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High performance 5-axis measurement

Fastest scanning and discrete point measurement

Eliminate measurement bottlenecks

Unparalleled flexibility

5-axis measurement technology

For more than 30 years, Renishaw has delivered innovations that have been milestones in industrial metrology, from the original touch-trigger probe and motorised indexing head, to repeatable stylus changing and modular scanning systems. Renishaw's 5-axis measurement technology represents the biggest step-change in measurement capability that we have ever introduced, resulting from the biggest research and development program that we have ever undertaken.

What is 5-axis measurement?

Based on advanced head, sensor and control technology, Renishaw's 5-axis measurement technology delivers unprecedented measuring speed and flexibility, whilst avoiding the speed versus accuracy compromises inherent to conventional techniques. It boosts measurement throughput, minimises lead times and gives manufacturers a more comprehensive appreciation of the quality of their products.

Unlike systems based around indexing heads or fixed probes, 5-axis motion enables the stylus to follow a continuous path around complex components without having to leave the surface to change stylus cluster or index the head. Controller algorithms that synchronise CMM and head motion produce an optimal tip path and minimise CMM dynamic errors.

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Increase throughput

The ultimate scanning speed of a CMM is limited by machine dynamics, typically to between 80 and 150 mm/sec. However, long before we reach this limit, measurement accuracy falls away – often limiting the effective maximum measuring speed to between 10 and 25 mm/sec.

How?

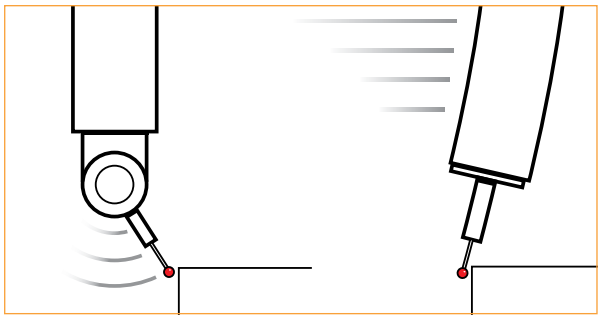
Non-linear motion on a Cartesian CMM induces accelerations and decelerations that twist and deflect the machine structure, and these dynamic deflections result in measurement errors that increase with measurement speed and acceleration.

To avoid dynamic deflections, Renishaw's 5-axis measurement minimises machine accelerations, whilst moving the stylus very rapidly over the component surface.

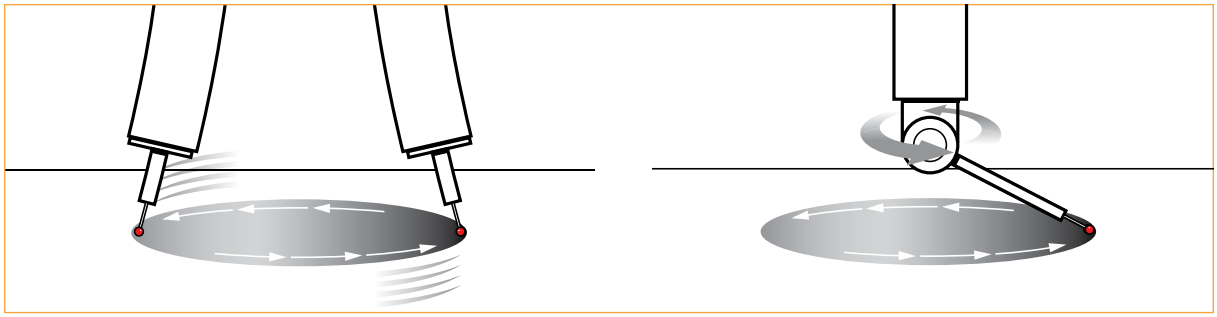
Reduce measurement cycle times without compromising accuracy

- eliminate bottlenecks
- rapid process feedback
- high speed head and sensor calibration
- less time spent indexing and more time spent measuring
- avoid changing stylus clusters

