz (approx)

Zerodur® is a registered name of Schott Glass Technologies.

System software for QC20-W ballbar

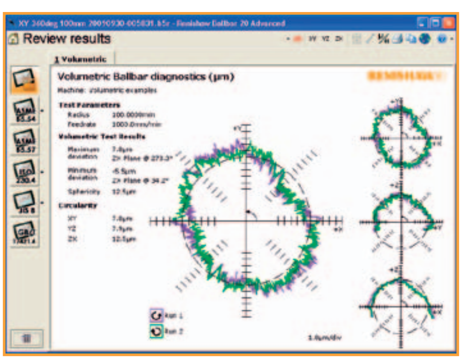
Ballbar 20 software

Just like the QC20-W ballbar, Ballbar 20 software is powerful and easy to use. The intuitive interface and step-by-step instructions mean you can be using the system in minutes.

Key features are:

- Easy to use interface (Windows XP, Windows Vista®, Windows 7 compatible)
- Live data capture
- Analysis and display of test data in accordance with the latest ISO 230-4, JIS B 6190-4, B5.57 and B5.54 standards as well as extensive Renishaw analysis that automatically diagnoses machine errors

Volumetric analysis



This is a new report option that allows the user to select three test files and then display a numeric 'sphericity' result and the overall max and min circularity values. Graphical results are given for each of the three planes together with their individual circularity results. This analysis option also shows individual test circularity results. The volumetric analysis is only available when viewing results in the 'Renishaw analysis' and is not supported in ISO, ASME and other standards' analyses.

To ensure the validity of the analysis the software carries out checks on data files, e.g. consistent machine name, feedrate, radius and that test planes are orthogonal, and will only display an analysis if these criteria are met.

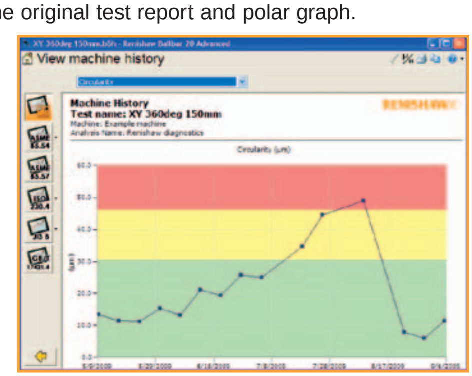
Volumetric analysis will only work with data captured using Ballbar 20 software, although this can be used with QC10 (3 off 360° tests), or QC20-W (360°, plus 2 off 220° tests).

Machine history

The machine history function allows you to build and review a test history for any specific machine. Just choose a machine, a test template and then select some or all of the corresponding tests in the machine folder.

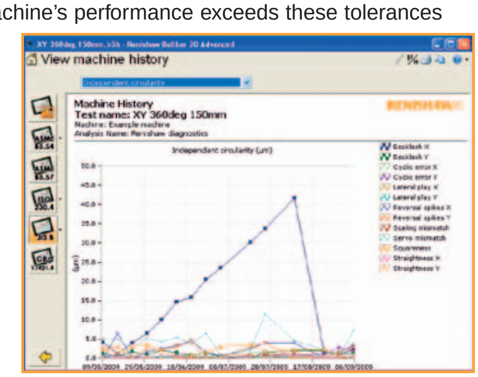
The machine history function allows the variations in the performance of your machine over time to be displayed graphically, using any of the standard report values.

You can clearly see how your machine's performance has varied and can even 'interrogate' individual plot points back to the original test report and polar graph.



In short, review a complete 'medical record' for your machine! The software also allows you to:

- Set individual warning and failure performance bands for each machine parameter
- Get instant notification, during the ballbar test, if a machine's performance exceeds these tolerances



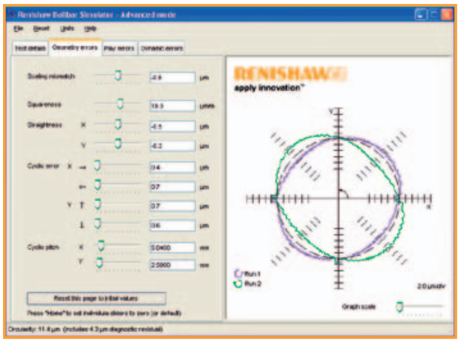
There's even a combined history plot which shows the independent circularity values for all parameters over time. This is a very useful 'first stop' in reviewing the relative importance of these and their variation over time.

