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XK10 alignment laser system

www.renishaw.com/xk10

#renishaw

ContentsList

Legal information

Terms and Conditions and Warranty

Unless you and Renishaw have agreed and signed a separate written agreement, the equipment and/or software are sold subject to the Renishaw Standard Terms and Conditions supplied with such equipment and/or software, or available on request from your local Renishaw office.

Renishaw warrants its equipment and software for a limited period (as set out in the Standard Terms and Conditions), provided that they are installed and used exactly as defined in associated Renishaw documentation. You should consult these Standard Terms and Conditions to find out the full details of your warranty.

Equipment and/or software purchased by you from a third-party supplier is subject to separate terms and conditions supplied with such equipment and/or software. You should contact your third-party supplier for details.

Safety

Before using the laser system, consult the *XK10 alignment laser safety* information booklet (Renishaw part no. M-9936-0740).

Legal information

International regulations and conformance

EC and UKCA compliance

Renishaw plc declares that the XM system complies with the applicable directives, standard and regulations. A copy of the full EC Declaration of Conformity is available upon request.

In compliance with BS EN 61010-1:2010 the product is safe to use in the following minimum environmental conditions:

- Indoor use only
- Altitude up to 2000 m
- Maximum relative humidity (non-condensing) of 80% for temperatures up to 31 °C decreasing linearly to 50% relative humidity at 40 °C
- Pollution Degree 2

USA and Canadian regulations

FCC notice

47CFR:2001 part 15.19

This device complies with Part 15 of the FCC rules. Operation is subject to the following conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

47CFR:2001 part 15.105

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not used in accordance with this user guide, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case you will be required to correct the interference at your own expense.

47CFR:2001 part 15.21

The user is cautioned that any changes or modifications, not expressly approved by Renishaw plc or authorised representative, could void the user's authority to operate the equipment.

47CFR:2001 part 15.27

This unit was tested with shielded cables on the peripheral devices. Shielded cables must be used with the unit to ensure compliance.

Legal information

Canada – Innovation, Science and Economic Development Canada (ISEC)

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux ISEC applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

REACH regulation

Information required by Article 33(1) of Regulation (EC) No. 1907/2006 (“REACH”) relating to products containing substances of very high concern (SVHCs) is available at: **www.renishaw.com/REACH**

RoHS compliance

Compliant with EC directive 2011/65/EU (RoHS)

China RoHS
For more information, on China RoHS visit:
www.renishaw.com/calchinarohs

Packaging

Packaging components	Material	Material abbreviation	Material numerical code
Outer box	Cardboard	PAP	20
Inserts	Cardboard	PAP	20
Bag	Low density polyethylene	LDPE	4

Legal information

Disposal of waste electrical and electronic equipment.

The use of this symbol on Renishaw products and/or accompanying documentation indicates that the product should not be mixed with general household waste upon disposal. It is the responsibility of the end user to dispose of this product at a designated collection point for waste electrical and electronic equipment (WEEE) to enable reuse or recycling.

Correct disposal of this product will help to save valuable resources and prevent potential negative effects on the environment. For more information, please contact your local waste disposal service or Renishaw distributor.

Disposal of batteries

The use of this symbol on the batteries, packaging or accompanying documents indicates that used batteries should not be mixed with general household waste. Dispose of the used batteries at a designated collection point. This will prevent potential negative effects on the environment and human health which could otherwise arise from inappropriate waste handling. Contact your local authority or waste disposal service concerning the separate collection and disposal of batteries. All lithium and rechargeable batteries must be fully discharged or protected from short circuiting prior to disposal.

For more information, see the relevant battery manufacturer's website. See also 'Transportation'.

Radio communications

The wireless communication module used within the XK10 alignment laser system is pre-approved in a number of regions including the EU, EFTA countries, USA and Canada.

Module manufacturer: ublox
Part no.: OBS421i
FCC ID: PVH0946
Module ID No.: cB-0946

Further radio approval country-specific statements can be found below:

China

本设备包含型号核准代码为CMIIT ID：2015DJ1181的无线电发射模块

Taiwan

取得審驗證明之低功率射頻器材，非經核准，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。低功率射頻器材之使 用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。前述合法通信，指依電信管理法規定作業之無線電通信。低功率射頻器材須忍受合法通信或工業、科學及醫用電波輻射性電機設備之干擾。

Safety information

WARNING: Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Ensure that you read and understand the XK10 system user guide before using any XK10 system.

The XK10 alignment laser system can be used in a variety of environments and applications. To ensure the safety of the user and other personnel in the vicinity it is therefore paramount that a comprehensive risk assessment is carried out for the machine under test before using the XK10 alignment laser system.

This should be carried out by qualified users (requiring machine competency, applicable technical knowledge and a trained risk assessor) with consideration for the safety of all personnel. The risks identified must be mitigated prior to using the product. The risk assessment should pay particular attention to machine, manual handling, mechanical, laser, electrical and power safety.

Based on current research, the wireless devices used in this product would not seem to pose a significant health problem for the vast majority of pacemaker wearers. However, people with pacemakers may want to ensure a minimum distance of 3 cm between the product and pacemaker.

Safety labelling

WARNING: There are no user-serviceable parts inside the XK10 system. Do not remove any part of the housing.

CAUTION: Ensure that you read and understand the XK10 user guides before using any XK10 system.

