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XK20 alignment laser

www.renishaw.com/xk20

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Contents

XK20 hardware

Principles of measurement

XK20 is an alignment laser kit capable of performing various tasks including but not limited to:

- Machine tool alignment to recognised standards during manufacture
- Set-up of manufacturing lines
- Service activity, such as machine realignment
- Pre-machining alignment

Measurement capability includes:

- Straightness
- Long range straightness
- Squareness
- Parallelism
- Level

System components

1	**Launch unit** A laser transmitter with a 360 degree sweeping head and pentaprism optic.
2	**S unit** The 'Stationary' unit, containing a position sensitive detector (PSD).
3	**M unit** The 'Motion' unit, containing a position sensitive detector (PSD).
4	**Display unit** A touch screen tablet containing the measurement software and user guide.
5	**Low profile magnetic base** A magnetic base used for mounting the S unit, M unit, pentaprism or Launch unit in conjunction with other brackets and accessories.
6	**Tripod translation stage** The tripod translation stage allows for precise translation of the Launch unit. A fail-safe, quick release mechanism allows mounting to a tripod.
7	**Launch L-bracket** Upright bracket that enables the user to mount the Launch unit at a 90 degree angle.
8	**M6 pillars × 4** 150 mm pillars that can be screwed into magnetic bases for mounting the S unit, M unit and pentaprism optic.
9	**M6 short pillars × 4** 70 mm pillars that can be screwed into magnetic bases for mounting the S unit, M unit and pentaprism optic.
10	**Universal power supply kit** *(not pictured)* This includes; 1 × power supply and 3 × kettle leads for UK, EU and USA sockets.
11	**DC split cable** *(shown on page 9)* This cable allows for the charging of three system devices from a single power source (Launch unit, M unit and S unit).

NOTE: To see the parts used in different set-up assemblies, refer to the *XK20* Hardware guide (Renishaw part no. H-9971-9037).

System components continued

1	**Pentaprism optic** The pentaprism optic can be used to reflect the beam 90 degrees for horizontal parallelism measurements and some squareness measurements.
2	**Launch spindle mount** The launch spindle mount is used to mount the Launch unit into a spindle or chuck for rotational measurements.
3	**Transceiver spindle bracket** The transceiver spindle bracket is used to mount either the M unit or the S unit in a spindle or chuck for rotational measurements
4	**90 degree transceiver bracket** The 90 degree transceiver bracket can be screwed onto either the M unit or the S unit to allow 90 degree mounting when used with the magnetic bases, mounting posts or spindle brackets.
5	**Transceiver lowering bracket** The transceiver lowering bracket enables the lowering of the M unit when fixtured to the rotary magnetic base.
6	**Pentaprism translation stage** The pentaprism translation stage is for use with the pentaprism optic to allow lateral adjustment during measurements. The stage is mounted to a low profile magnetic base.
7	**Rotary magnetic base** The magnetic base has a rotating head so that the M unit can be rotated when taking flatness measurements. The base has an on/off switch. It is used for mounting the M unit or S unit in combination with the M6 pillars.
8	**Tripod** The tripod provides a stable mounting for the Launch unit and allows the height to be adjusted.
9	**Magnetic reference mount** The magnetic reference mount enables the M unit to be magnetically mounted against the reference edge of a casting. The M unit can be mounted in a fixed position or on to the rotary head of the magnetic reference mount.
10	**USB-DC adapter** The USB-DC adapter is used to charge other devices via the display unit.

Launch unit

The Launch unit contains a fibre-coupled diode laser, which produces a stable Class 2 output laser beam.

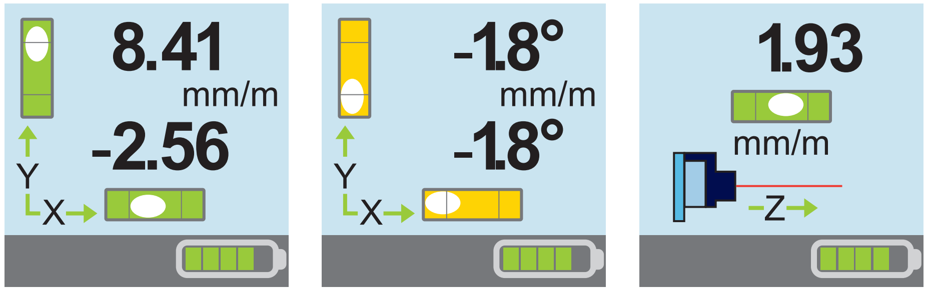
The output beam can be flipped between two orientations using the pentaprism optic in the sweeping head.

WARNING: Do not conduct a measurement whilst the Launch unit is charging.

The Launch unit contains a rechargeable lithium-ion battery and is charged using the power supply or via the XK20 display unit, in conjunction with the USB-DC adaptor and split cable. It is recommended that the Launch unit should be charged before or after every use to maintain the battery.

Specifications about the power supply can be found on **page 13**.

2 Display screen examples



The Z axis is displayed only when the Launch unit is oriented as shown on screen, with the Renishaw label facing upward.

The display will show changes up to a resolution of 10 mm per 1mm (mm/m) after which the units will appear as degrees.

1	Power on/off, change display view	5	Pitch/yaw screw
2	Display	6	Release lever
3	Laser head	7	Charging port
4	Fine head adjustment dial	8	Launch pentaprism

M unit and S unit

The M unit is a wireless device used as the main detector in all measurements.

The S unit is a wireless device primarily used in rotational alignment applications.

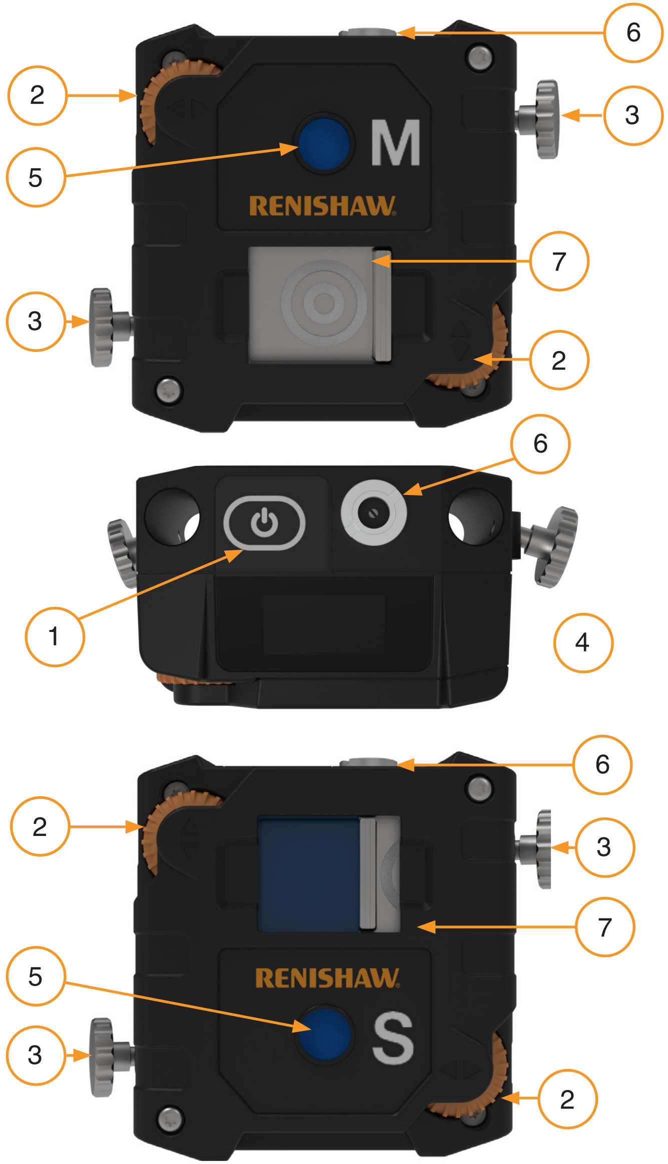
The detection of position is provided by a 2-axis position sensitive diode (PSD). The unit features a Class 2 laser diode output which allows the device to be used with the M unit.