* Available in English, German, French, Italian, Spanish, Chinese, Japanese, Czech, Korean, Russian and Polish.

Machine history allows you to:

- See how machine performance is degrading with use
- Predict maintenance requirements in advance to reduce unscheduled downtime
- Compare performance before and after a crash to pinpoint corrective maintenance requirements
- Review the effects of maintenance and service adjustments as they are carried out
- Assess machine history to spot recurring problems, and the effectiveness of previous fixes

Ballbar plot simulator



This is a powerful tool to aid decisions on corrective action or maintenance prediction. The simulator allows users to see their test results on screen and then to change various machine geometry, play and dynamic parameters to see 'what if' results on the ballbar plot, circularity and positional tolerance values.

Ease of use

- User modes
    - Advanced - Full access to set up, edit and organise machine data. Create and use test templates and machine files.
    - Operator - Use for regular comparative testing. Access library of machines and test templates for quick and consistent testing.
    - Quick check - Use for one-off testing of machines with differing set-ups.

- Test and machine set-up
  Ballbar 20 allows you to set up a 'test template' to ensure repeatable testing which is the basis of the 'Machine History' function. The test template defines the key test parameters and can be associated with one or more machines. Each machine tested also has its own machine file providing key machine details.

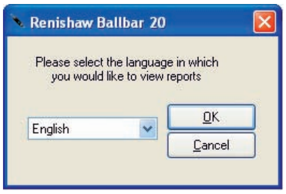
  If you've got multiple machines you still want to find the right machine easily. Sort by 'category' and then by name, location (great for multi-site users) or date last tested. Machine files can be duplicated and edited to save set-up time and test templates copied from one machine to another. It's a truly flexible solution.

- Part program generator
  This facility allows the automatic generation of a part program for the specific ballbar test. Simply define a ballbar test or select an existing test template, select a pre-defined CNC controller definition and then click the 'generate' button. The part program generated can be reviewed on-screen prior to printing or exporting to a removable storage device.

- Comprehensive manual and multilingual support*

Integrated manual

Integrated manual, with hotlinks and search.



Multilingual support

Ballbar 20 allows multi-language report generation as well as a choice of operating language.*

PC requirements for Ballbar 20

The same as for Laser systems (page 11) except:

- Minimum screen resolution 800 x 600 pixels
- Interface - *Bluetooth* enabled PC (Microsoft enumerator) or compatible *Bluetooth*-USB adaptor (ask Renishaw for current recommendations)

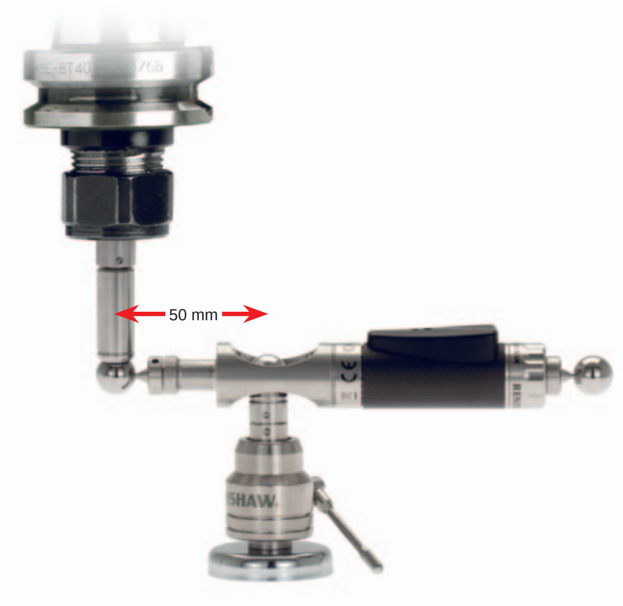
QC20-W ballbar accessories

Small circle accessory kit

The small circle accessory kit is used with the QC20-W ballbar to allow tests with a radius of 50 mm. This can be useful when testing machine axes with short axis travel, or to emphasise the effects of servo and dynamic errors on the machine (small circles require higher machine accelerations and decelerations).

