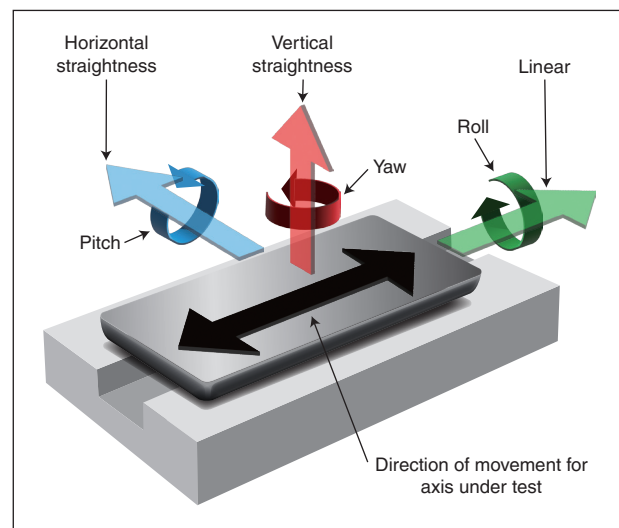




Enhancing machine tool accuracy with Renishaw's XM-60 multi-axis calibrator in conformance with ISO international standards

Errors can occur in machine tools during assembly which can affect part production. Manufacturers usually perform geometric measurements of 21 errors including the displacement, straightness and angle of linear axes. They also assess the positioning accuracy and repeatability of CNC axes in accordance with ISO international standards.

Using traditional methods to perform these accuracy measurements requires at least three different tools. Typically, tools such as laser interferometers and multiple mirror and optic systems, autocollimators, precision levels, different sizes of straight edges, and micrometers are used. Each axis on the machine tool must be set up six times to collect test data for error analysis, so a total of 18 set-ups are required for the X, Y and Z axes. Linearity, horizontal straightness, vertical straightness, pitch angle, yaw angle, and roll angle are tested.



This table shows an example three-axis machine tool and the interval distances between target positions that a manufacturer might use when performing geometric measurements.

X axis length: 600 mm	Interval distance: 30 mm	Measurement points: 21 points in total
Y axis length: 400 mm	Interval distance: 20 mm	Measurement points: 21 points in total
Z axis length: 450 mm	Interval distance: 22.5 mm	Measurement points: 21 points in total

* These test set-ups are for reference only; the actual requirements are adjusted according to different application scenarios.

Measuring using traditional methods

Traditional measurement methods require switching between tools to get the necessary data, which can increase set-up and measurement time. Some tools (for example, straight edge, micrometer) require multiple operators to perform the measurement. The test results must be manually consolidated for error analysis in accordance with ISO international standards, leading to increased labour costs.

Machine tool accuracy testing in accordance with ISO international standards – traditional methods

Measurement type	Process	Time
Linear	Set-up	15 minutes
	5 bidirectional measurements	35 minutes
Straightness	Vertical set-up	20 minutes
	Bidirectional measurement	5 minutes
	Horizontal set-up	20 minutes
	Bidirectional measurement	5 minutes
Angular	Pitch angle set-up	15 minutes
	Bidirectional measurement	5 minutes
	Yaw angle set-up	15 minutes
	Bidirectional measurement	5 minutes
	Roll angle set-up (precision level)	5 minutes (only possible in horizontal axis)
	Bidirectional measurement	5 minutes (only possible in horizontal axis)
Total for each axis		150 minutes
Total accuracy measurements for each machine tool		450 minutes

Measuring using a single XM-60 multi-axis calibrator

Using the XM-60 multi-axis calibrator simplifies gathering data for performing accuracy measurements on a three-axis machine tool. It can simultaneously measure all six degrees of freedom (6DoF) along a linear axis in a single set-up. The X, Y and Z axes can be fully measured in just three set-ups, reducing the overall operation time by 66% compared to traditional methods. This saves time and gives a true assessment of the machine tool's performance.

The XM-60 system is straightforward to set up and operate. It features an intuitive interface that helps users to collect and manage measurement data, which enables manufacturers to allocate resources and further enhances manufacturing productivity.

Renishaw's CARTO software displays test results and automatically generates measurement uncertainty reports. These reports include error analysis and comparisons in line with standards like ISO 10791-2 (2023). This makes measurement

result assessments more reliable, and it reduces the operator's required technical expertise.

The system is supplied in a robust case to protect and easily transport the equipment in machine shops or across multiple sites.