WARNING: Do not conduct a measurement whilst the M unit and S unit are charging.

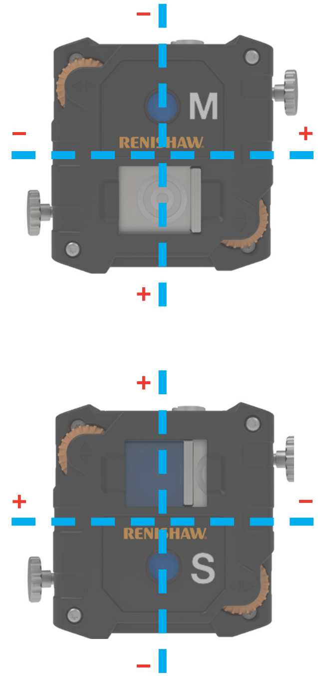
The M unit and S unit both contain a rechargeable lithium-ion battery. The M unit and S unit are charged using the power supply or via the XK20 display unit, in conjunction with the USB-DC adaptor and split cable. It is recommended that the M unit and S unit should be charged before or after every use to maintain the battery.

Specifications about the power supply can be found on **page 13**.

1	Power on/off
2	Pitch/yaw adjuster
3	Clamp screw
4	Device status display
5	Laser output
6	Charging connector ports
7	PSD receiver / target shutter



Sign convention



Display unit

The display unit is used for hardware set up and data capture.

WARNING: Do not conduct a measurement whilst the display unit is charging.

The display unit contains a rechargeable lithium-ion battery and is charged using the power supply. It is recommended that the display unit should be charged before or after every use to maintain the battery.

Specifications about the power supply can be found on **page 13**.

Charging

You are able to charge multiple devices from the display unit via the USB-DC and split cable.

1	Power supply
2	USB-DC adapter
3	Split cable

1	Battery status button
2	Power on/off
3	'Capture' button
4	Touch screen
5	Battery status LED's

6	HDMI port
7	**USB A port** - connection for the USB-DC adapter to charge devices
8	**USB C port** - for data transfer (see '**Data transfer**') and charging
9	**DC-IN port** - for charging with the power supply

System specifications

XK20 system	
Specified accuracy range	–10 °C to 50 °C
Recommended recalibration period	2 years

Launch unit	
Beam measurement range	40 m
Laser output	Class 2
Dimensions	147 mm × 136 mm × 152 mm
Weight	2.26 kg
Power	2 × Lithium-ion (7.4 Wh) internal batteries
Operating time	~30 hours
Warm-up time	15 min *Valid when the unit has been stored in room temperature and measurement takes place in the same environment.*
Digital spirit level accuracy	20 µm/m +/-1%
Digital spirit level resolution	0.001mm/m
IP rating	N/A

M unit and S unit	
Beam measurement range	20 m
Laser output	Class 2
Dimensions	76 mm × 76.4 mm × 45.9 mm
Weight	272 g
Power	Lithium-ion (7.4 Wh) internal battery
Operating time	~24 hours
Warm-up time	~30 minutes
Inclinometer accuracy	±1°
Inclinometer resolution	0.1°
IP rating	IP 66/67 (IEC 60529)

Display unit	
Dimensions	269 mm × 190 mm × 49.4 mm
Weight	1.4 kg
Power	Lithium-ion (68.04 Wh) internal battery
Operating time	~16 hours (internal battery only)
Screen size	8 in
Wireless range	30 m
IP rating	IP 66/67 (IEC 60529)

System storage and transportation environment

Storage and transportation	
Temperature	–20 °C to +50 °C
Pressure	1000 mb – 700 mbar
Humidity	10 % to 95% RH (non-condensing)

Translational measurements – performance specifications

Straightness	
Range	±5 mm
Accuracy	±0.008A ±0.8 µm
Resolution	0.1 µm

A = displayed straightness reading (µm)

Squareness	
Range	±5 mm
Accuracy*	±0.008A/M ±1.4/M ±4 µm/m
Resolution	0.1 µm

* with squareness calibration factor

A = straightness reading of the furthest point (µm)
M = length of the (shortest) axis (m)

Parallelism	
Range	±5 mm
Accuracy (i)	±0.008A/M ±1.4/M ±2 µm/m*
Accuracy (ii)	±0.008A ±1.4 ±2M µm*
Resolution	0.1 µm

* laser to pentaprism distance > 0.2 m

A = (largest) straightness reading (µm)

M = length of the axis (m)

i. To be used when the quantity of interest is the angle between rails.

ii. To be used when parallelism between rails is:

- specified as a tolerance zone defined by two parallel lines parallel to a datum axis (for example, reference rail) within where the axis of the feature (for example, measurement rail) must lie.
- intended as a point by point variation in the separation between the rails, with respect to the separation between the first two points

Power supply

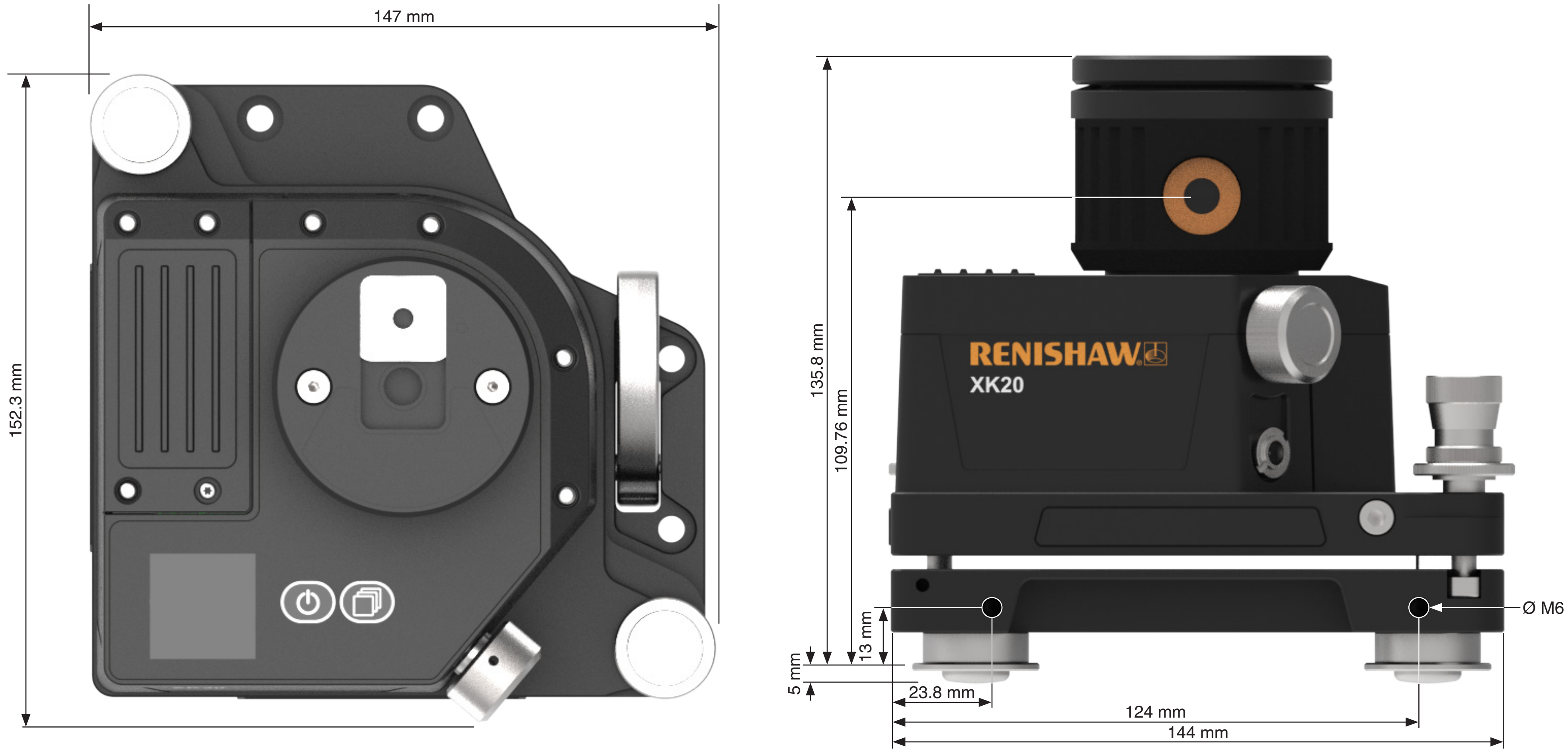
Power supply	
Input voltage	100 V to 240 V
Input frequency	63Hz
Maximum input current	2.0 A
Output voltage	15 V
Maximum output current	4 A
Safety standard	EN 62368

NOTE: The power supply has been qualified for use with the XK20 system. Do not use an alternative power supply. If the power supply becomes damaged or lost, a new supply can be purchased from **Renishaw's online store** or contact your **local Renishaw office**.