The kit includes a 50 mm Zerodur® calibrator (and calibration certificate) and the small circle adaptor, which is supplied with an additional centre ball already fitted. The adaptor is a simple screw fitting to the main ballbar body. The kit is not recommended for use with the lathe accessory. The adaptor is available separately for customers upgrading from QC10 to QC20-W who already have a small circle accessory kit.

Contents of QC20-W small circle accessory kit

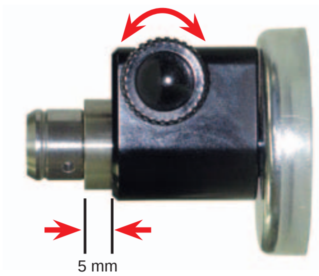


VTL adaptor

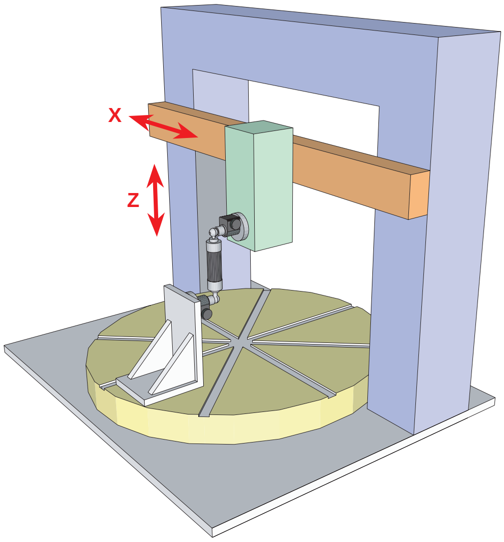
For 2-axis CNC applications the VTL adaptor is available (this replaces the ‘tool cup’ in the standard set-up and restricts movement of the centre cup to a single axis only.) This enables typical 2-axis machines such as vertical turning lathes and laser cutting machines etc, to benefit from QC20-W ballbar diagnosis.

With the zero position co-ordinates set, the VTL accessory allows for one magnetic cup to be withdrawn (to allow it to be driven to the test start position using the free axes’ motion) and then be pulled forward (to the third axis zero position) without introducing any offset error in the other two axes.

The schematic below shows a typical application on a VTL where the tool head always runs along the X-axis on the centre-line of the rotary axis.



VTL adaptor restricts movement of the magnetic cup to 5 mm in one axis only.



Typical two-axis vertical turning lathe showing VTL adaptor on tool holder.