CMM dynamics' touch trigger effect

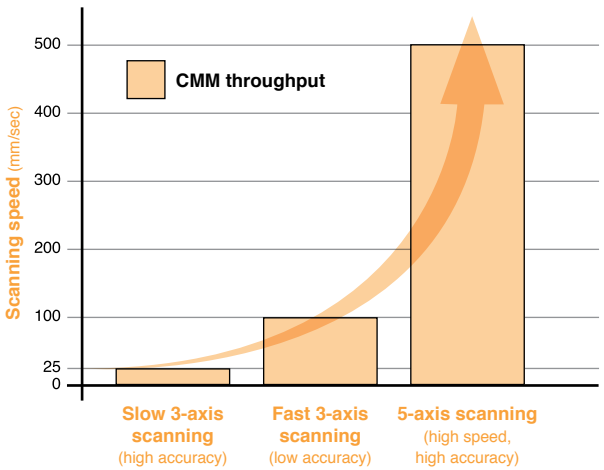


CMM dynamics' scanning effect



Advantages of Renishaw's 5-axis measurement

Renishaw's 5-axis measurement breaks through the dynamic performance barrier by minimising the accelerations and hence the inertial loads on the machine structure. Renishaw's dynamic heads do most of the measurement work, enabling exceptional throughput without compromising accuracy.



Renishaw's unique 5-axis measuring features

Renishaw's 5-axis measurement technology allows you to replicate your current measurement strategies – only much faster and also produces new scanning techniques. Bores can be measured using touch points, circular scans or helical scans, whilst data on contoured surfaces and edges can be captured with a sweeping motion of the head.

Renishaw's 5-axis measurement technology not only makes new ways of scanning possible, but also allows you to replicate your current measurement strategies, faster than before.

5-axis scanning

- simultaneous motion control of 5 axes
- data gathered 'on the fly' whilst the head is moving
- dynamic 2-axis head provides most of the stylus motion
- unique tip-sensing probe technology
- Scanning with 5-axes of simultaneous motion allows unparalleled measurement flexibility

5-axis touch trigger

- 'Head-touches' take measurement points faster, with improved accuracy and repeatability
- 5-axis motion eliminates time spent indexing the head
- Infinite positioning capability guarantees optimal feature access, minimising stylus changes
- 5-axis simultaneous motion allows larger parts to be measured on the CMM by minimising the space required around the part for head rotation

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5-axis measurement controller technology

The motion controller is a vital factor governing the performance of any CMM. Renishaw's UCC controllers provide the powerful platform for 5-axis measurement systems, bringing unprecedented flexibility and productivity to CMM users.

The UCC is designed to meet the exacting demands of 5-axis scanning and the processing of 4,000 data points per second at speeds of up to 500 mm/sec. It also provides smooth, simultaneous motion of the CMM and head axes ensuring minimal dynamic deflection of the CMM structure for optimal metrology performance.

Renishaw's UCC controller range supports the I++DME command protocol which is also supported the by the majority of CMM metrology software products. The system operates on a Client (application software) / Server (controller software) basis where the responsibility for metrology performance lies with the Server. Renishaw has developed the UCCserver application to manage all aspects of CMM metrology and probe calibration.

UCC's role in…

…rapid infinite head positioning

- **Synchronised CMM and head motion**
  - trajectory planning and control, minimising non measurement moves
  - unique 5-axis motion blending of moves on a CMM

…measurement

- **Head touch**
  Control of the head motors offers Renishaw's unique head touch capability where measurement data is rapidly collected with no machine movement.
- **Scanning**
  The ability of the software to maintain the correct displacement of the tip whilst in contact with the scan surface (during scanning) is unique to UCC and is the key to high speed 5-axis scanning.
  - Head scanning algorithm: minimised CMM motion with maximised head motion during cylinder/bore scanning
  - 3 axis scanning: enhanced by the infinite orientation and positioning of the head
  - Curve scanning: throughput and accuracy are increased through speed control and way point blending (whilst scanning).
  - Sweep scanning: defined by a parabolic surface approximation, in which the width & height are described, allowing the sweep algorithm to deal with different shapes and surfaces.