Weights and dimensions

Item	Weight (approximately)
XK20 system	Maximum 25 kg
Launch unit	2.26 kg
Display unit	1.4 kg
M unit	272 g
S unit	272 g

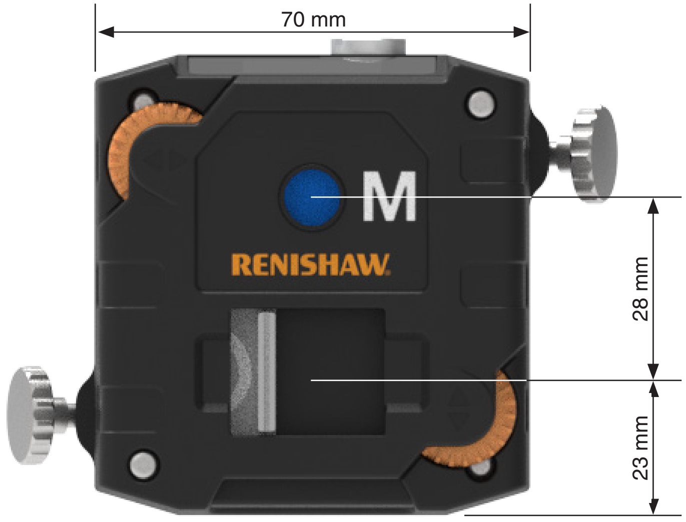
Launch unit

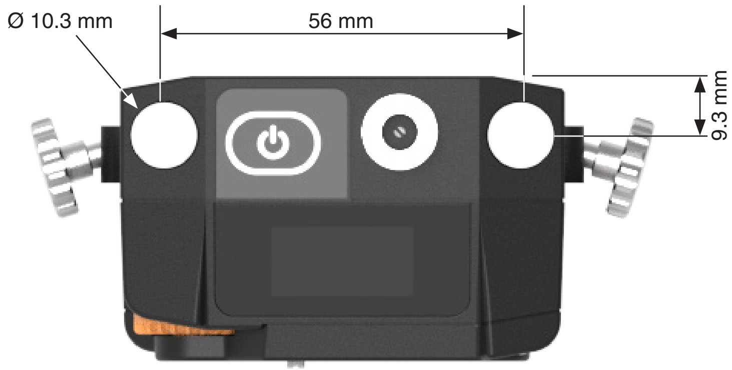


147 mm
152.3 mm
135.8 mm
109.76 mm
RENISHAW
XK20
Ø M6
13 mm
5 mm
23.8 mm
124 mm
144 mm