Machine tool accuracy testing in accordance with ISO international standards – multi-axis technology (XM-60)

Measurement type	Proces	Time
6DoF	Set-up	15 minutes
	5 bidirectional measurements	35 minutes
Total for each axis		50 minutes
Total accuracy measurements for each machine tool		150 minutes

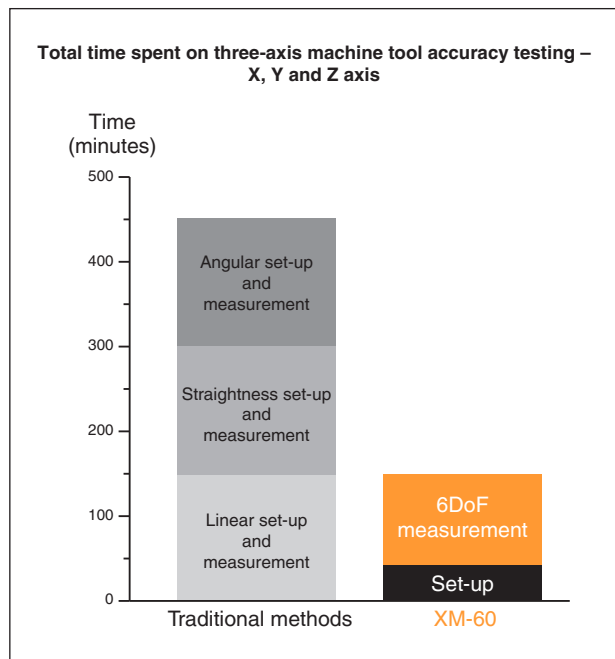
Conclusion

Machine tool production is moving towards high-end, multi-axis, modular and high-precision solutions. The requirements to conform to ISO international standards for accuracy testing are becoming increasingly stringent. Can traditional testing methods still meet the ever-increasing testing requirements of manufacturers?

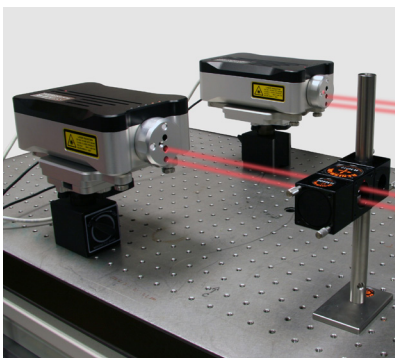
Measurement time

The XM-60 multi-axis calibrator uses unique optical roll measurement technology. This allows it to measure all six degrees of freedom errors in any orientation along a single axis, with just one set-up. It can help machine tool manufacturers improve overall machine accuracy and optimise measurement speed, data storage, labour allocation and cost-effectiveness.

Renishaw has a range of calibration solutions for measuring and analysing errors in rotary axis positioning accuracy. These solutions can also assess spatial accuracy and synchronisation accuracy on machine tools in accordance with various ISO standards. The table below uses a vertical machining centre as an example:



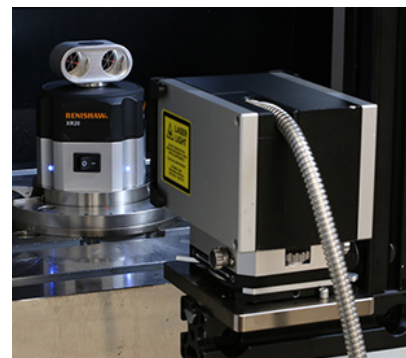
Error analysis	International ISO standard	Recommended measurement device
Linear axis 6DoF accuracy	ISO 230-1 ISO 10791-2	XM-60 multi-axis calibrator
Linear axis positioning accuracy	ISO 230-2	XM-60 multi-axis calibrator or XL-80 laser interferometer
Linear interpolation movement	ISO 10791-6	XM-60 multi-axis calibrator
Arc interpolation movement accuracy of two linear axes	ISO 230-4 ISO 10791-6	QC20 ballbar
Blade tip synchronisation accuracy	ISO 10791-6	QC20 ballbar
Spatial and planar diagonal position accuracy	ISO 230-6	XM-60 multi-axis calibrator or XL-80 laser interferometer
Rotary axis positioning accuracy	ISO 230-7 ISO 10791-4	XR20 rotary axis calibrator used with: XM-60 multi-axis calibrator or XL-80 laser interferometer



XL-80 laser interferometer



QC20 ballbar



XR20 rotary axis calibrator

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