Typical Retrofit Package

GMEC – Geometric machine error compensation

The UCCSuite includes a complete set of tools to identify and maintain the geometrical quality of the CMM.

The geometric compensation model (error map) includes the well known 18 compensation functions and 3 squareness errors. Further compensation for horizontal arm machines and large dual drive machines is also included.

Data acquisition

The error map data acquisition software can utilise a comprehensive set of devices such as the Renishaw XL80 laser, electronic levels, Renishaw Machine Checking Gauge (MCG), straight edge and length bars. A unique feature is that the Z roll of a CMM, which is difficult to measure, can be determined with the XL80 and its vertical straightness optics; this is an advantage when error mapping a large CMM.

Data analysis

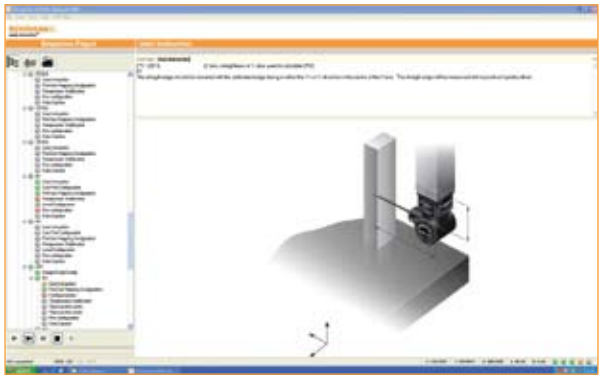
The GMEC calculator is a powerful analysis tool, it can analyse data collected with different devices in any location or orientation in the machine volume: the engineer can decide the optimal error mapping strategy according to the machine configuration and the equipment available.

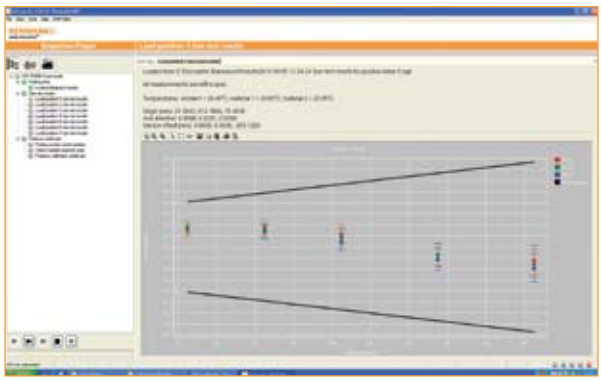
Where a CMM axis is longer than the capability of a device (i.e. a straight edge) the full axis error can be determined by ‘stitching’ data sets together over the axis length. The calculator can also analyse redundant data and identify bad data or inconsistent machine behaviour very early in the error mapping process, saving valuable time.

Furthermore, knowing the uncertainty associated with each device, the analysis applies a weighting to the data collected that is proportionate to the device uncertainty. The consequence is that the compensation parameters are determined along with their associated uncertainty.

Performance maintenance

The maintenance of the machine error correction has been greatly simplified, with the integration of the MCG and the ISO10360 length bar test within the GMEC calculator. The data collected is analysed and used to update the existing machine error compensation providing optimal metrology performance.