Test a wide range of machines

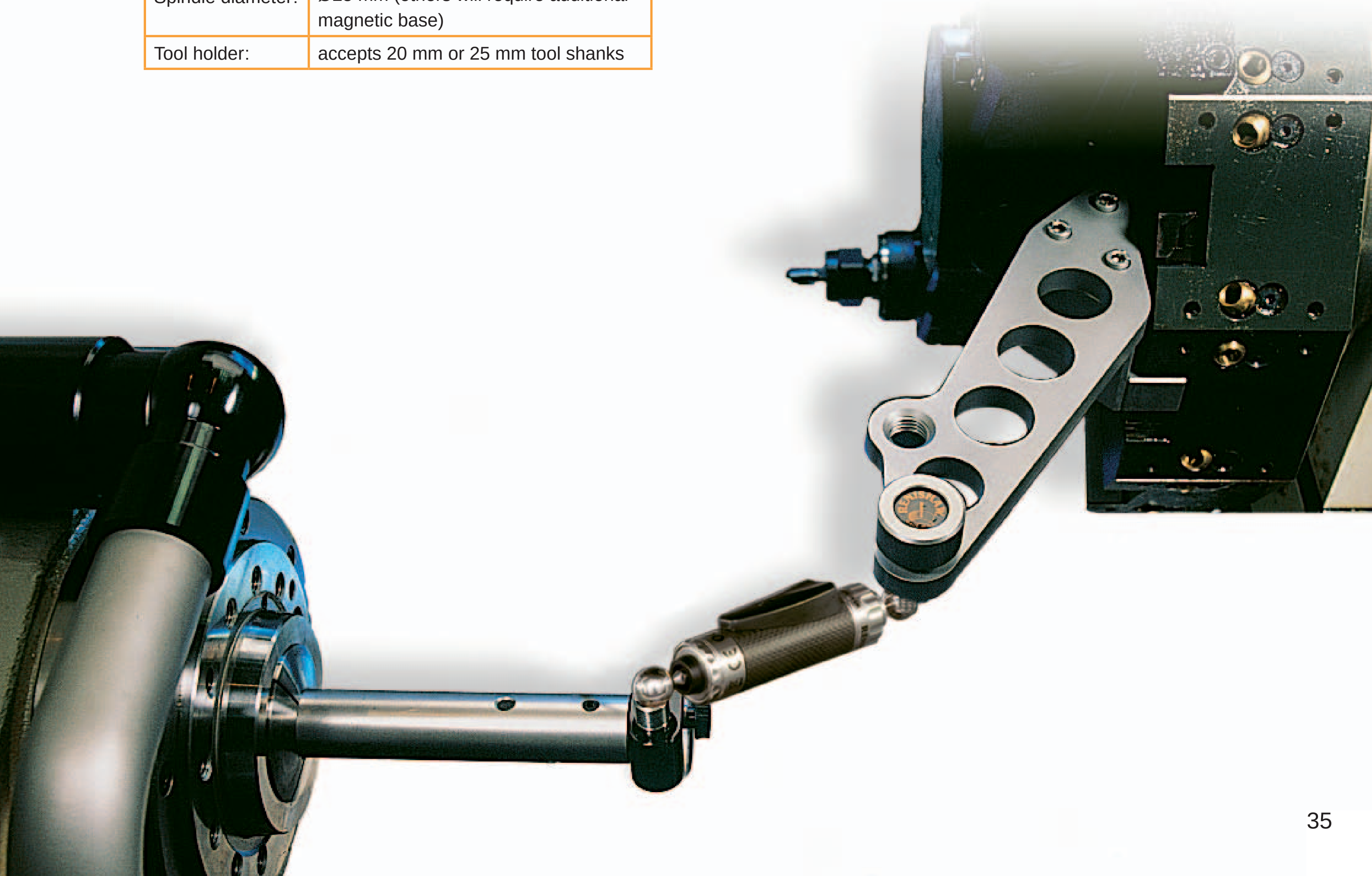
Lathe accessory kit

The lathe adaptor kit allows you to perform 360°, 100 mm radius ballbar tests on a lathe. The kit consists of an arm assembly for attachment to the lathe turret and a spindle bar for attachment in the lathe spindle. Both arm and spindle include magnetic cups in which to locate the ballbar; the one in the arm is equivalent to the tool cup in the normal kit set-up and the one in the spindle bar is equivalent to the pivot assembly/centre cup.

Note that to use this kit your lathe must have the following capabilities:

Axis clearance:	X-axis: 220 mm from centre-line Z-axis: 330 mm from chuck
Spindle diameter:	Ø25 mm (others will require additional magnetic base)
Tool holder:	accepts 20 mm or 25 mm tool shanks

Lathe adaptor kit



Total confidence

Quality in design, build and technical support are Renishaw hallmarks. That's vital, whether you're dealing in microinches or nanometres

Design

The XL system design is based on extensive feedback from laser and non-laser users to design out current system limitations and design in expected future requirements. The XL-80 is designed to allow updates and developments as user requirements change in the future.

The performance of Renishaw laser systems has been independently verified by the National Physical Laboratory (NPL), UK and Physikalisch-Technische Bundesanstalt (PTB), Germany.

NPL National Physical Laboratory

PTB

Build

Renishaw's extensive manufacturing capabilities allow it to produce nearly all components and assemblies in its own factories.

It has an extensive and modern machine shop including surface finishing. There's even a complete PCB design, build and test facility.

This in-house manufacture, together with design, gives Renishaw the capability to fully understand and control the design and build process, unlike suppliers who outsource these activities.

Total confidence

Quality in depth

Renishaw plc is certified and audited regularly to ISO 9001:2008, the most recent ISO QA systems standard. This covers all aspects of design, manufacture, sales and after sales support, including our recalibration facilities.

The certificate is issued by BSI Management Systems, an internationally recognised certification body, accredited by UKAS.