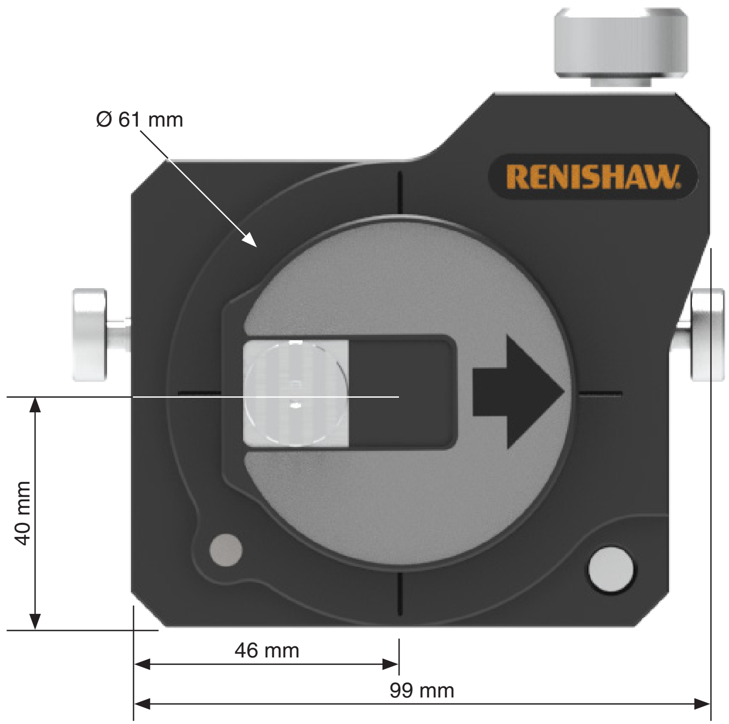
Display unit

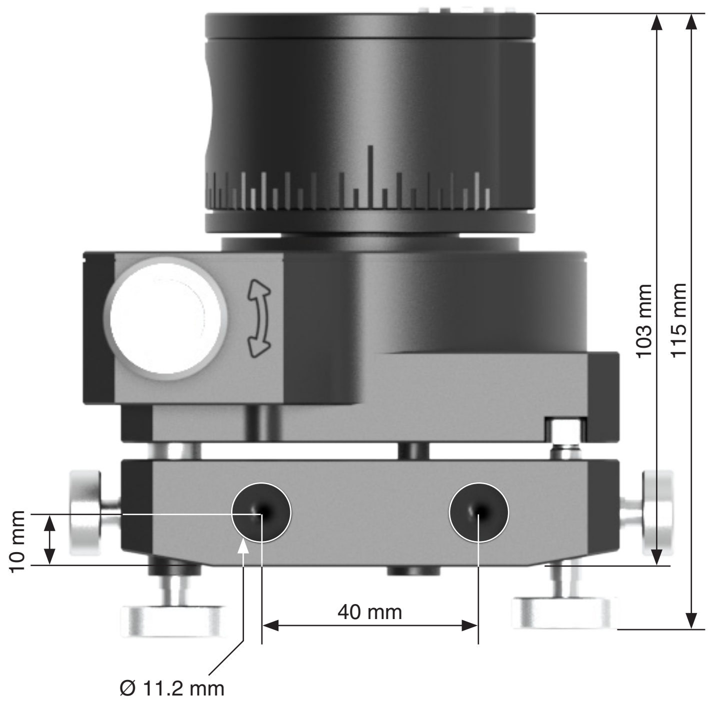
M unit



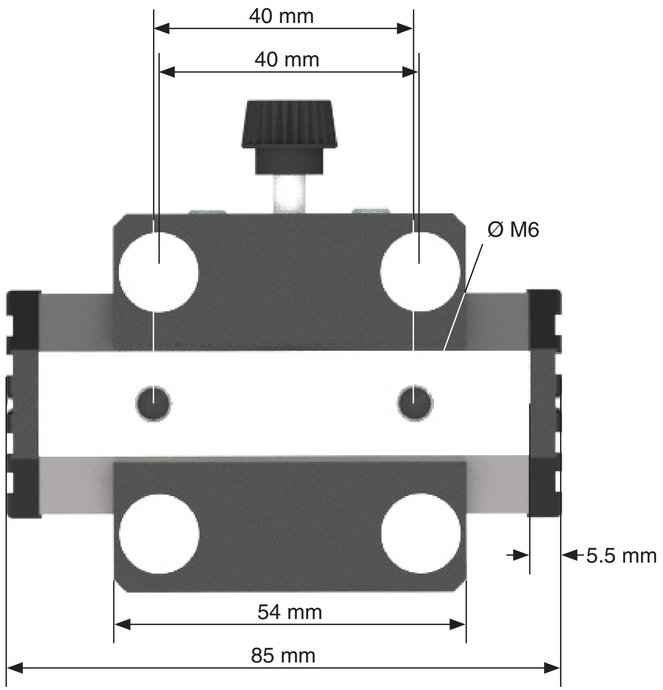


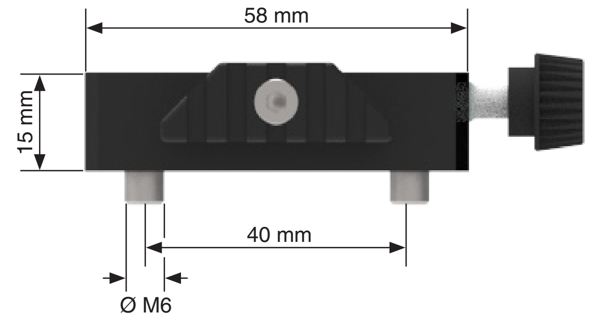
Pentaprism optic





Pentaprism translation stage





XK20 software

Display unit and software overview

Abbreviations

The software uses a range of abbreviations. Whilst they may be clear in context, the table below shows their long form:

Abbreviation	Long form
Std. Dev.	Standard deviation
Pos	Position
H	Horizontal
V	Vertical
Ref	Reference
Sec	Secondary
M-H	M unit – horizontal
M-V	M unit – vertical
H Ref	Horizontal reference
V Ref	Vertical reference
H Sec	Horizontal secondary
V Sec	Vertical secondary
H Par	Horizontal parallel straightness
V Par	Vertical parallel straightness
Max	Maximum
Min	Minimum

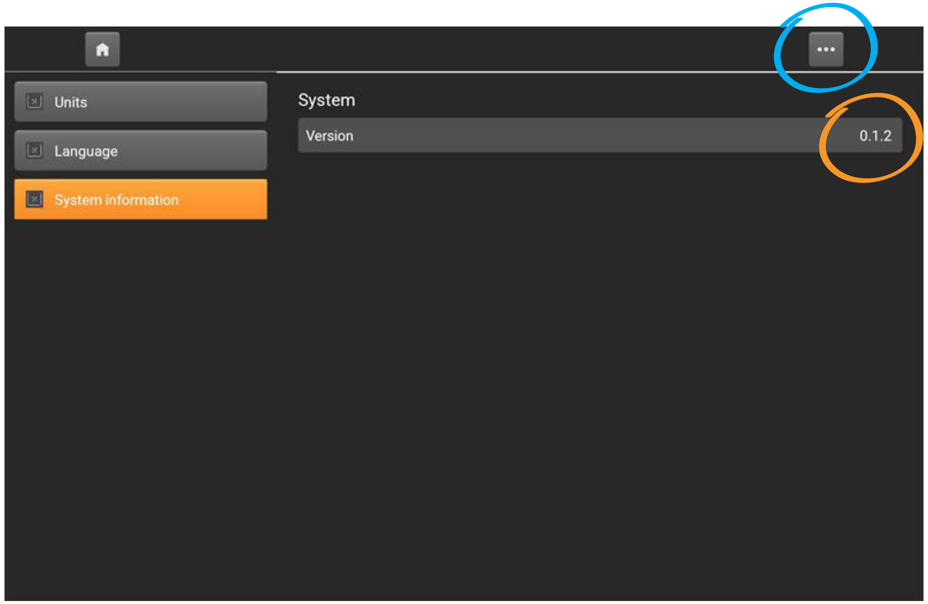
NOTE: If using the XK20 display unit, software updates can be found on the Renishaw website (**www.renishaw.com/calsoftware**). See **'Updating the XK20 display unit software'** for further information.

If using a third party tablet, software can be installed and updates will be available from the relevant application store. Search for 'CARTO XK20'.

Updating the XK20 display unit software

The display unit software must be updated manually via USB stick*. It is recommended to check the Renishaw website periodically for software updates. Your local Renishaw office may also send out communications.

1. Download the software from the Renishaw website (**www.renishaw.com/calsoftware**) and transfer it on to an empty USB stick.
2. Ensure the display unit is turned off. Plug in the USB stick.
3. Power on the display unit. The display unit will load to the home screen.
4. Power off the display unit. Once powered off, remove the USB stick.
5. Power on the display unit. Check the version number has updated in settings.



*Renishaw does not provide a USB stick.

Data transfer

The display tablet has the same function as a hard drive. Data can be transferred from the device to a computer via a USB C cable. The files on the display unit can then be accessed via the computer's file explorer system.

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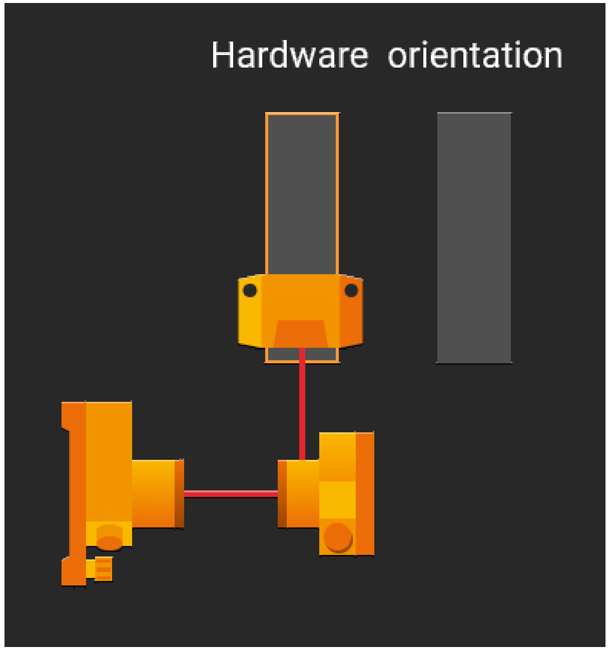
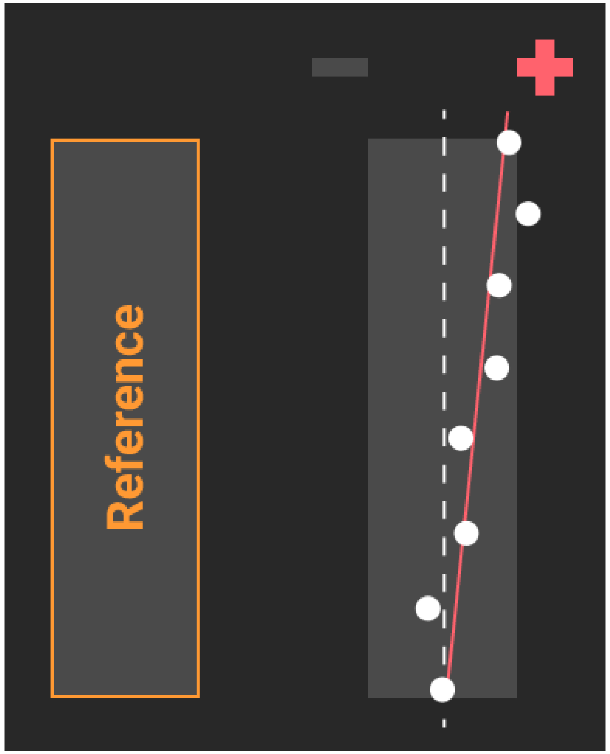
Reference rail and secondary rail

When measuring two rails, the software will refer to a 'reference rail' and a 'secondary rail'. The reference rail is the rail that is measured first. This rail is not adjusted. The secondary rail is measured second and is adjusted as required according to the measurement results.