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Retrofits

Renishaw's 5-axis measurement technology can provide a new lease of life to your existing CMM

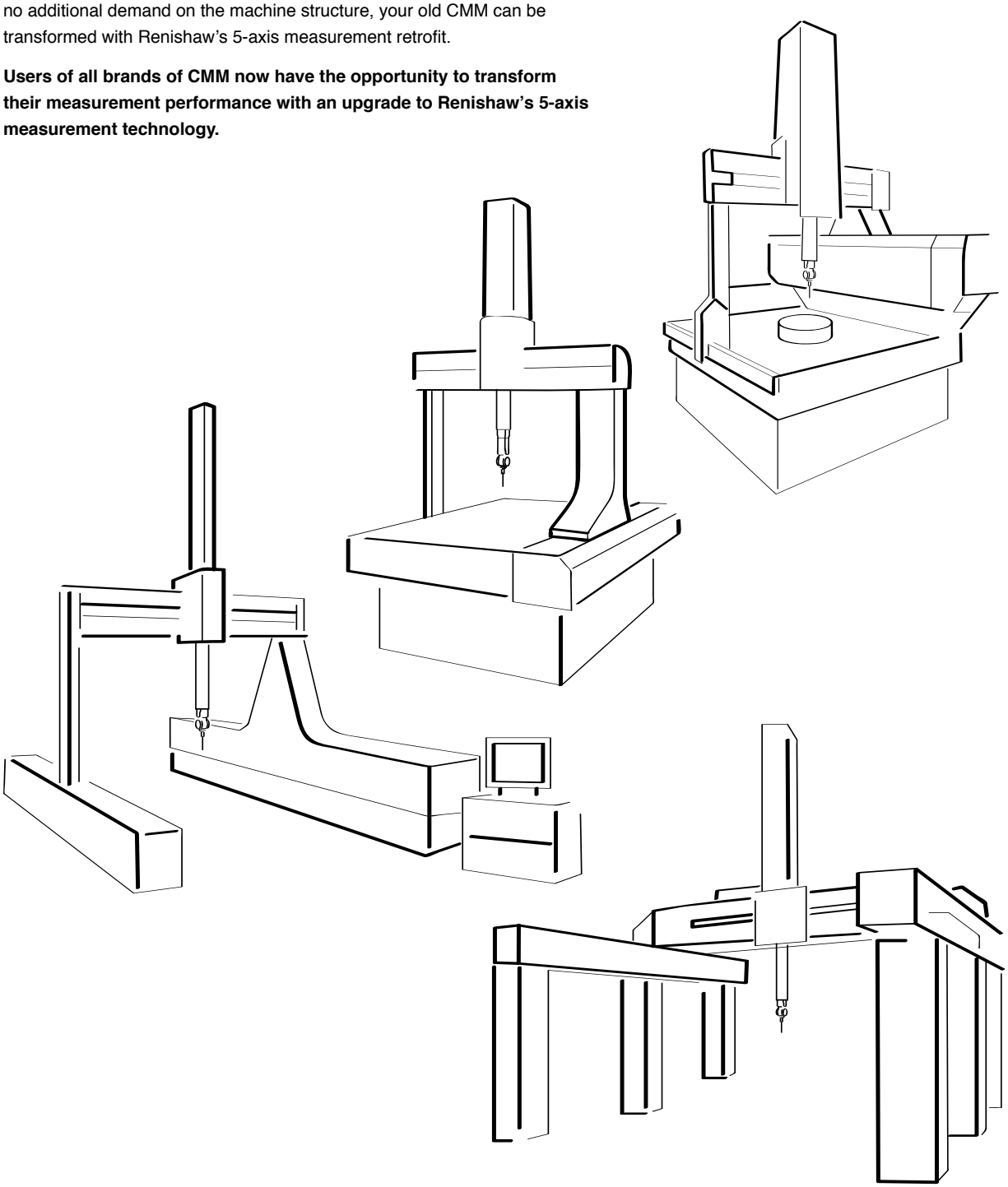
Measurement is vital to any manufacturing business, providing essential information to control processes and verify products. But older co-ordinate measuring machines (CMMs) can become bottlenecks if they fail to keep pace with changing measurement needs. In the current climate, upgrading makes good economic and environmental sense.

Most CMM structures are not subject to high levels of wear and so remain perfectly serviceable for many years. As 5-axis measurement places no additional demand on the machine structure, your old CMM can be transformed with Renishaw's 5-axis measurement retrofit.