Certificate of Registration

QUALITY MANAGEMENT SYSTEM - ISO 9001:2008

This is to certify that:

Renishaw Plc
New Mills Operations
New Mills
Wotton-under-Edge
GL12 8JR
United Kingdom

Holds Certificate No: FM 10671

and operates a Quality Management System which complies with the requirements of ISO 9001:2008 for the following scope:

The design, manufacture and servicing of metrology systems including inspection probes, scanning equipment, electronic controls, laser and calibration systems, encoder and dental systems.
TickIT

For and on behalf of BSI:

Managing Director, BSI EMEA

Originally registered: 07/09/1990 Latest Issue: 12/12/2009 Expiry Date: 22/01/2013

Page: 1 of 1

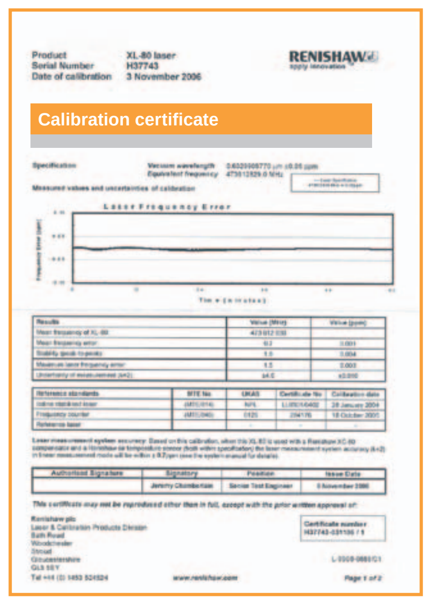
ISO9001:2008 quality certificate

Test and certification

Product calibration of all laser and ballbar systems is carried out by Renishaw and is traceable to the NPL (National Physical Laboratory) in the UK, using Renishaw's own certified iodine stabilised laser calibration system. Comprehensive calibration certificates are issued with all XL-80, XC-80, XR20-W and QC20-W systems giving test data in both tabular and graphical format, as well as full details of calibration standards used and of traceability to international standards.

Separate laser and sensor certification allows you to interchange components whilst maintaining traceable accuracy.

Product recalibration is available through your local Renishaw contact at facilities in the UK and USA (with NPL traceability), and Germany (with PTB traceability).



Product XL-80 laser
Serial Number H37743
Date of calibration 3 November 2006

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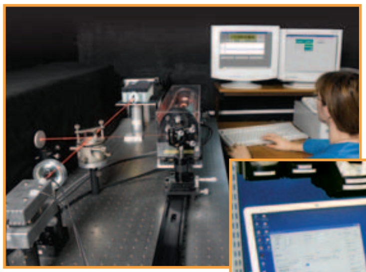
Calibration certificate

Laser Frequency Error



Laser calibration

Ballbar calibration

Service and support

Worldwide support

Renishaw's sales and support engineers are renowned for their pre- and post-sales support. We know that buying a laser system is a major investment for you and your company. Please ask us if you have any questions, we've nothing to hide and we want you to be sure you choose the right solution for your application.

There is a dedicated team of product and applications support engineers at Renishaw's headquarters in the U.K. with wide experience of product development and applications, as well as detailed product knowledge.

Renishaw also has established subsidiary companies in all major markets to give its customers the benefit of local support for commercial and technical enquiries. For other key areas around the globe, support is provided through appointed distributors.

International contact details can be found on the back of this brochure or visit www.renishaw.com/contact

Training
Full operator training is available, either on-site or in-house at one of Renishaw's training centres. Various entry level courses are available with refresher courses, user group sessions and seminars held at regular intervals.

Documentation
Great care is taken to provide comprehensive but clear instruction and information about system components, software, applications and system use. Background information also includes explanation of basic principles. Increasingly, electronic format manuals provide the best means for delivering this and enable us to easily provide updated information in a timely fashion.

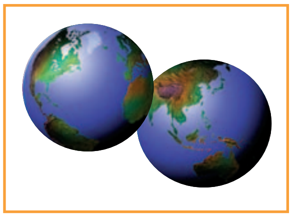
Support packages
A multi-lingual system manual is supplied on CD with each laser system. This contains written and illustrated set-up procedures for each measurement, calibration tips and analysis information. It can be installed to your PC and accessed directly using the software Help button or used as a stand-alone reference. Extra CDs are available free of charge. The QC20-W ballbar system online manual is integrated with Ballbar 5 software.