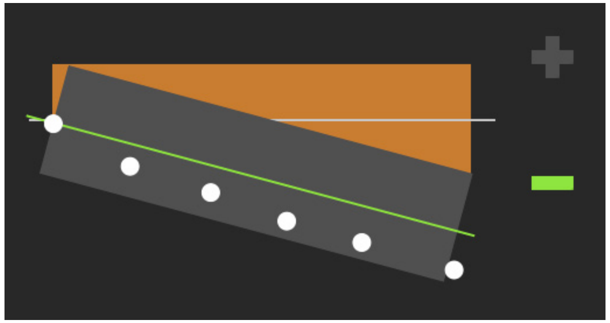
The difference between the two rails is highlighted visually – an entire rail is orange or is outlined in orange – and sometimes with on-screen descriptions. Some examples of this are as follows:



Horizontal parallelism – define screen



Horizontal parallelism – results screen



Vertical parallelism – results screen

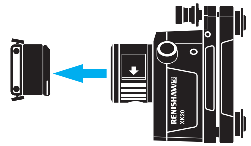
XK20 applications

Measurement modes

Straightness

Measures vertical and horizontal straightness along an axis. Used for all machine builds to ensure accuracy when mounting and aligning stages and guideways.

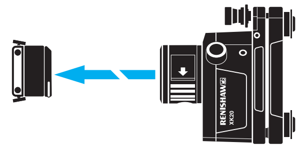
This is done by measuring the position of the Launch unit's beam when moving the M unit along the axis under test.



Long range straightness

Measures vertical and horizontal straightness along an axis. Used for all machine builds to ensure accuracy when mounting and aligning stages and guideways.

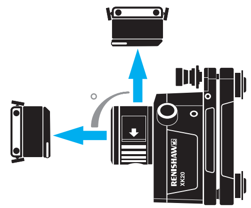
This is done by measuring the position of the Launch unit's beam when moving the M unit along the axis under test.



Squareness

Measures the orthogonality of two machine axes. This would typically be used to ensure that machine arms and beds are at right angles, to align machine rails, or when squaring separate machine assemblies.

This consists of two straightness measurements done at 90 degrees to one another.



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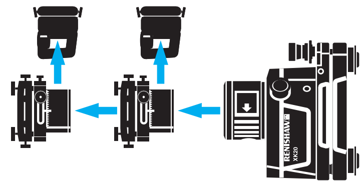
Measurement modes continued

Parallelism

Measures the straightness deviation or overall misalignment angle between two nominally parallel axes. It is typically used during the manufacture of machine tool structures.

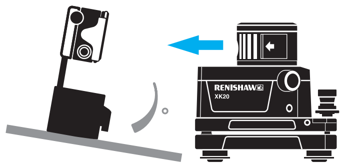
This is done by using the optional pentaprism optic to direct the beam along the axes, taking measurements with the M unit while keeping the Launch unit as a fixed reference.



Level

Measures machine level with respect to gravity, or to another machine surface. This is typically used to align machine stages and to check gradual distortion of machine structure over time. It can also be used to level one machine relative to another.

This is done by comparing the height of the structure at multiple points to the output of the Launch unit's beam.



Measurement considerations

Slope error

Slope error is caused by poor alignment. This can be reduced by the following steps:

1. Minimise misalignment of the beam to the axis to reduce PSD scale error by ensuring the software target stays green along the entire rail.

2. End-point fit data to remove residual slope error.

PSD scale error

Large misalignments along the axis increases PSD scale error which is inherent in PSD technology. Aligning the beam within the advised alignment tolerance will minimise this error. Ensuring the beam is aligned as close to the PSD centre as possible will also minimise this error.

Coning

Coning is the process of making the laser beam parallel to the axis of the spindle being measured. This forms a datum from which the spindle direction error can be measured.

Alignment

Alignment is the process of making the laser beam parallel to the axis being measured. This forms a datum from which the straightness deviation along the axis can be measured. Optimal alignment reduces slope error and PSD scale error.

Environment

The environmental conditions during measurements will significantly affect measurement accuracy. The factors listed can introduce noise and drift to measurements. These should be reduced or eliminated where possible before commencing.

- Thermal stability
- Shock and vibration
- Air turbulence

Once minimised, any further noise can be reduced using **detector value filter (see Appendix B for details).**

Alignment tolerances

To minimise slope error and the effects of PSD scale error, aim to align the laser beam to within the following tolerances:

Software tolerance
Ensure the software target stays green along the axis being measured. For numerical values, tap the software target on the screen.

Geometric tolerance
±100 µm* along the axis being measured.
This is confirmed by the alignment target turning green.

Rotational tolerance
Coning alignment should be ±100 µm* through a 180 degree rotation.

* Environmental conditions permitting

Data fitting methods

End point fit

A straight line is drawn between the first and last end point and subtracts it from the dataset.

Least squares fit

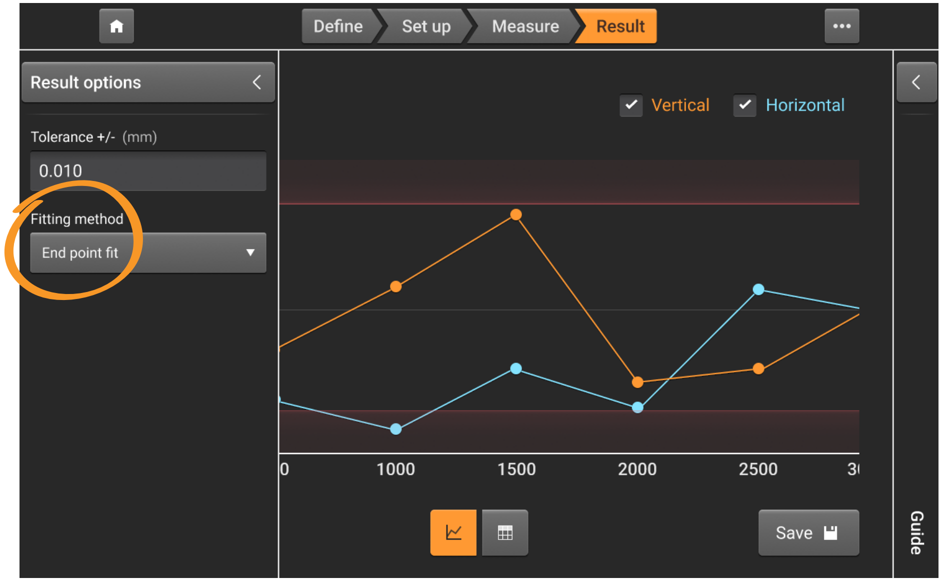
Calculates the best fit straight line through all the data points using the least squares approach, and then removes it.

Zero first

Only the start position is constrained and the deviations are fitted about this point only.

Raw data

No fitting method has been applied and the position value recorded on the PSD is reported at each position.



ISO standards

The International Organisation for Standardisation (ISO) publishes a set of internationally recognised guidelines that ensure a consistent quality of performance. XK20 is compliant to ISO 230 which specifies the use of alignment lasers to measure a range of machine tool geometric features.

Furthermore, XK20 can provide data analysis against the following standards for machine tool building:

- ISO 10791
- ISO 3070

It's important to understand that each ISO standard is specific to a certain kind of machine type. For example ISO 10791:1:2015 is only reference-able against machine tools with Horizontal spindles as their Z axis.

The table below offers further detail:

Standard	Title	Subtitle	Description	Notes
ISO 230-11:2018	Test code for machine tools.	Measuring instruments suitable for machine tool geometry.	This standard documents the characteristics of precision measuring instruments for testing the geometric accuracy of machine tools.	
ISO 10791-1:2015	Test conditions for machining centres.	Part 1: Geometric tests for machines with horizontal spindle (horizontal Z axis).	This standard specifies the geometric tests and tolerances for machining centres with horizontal spindles.	Methods based on measurements of angles (auto-collimators) (ISO 230-1:2012, 12.1.3) shall not be applied as these methods are restricted to measurements of functional surfaces.
BS ISO 10791-2:2023	Test conditions for machining centres.	Geometric tests for machines with vertical spindle (vertical Z-axis).	This standard specifies the geometric tests and tolerances for machining centres with vertical spindles.	Methods based on measurements of angles (auto-collimators) (ISO 230-1:2012, 12.1.3) shall not be applied as these methods are restricted to measurements of functional surfaces.
BS ISO 3070-1:2007	Test conditions for testing the accuracy of boring and milling machines with horizontal spindles.	Machines with fixed column and moveable table.	This standard specifies geometric tests and tolerances for horizontal spindle boring and milling machines that have a fixed column and movable table.	
BS ISO 3070-2:2016	Test conditions for testing the accuracy of boring and milling machines with horizontal spindles.	Machines with moveable column along the X-axis.	This standard specifies geometric tests and tolerances for horizontal spindle boring and milling machines that have a moveable column along the X-axis.	
BS ISO 3070-3:2007	Test conditions for testing the accuracy of boring and milling machines with horizontal spindles.	Machines with moveable column and moveable table.	This standard specifies geometric tests and tolerances for horizontal spindle boring and milling machines that have a moveable column & table.	