Users of all brands of CMM now have the opportunity to transform their measurement performance with an upgrade to Renishaw's 5-axis measurement technology.

Operational benefits

- Increased throughput
- Greater software functionality & usability
- Automation & lower operating costs
- Future-proofed investment



PH20 – use your head!

The 5-axis technology pioneered by Renishaw's award-winning REVO® is now available for touch-trigger applications with dramatic impact on inspection timescales, costs, capability and flexibility on all sizes of CMM.

Increased throughput

PH20's unique head touches allow measurement points to be taken by moving only the head rather than the CMM structure.

Using only the rapid rotary motion of the head, points can be taken faster, and with improved accuracy and repeatability.

Furthermore, 5-axis motion eliminates time spent indexing the head.

Together these speed increases typically result in a 3-fold improvement in throughput over conventional systems.

Easy access to features at any angle

PH20's infinite positioning capability guarantees optimal feature access, minimising stylus changes.

5-axis simultaneous motion allows larger parts to be measured on the CMM by minimising the space required around the part for head rotation.

PH20 automatically aligns itself with the part coordinate system, avoiding stylus collisions and the requirement for accurate fixtures.

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Integral industry standard TP20 probe

Users of the PH20 probe head will immediately have access to the range of proven TP20 probe modules, providing a wide selection of trigger forces, directional sensing options and extensions to meet application requirements*. The detachable modules provide crash protection and can be automatically changed using the MCRNI change rack.

*Except for the extended force module

Improved touch-trigger metrology performance

- **Repeatability**
  – **improved when 'head touch' method is used**
- **Accuracy**
  – **improved by using feature orientation based calibration and 'head touches'**
- **Pre-travel variation**
  – **automatic compensation**
- **Module changing**
  – **automatic tip offset correction**

TP20 probe system

The TP20 is a touch-trigger probe that gives its users the ability to change stylus configurations manually or automatically, without re-qualification.

The range of modules

A range of application specific, stylus modules is available:

- The low force module (LF) for high accuracy with short styli and delicate materials.

- The medium force module (MF) is suitable for vibration resistance when using longer styli.

- The standard force module (SF) is suitable for most applications.

- The 6-way module (6W) for measuring grooves and undercuts.

- Two standard force extension modules (EM1 and EM2) improve reach and offer better metrology performance than using equivalent length styli.

Faster calibration

The unique 'inferred calibration' technique developed for PH20 determines the head orientation and probe position in a single operation, allowing subsequent measurement at any head angle.

These dramatic time savings accumulate as the calibration process is repeated on a regular basis to comply with quality procedures or following a probe crash.

Available with your new CMM or as retrofit to existing equipment

- **Compact design – suitable for a wide range of CMMs using shank or quill mounting**
- **Renishaw CMM controller – I++DME communication, wide selection of metrology software**
- **Index head compatibility – no requirement to modify existing programs in the majority of cases**
- **Integral TP20 probe – allows re-use of existing equipment**
- **Mechanical bearings – no air supply required**

Throughput study

Valve block – measurement comparison PH20 versus traditional motorised indexing head

300% improvement in throughput

We measured a valve block with a traditional motorised indexing head. We fitted a PH20 to the same CMM and measured the same features, with the same number of points on the same part. The CMM speed and acceleration settings were kept the same.