Your guarantee

All new XL-80 laser systems and accessories* are covered by a 3-year warranty. QC20-W systems and accessories* are covered by a 1-year warranty (repairs and exchange units are covered by a Renishaw warranty of 3 and 6 months respectively).

An extension to 5 years is available for a small price premium (please ask for details) on XL-80 laser systems.

*All software has restricted warranty covering media quality only.



Worldwide support

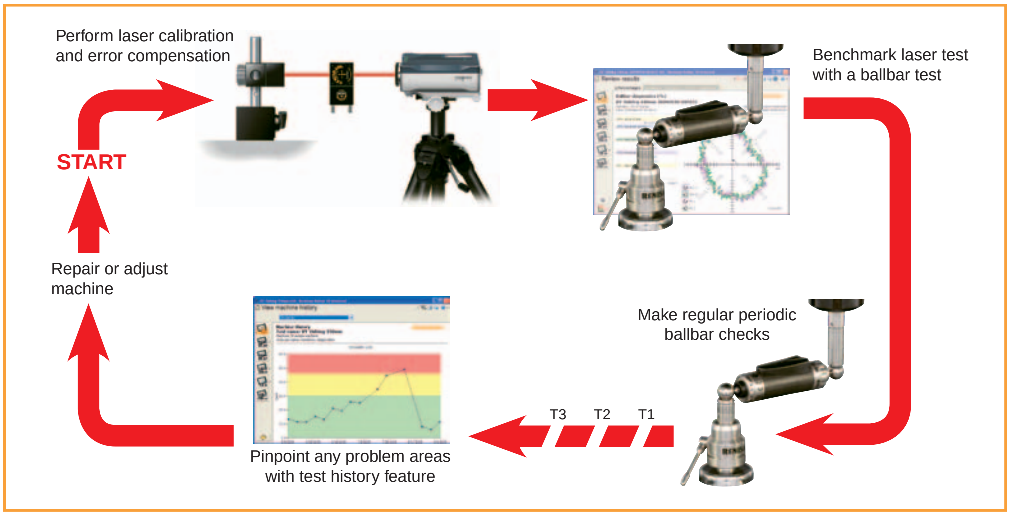
Training

Documentation

Support packages

Complementary products

Ballbar and laser, working together for maximum benefit



The Renishaw ballbar system is internationally recognised as the ideal solution to quickly check machine tool performance and benchmark in between scheduled laser calibrations.

RLE laser and RSU10 USB interface

For some applications (for example system test rigs) portability and measurement flexibility are less important than ease of installation on the rig.

The Renishaw RLE laser has a very compact laser head (98 mm x 50 mm) linked by a detachable fibre optic cable to its remote laser source. This makes fitment into test rigs or other equipment very straightforward, with only a minimal 'footprint; and easy connection.

Signals from the laser are processed via the RSU10, which provides an analogue to digital interface and signal interpolation, so you can use XL-80 system software (LaserXL and QuickViewXL™) with enhanced resolution.

High specification

50 kHz sampling, ±0.5 ppm accuracy, 4 metre linear range. Linear displacement only with maximum velocity 1 m/s, with resolution to 9.64 picometres (in plane mirror configuration).

Additional capability

Compatible with the XC-80 compensator for applications with fluctuating environmental conditions (not shown in photo).

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About Renishaw

Renishaw is an established world leader in engineering technologies, with a strong history of innovation in product development and manufacturing. Since its formation in 1973, the company has supplied leading-edge products that increase process productivity, improve product quality and deliver cost-effective automation solutions.

A worldwide network of subsidiary companies and distributors provides exceptional service and support for its customers.

Products include:

- **Dental CAD/CAM** scanning and milling systems
- **Encoder systems** for high accuracy linear, angle and rotary position feedback
- **Laser and ballbar systems** for performance measurement and calibration of machines
- **Medical devices** for neurosurgical applications
- **Probe systems and software** for job set-up, tool setting and inspection on CNC machine tools
- **Raman spectroscopy systems** for non-destructive material analysis
- **Sensor systems and software** for measurement on CMMs (co-ordinate measuring machines)
- **Styli** for CMM and machine tool probe applications

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