ISO standard analysis explained

Global deviation

This is the deviation that occurs across the entire measurement length. Each standard specifies a tolerance for a given measurement length, refer to the relevant ISO standard to find the tolerance that relates to your measurement length for global deviation compliance.

Max / min local deviation

This is the deviation that occurs along a length defined by the specific standard that is selected. For example, in ISO 10791-2 the defined local length is 300 mm. The max / min deviation that is allowed according to ISO 10791-2 is +/- 0.007 mm over any 300 mm section. If the result is outside of the tolerance, it is highlighted in red.

ISO 10791-2 (0.007mm/300mm) ▼

Deviation	V (mm)	Section (mm)
Global	0.016	0-2000
Max local	0.013	800-1100
Min local	0.003	1600-1900

Deviation	H (mm)	Section (mm)
Global	0.037	0-2000
Max local	0.037	600-1100
Min local	0.002	1600-1900

Renishaw 2012 analysis explained

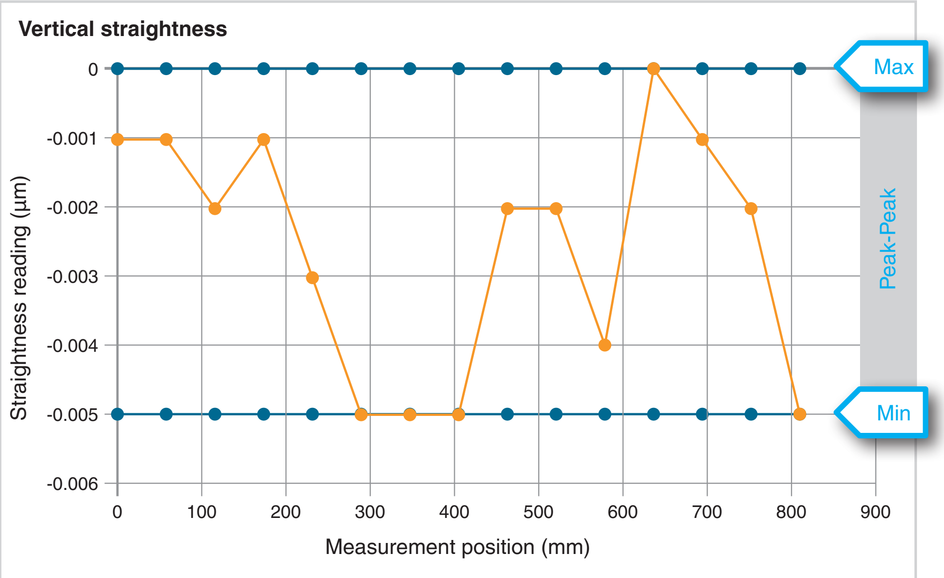
Once measurements and complete, statistics are displayed in a table.

Max and Min
Max and Min are the maximum and minimum straightness deviations along the measured axes.

Peak-peak
This is the difference between the maximum and minimum straightness values.

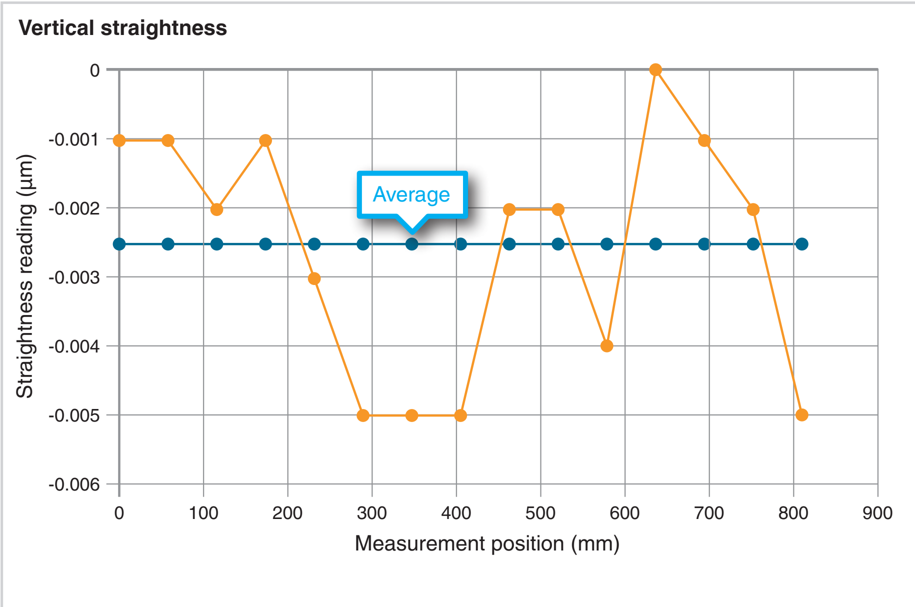
Statistic	V	H
Peak-Peak (mm)	0.035	0.016
Standard Deviation (mm)	0.013	0.008
Max (mm)	0.007	0.011
Min (mm)	-0.028	-0.012

These are useful statistics for determining whether an alignment is within assembly tolerances and understanding the size of deviation along an axis.



Deviation from the average

Standard deviation (STD)
Standard deviation (STD) represents the amount of deviation/spread from the average. It represents the uniformity of straightness, i.e. the smaller the STD, the better the straightness. Therefore, an axis with a very small STD would be considered very 'straight'.



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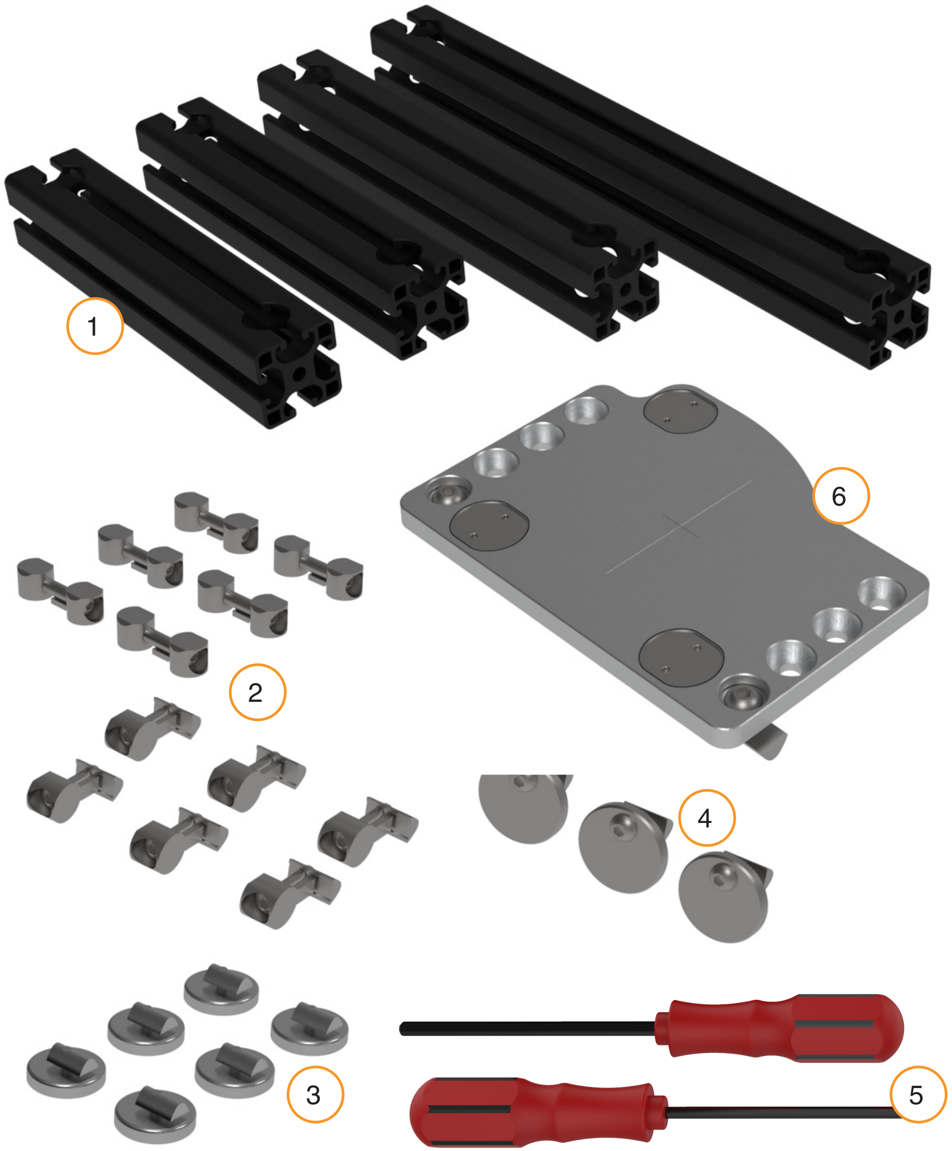
Appendix A