The measurements

- 8 bores measured

Before

- 3-axis motorised indexing head, measurement time = 1 min 52 sec

After

- with the PH20 5-axis touch trigger probe head, measurement time = 37 seconds
  300% throughput increase for measurement process

Calibration

- Before: 1 tip, 8 positions 4 minutes
- 1 tip, inferred calibration for all positions, 2 min 30 seconds
  37.5% throughput increase for calibration process

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REVO® – 5-axis multi-sensor scanning system

REVO® is a revolutionary measuring head and probe system from Renishaw. Every process and feature in a REVO® system has been designed to enable users to achieve previously unobtainable levels of inspection throughput:

- 5-axis scanning of complex form; REVO®'s ability to gather very large quantities of accurate inspection data at ultra-high scanning speeds is invaluable.
- Very high speed gathering of touch points using the servo head's infinitely variable 2-axis motion.
- Innovative, patented tip-sensing probe technology allowing the sensing to be very close to the surface measured, yielding better accuracy.
- Novel calibration, Renishaw's 5-axis measurement tip-sensing probe heads only require a single tip calibration to be accurate at all angles of rotation, typically saving several hours in the set-up routine.
- Infinite positioning and 5-axis synchronised motion, which facilitates access to features.

REVO® dynamic scanning head

The REVO® measuring head features spherical air bearing technology in each of its two axes, driven by brushless motors linked to high-resolution encoders to provide fast, ultra-high accuracy positioning.

Measure faster

- **up to 50 times faster surface speed than 3-axis scanning**

Measure more points

- **4000 points per second acquisition rate**

Measure more accurately

- **with the REVO® tip-sensing probe**

Measure more features

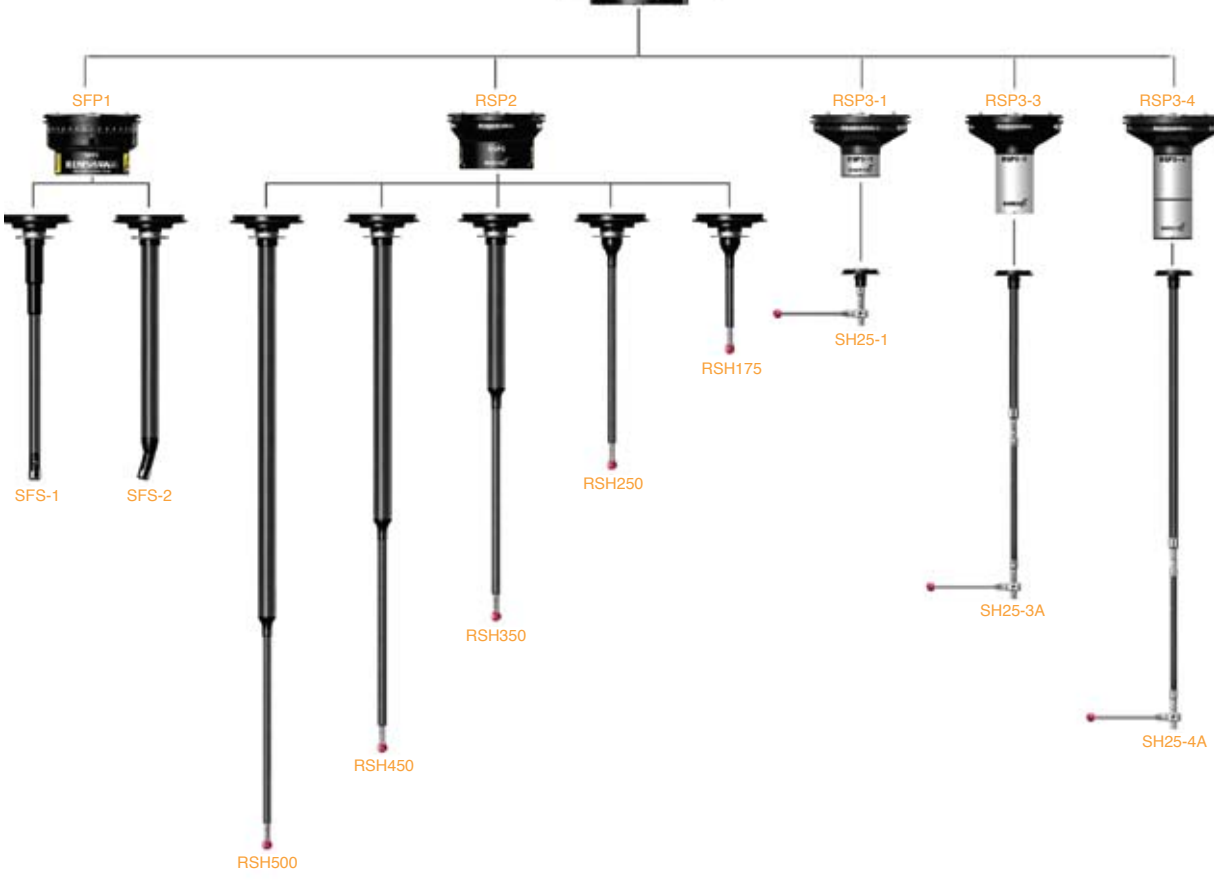
- **infinite positioning for unparalleled flexibility**