XK20 fixturing kit

1	**Extrusions** Aluminium box section extrusions (350 mm, 250 mm and 2 × 200 mm) that can be connected together in numerous variations using the supplied connectors.
2	**Extrusion connectors × 12** 6 off universal fastenings and 6 off universal butt fastenings that can be used to connect extrusions.
3	**Magnets × 6** These magnets are used to fix the extrusion securely to a machine bed or casting.
4	**Position discs × 3** These discs are used to position the extrusion on the machine bed and prevent lateral movement.
5	**Hex drivers (4 mm, 5 mm)** Allen keys to fasten extrusion connectors, position discs and magnets.
6	**Launch unit extrusion mount** The mount allows the Launch unit to be attached to an extrusion for more versatile mounting. The Launch unit can be fixed to the plate using the built in magnetic feet. The plate is lined with 8 through holes for mounting to an extrusion with the provided connectors.

NOTE: To see the parts used in different set-up assemblies, refer to the *XK20* Hardware guide (Renishaw part no. H-9971-9037).



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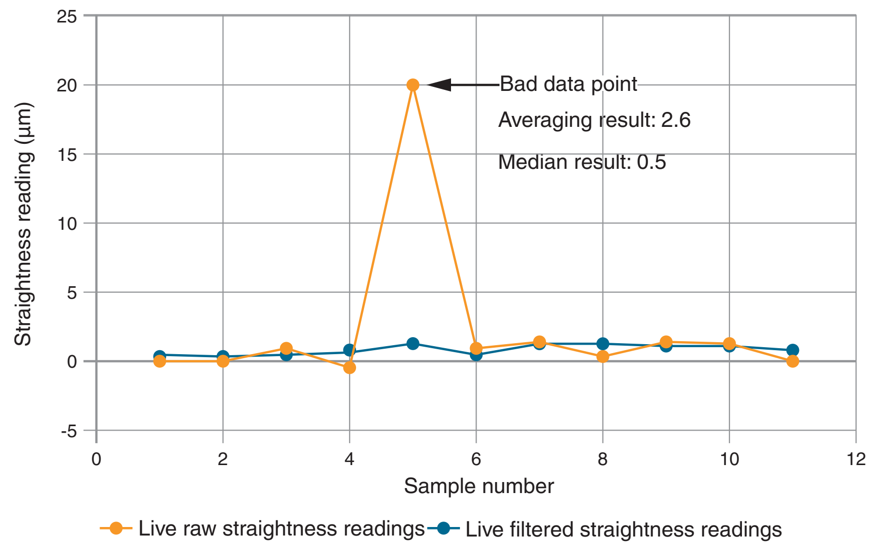
Appendix B

Filtering

Median filter at data capture

When data is captured, a sample of data is taken, and the system returns the median value of the sample. The size of the sample is dependent on the filtering level.

Straightness data capture



Live raw straightness readings	Live filtered straightness readings
0	= median (0, 0, 0.5) = 0
0	= median (0, 0.5, -0.5) = 0
0.5	= median (0.5, -0.5, 20) = 0.5
-0.5	0.5
20	1
0.5	0.5
1	1
0	1
1	1
1	1
0	0.5

Median filter at data capture

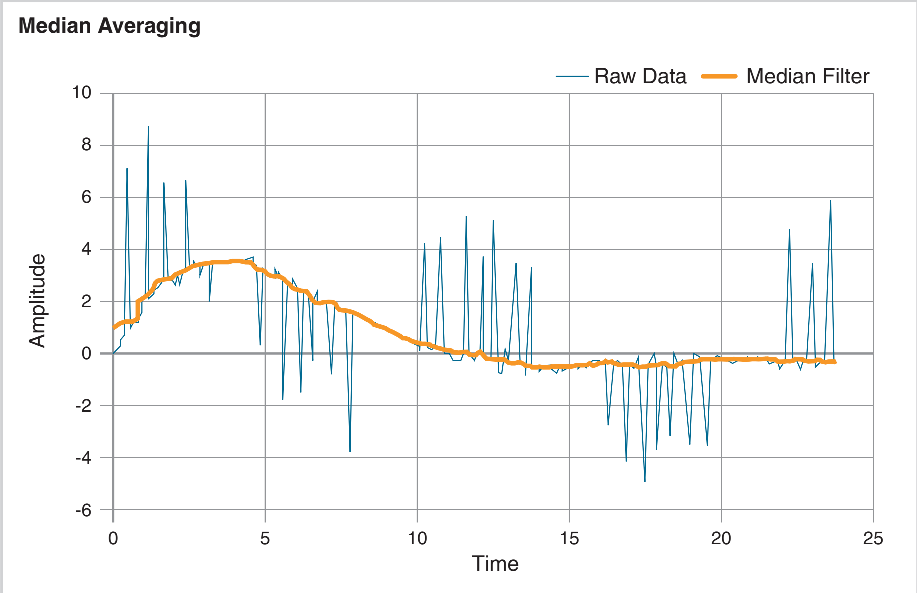
Filtering vs averaging

XK20 uses a median filter instead of averaging. The reason for this is that median filters are better suited to smooth sudden fluctuations caused by air turbulence and random vibrations.

With averaging, when data is captured (for example, 6 second averaging) the average of all data points over a 6 second period is returned; this means that noisy data is also included in the result. However, with a median filter, noisy data points are replaced with the median data point within the sample.

Low	2 seconds
Medium	6 seconds
High	10 seconds

NOTE: Median filtering is part of the reason you may get different straightness results when compared to laser interferometers.

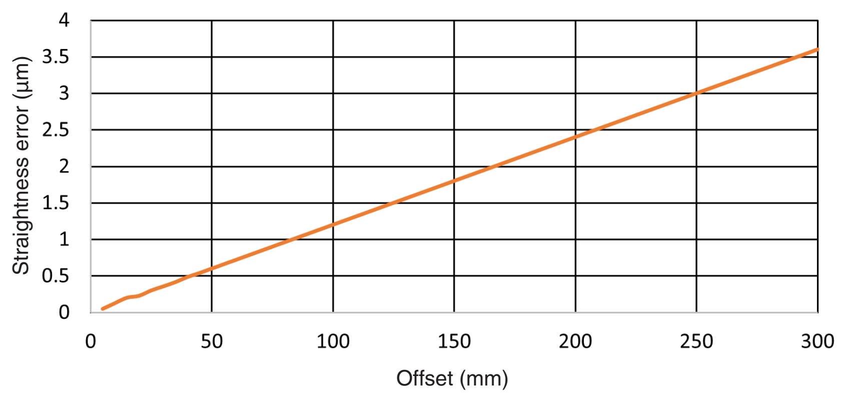


Appendix C

Parallelism – combined horizontal and vertical

When measuring combined parallelism between two rails, the true straightness error can be affected by the roll of the carriage along the axis of travel. This roll error of the carriage combined with the M unit being offset from the carriage can cause the measured straightness error to appear larger than the true straightness error. This is why it is important to minimise the offset of the M unit from the point of interest.