Measure without compromise

- **100% inspection for optimal part verification and process control**

Measure surface finish

- **passive C axis rotation for maximised feature access**
- **automate more measurement tasks**



REVO® probes

RSP2

RSP2 is a dedicated lightweight tip-sensing probe for use on REVO® systems, capable of 2D-scanning (x, y) and 3D-touch trigger measurement.

The RSP2 has a universal body to which a number of different length stylus holders, with a maximum reach of 500mm, can be fitted. The RSP2 works by using an enclosed laser that is directed onto a reflector at the stylus tip. As the stylus touches the part and bends, the reflector is displaced. The altered return path of the laser is then sensed and the exact tip position of the stylus is known because the reflector and stylus ball are close together. Stylus wear is minimised by the low scanning forces that are required.

RSP3

RSP3 provides the REVO® system with 3D-scanning (x,y,z) and crank stylus capabilities.

The RSP3 is used for 3-axis scanning, such as with a fixed REVO® head angle during measurement. The range of probes allows different lengths of stylus to be used whilst maintaining optimum metrology performance.

Based on the SP25M technology pivoting motion system with two diaphragm springs, one of the RSP3 springs allows movement in all directions whilst the other (pivot) spring is stiff in (probe) x and y, but allows movement in Z.

Unlike the SP25M, in RSP3 the probe and module elements are built as one. A range of RSP3 probes are now available to allow a range of stylus lengths to be used.

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REVO® surface finish probe (SFP1)

Surface finish measuring has traditionally required using hand-held sensors or moving the part onto a dedicated measuring machine.

The REVO® SFP1 probe however, makes surface finish inspection an integral part of your CMM measurement, enabling you to automatically switch from scanning to surface finish measurement.

The probe, part of the REVO® system, offers numerous benefits:

- The SFP1 probe takes advantage of the infinite positioning of the REVO® head.
- A passive C axis enables measurements at all required orientations around the part.
- The surface finish calibration artifact (SFA) is mounted on the MRS rack.
- Automatic change (probe and stylus holder) through the standard MRS rack and the RCP ports enables surface finish measurement to be fully integrated with the standard CMM inspection program.

Probe characteristics:

SFP1 is a skidded probe with a diamond stylus tip 2 μm radius, held against the surface with a constant force of approximately 1 mN.

Straight and cranked stylus holder facilitating access to a wide range of features.

The probe size with a straight stylus holder allows measurement within a 10 mm diameter bore to a depth of 100 mm.

Surface measurement capability: 6.3 to 0.05 Ra.

Output: Ra and RMS available through UCCServer to application software clients through the I++ protocol.

REVO® probe comparison chart

	Probe type		
	RSP2	**RSP3**	**SFP1**
Tip sensing	yes	no	yes
Cranked styli	no	50 mm	yes (SFS-2)
Sensing axes	XY scan XYZ touch	XYZ scan XYZ touch	N/A
Probe changing	yes	yes	yes
Stylus changing	yes	yes	yes

REVO® probe calibration

Calibration on traditional CMM systems consumes a considerable amount of time that could otherwise be used for part measurement. Using a table mounted sphere, the simple and practical calibration technique for REVO® determines the actual head and probe geometry, allowing measurement in any position from a single operation.

The REVO® probe changer system

The REVO® probe changer system allows automatic REVO® probe and stylus holder changing, enhancing flexibility through the use of a range of stylus configurations.

The RCP*TC* is a specially designed thermally controlled port for changing RSP2, RSP3 and SFP1 probes.

Key features of the RCP*TC* are:

- Maintains the probe at operating temperature when not in use, for optimum metrology.
- Probe changing for RSP2, RSP3 and SFP1.
- Compatible with MRS

The RCP2 is configured to change RSP2 and SFP1 stylus holders, whereas FCR25 is used for RSP3 stylus holders.

Metrology performance

Renishaw's 5-axis measurement provides excellent measurement performance with the REVO® system, even at unprecedented scanning speeds.

REVO® will make your measurement more accurate than a standard head and sensor even with long styli (stylus holders).

With Renishaw's 5-axis measurement you are getting the measurement accuracy that you are used to, except with longer styli and much higher speeds.

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REVO® throughput studies

REVO® 5-axis high speed, high accuracy measurement offers a wide range of benefits resulting in significant throughput improvements.

Two current applications have been selected, comparing actual cycle times of existing 3-axis measurement methods versus the REVO® system.

Throughput study

Cylinder head 690% improvement in throughput

Valve seat and guide measurement is one of the toughest measurement tasks in an automotive cylinder block. Using a helical scan, the REVO® head gathers thousands of data points from which the height, diameter, seat width and form can be determined.

The measurements

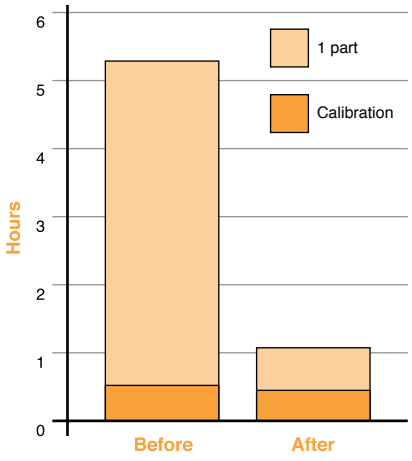
- 12 valve seats
- 12 valve guides

Before

- 3-axis scanning at 15 mm/sec
  measurement time = 29 min 13 sec

After

- REVO® at 400 mm/sec and 50 mm/sec
  measurement time = 3 min 42 sec
  690% throughput increase



Throughput study

Aero engine blisk 922% improvement in throughput

Bladed discs (known as 'blisks') present extreme access challenges and conventionally require numerous head indexes.

Renishaw's 5-axis measurement dramatically reduces cycle times through continuous scanning of blade sections, blade surfaces and root profiles.

The measurements

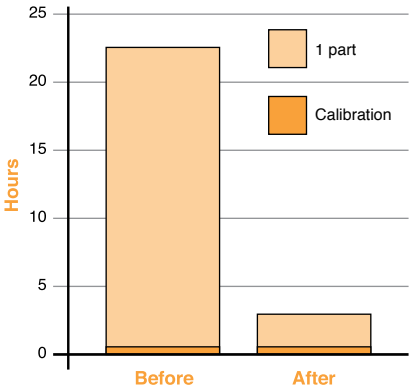
- 9 sectional scans, 8 longitudinal scans and 2 root profile scans per blade
- 1 scan of annulus profile

Before

- 3-axis scanning at 10 mm/sec
  measurement time; 1 blade = 46 min,
  all 29 blades = 22 hours 11 min

After

- REVO® at 200 mm/sec measurement time; 1 blade = 4 min 30 sec,
  all 29 blades = 2 hours 10.5 min
  922% throughput increase



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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 costeffective 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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Hybrid Part No. H-1000-0051-01-A

Issued 1011 Part no. H-1000-0050-01-A