The effect of M unit offset on true straightness error for a known rail roll error



This is based on an example rail and carriage to have a known roll error of 20Arc seconds.

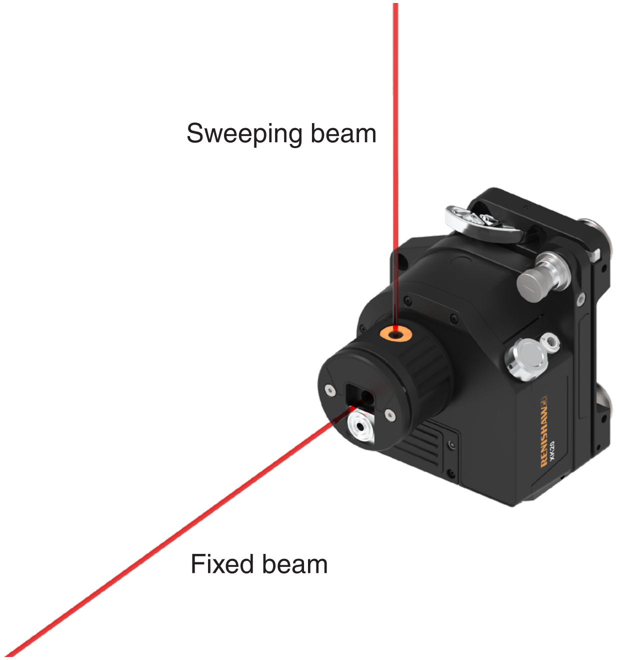
Appendix D

Squareness

When performing a squareness test, the software needs to know the orientation of the M unit on both the reference and secondary axes. This allows the software to re-orientate the sign convention of the data from the PSD and report the correct squareness angle.

Setting up the hardware

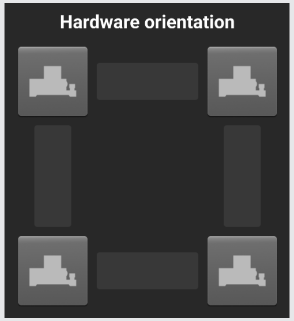
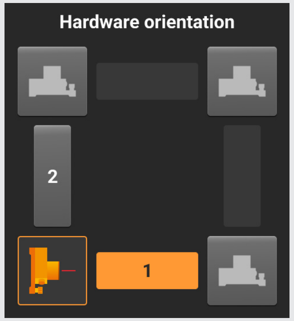
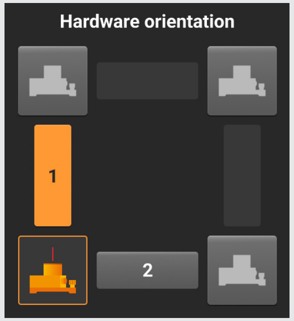
Mount the orientation of the XK20 Launch unit so that the fixed beam is pointing along the reference axis. The sweeping beam is used to measure the secondary axis.



Squareness application builder

During the set-up stage of the software, enter the orientation of the hardware mounted to the application. Defining the set-up varies between horizontal squareness and vertical squareness tests.

- Horizontal squareness – the image is based on a plan view of the hardware set-up.
- Vertical squareness – the image is based on a side view of the hardware set-up.

Not set	Reference rail option 1	Reference rail option 2
		
As default, no selection is made for hardware set-up.	Select the intersection to match the hardware set-up. The software then identifies an axis '1' (reference) and '2' (secondary).	Toggle the reference axis in the software to match the hardware set-up by selecting the XK20 icon.

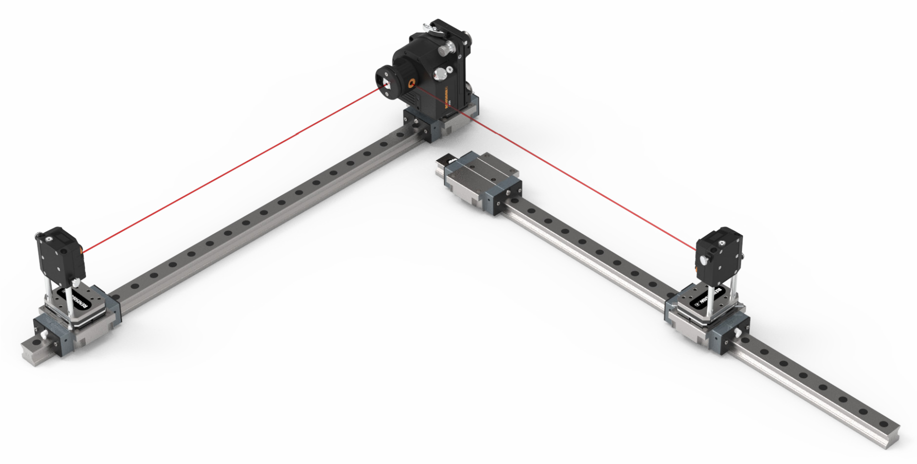
XK20 squareness options

When carrying out a squareness test, there are two measurement modes to choose from.
It is important to use the correct mode as the set-up process for horizontal and vertical squareness is not the same.

Horizontal squareness

Used this mode when the reference and secondary rails are both on a horizontal plane relative to the ground.

The software detects the M unit orientation and assigns the correct sign convention when any of the four edges of the M unit are facing ground.



Vertical squareness

Use this mode when one of the rails is vertical relative to the ground.

When capturing the vertical axis, the M unit faces towards, or away from the ground (depending on set-up). The inclinometers cannot read the orientation in this set-up.

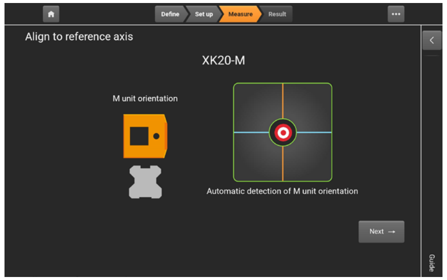
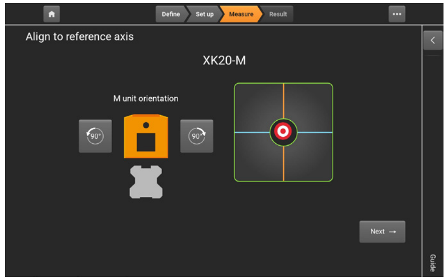
During the software process, the M unit orientation is set manually.

M unit inclinometers

XK20 M units have a built-in inclinometer, which allows the software to read its orientation with respect to gravity. Some applications automate the software set-up process, ensuring the correct sign convention is assigned to the M unit.

M unit orientation

The M unit can be mounted in any orientation relative to the rail, however, the orientation must be known by the tablet. The software assigns the relevant straightness deviations of each rail to ensure that the correct squareness angle is calculated.

Horizontal squareness	Vertical squareness
Horizontal squareness uses the built-in inclinometers to detect the orientation of the M unit relative to the ground.	Vertical squareness cannot use the built-in inclinometer. Therefore, the M unit orientation is set manually. **Horizontal rail** – in the software, set the M unit orientation relative to the ground. **Vertical rail** – in the software, set the M unit orientation relative to the rail.
	

Vertical squareness set-up requires the face of the M unit to be parallel to the ground on the vertical axis. This prevents the inclinometers from working and therefore the software cannot detect the orientation automatically.

During the test set-up process, set the orientation of the M unit relative to the rail using the rotational toggle buttons in the software.

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+44 (0) 1453 524524   uk@renishaw.com

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