Mechanical safety

- When setting up and mounting Renishaw XK10 systems, beware of pinch and/or crush hazards that may be created; for example, due to magnetic mounting bases.
- Beware of trip hazards that may be created when using the XK10 systems; for example, due to trailing cables.
- Exercise caution if components are to be mounted to moving or rotating machinery. Beware of cables becoming entangled.
- Exercise extreme caution if XK10 system components are to be mounted to machinery that may accelerate rapidly or move at high speed, which could lead to items colliding or being ejected.
- If it is necessary to operate the machine with the guards or any safety feature removed or disabled, it is the responsibility of the operator to ensure that alternative safety measures are taken in line with the machine manufacturer's operating instructions or relevant codes of practice.
- The XK10 system weighs approximately 16 kg in the case (23 kg with the fixturing kit attached). Users should exercise caution and follow local manual handling guidelines.

Laser optical safety

- In accordance with (IEC) EN60825-1, XK10 systems are Class 2 lasers and safety goggles are not required (under normal circumstances the eye will blink and look away before damage can occur).
- Do not stare directly into the laser beams or view them with optical equipment such as telescopes, convergent mirrors or binoculars, as permanent retinal damage could occur. Do not direct the beam at other people or into areas where people unconnected with laser work might be present. It is safe to view a diffuse-reflected beam during system alignment.
- Complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019.

Electrical and power safety

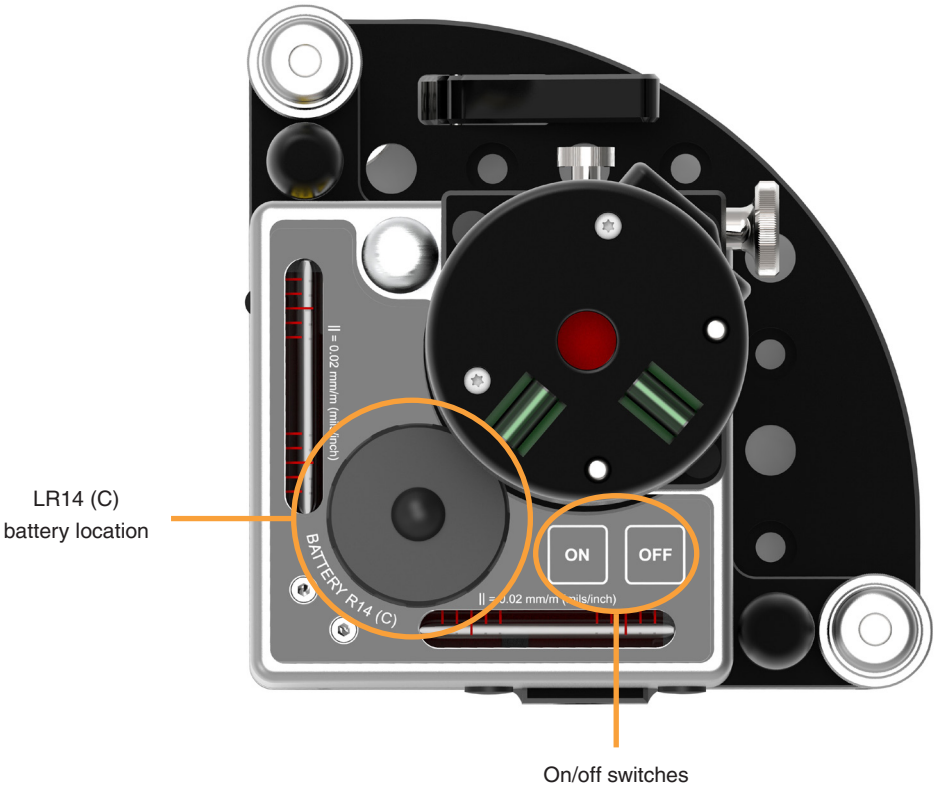
- The display unit power supply and device charging cables must not come into contact with fluids, for example, coolant on the floor.
- The power supply unit must not be positioned inside the machine volume.
- The display unit has been qualified for use with the power supply supplied with the system. A specification for this power supply unit can be found on **page 28**.
- In the event of damage to the single phase mains cabling section of the power supply (power lead), all power must be isolated from the equipment before any other action is taken.
- Never connect the system to devices not intended to be used with the XK10 system.

Battery safety

The XK10 system is supplied with a single LR14 (C) primary alkaline battery for the launch unit. Once depleted, dispose of the battery according to manufacturer's disposal procedures: do not attempt to charge the battery. The other system components contain built-in rechargeable batteries.

For information on charging procedures, see the relevant section of this manual. For specific battery operating, safety and disposal guidelines, refer to the battery manufacturers' literature **(see details on next page)**.

- The XK10 may be supplied or used with non-rechargeable alkaline or lithium-thionyl chloride batteries.
- Do not attempt to recharge the batteries.
- Dispose of waste batteries in accordance with your local environmental and safety laws.
- Replace the batteries only with the specified type.
- Ensure that all batteries are inserted with the correct polarity, in accordance with the instructions in this manual and indicated on the product.
- Do not store batteries in direct sunlight.
- Do not expose the batteries to heat or dispose of batteries in a fire.
- Avoid forced discharge of the batteries.
- Do not short circuit the batteries.
- Do not disassemble, apply excessive pressure, pierce, deform or subject the batteries to impact.
- Do not swallow the batteries.



- Keep the batteries out of the reach of children.
- Do not expose the batteries to water.
- If the batteries are swollen or damaged do not use them in the product and exercise caution when handling them.

Battery safety

Transportation

Ensure that you comply with international and national battery transport regulations when transporting batteries or XK10 system kits.

Lithium-ion batteries are contained within the product. Lithium batteries are classified as dangerous goods and strict controls apply on their shipment by air. To reduce the risk of shipment delays, should you need to return the XK10 system to Renishaw for any reason, please ensure the device has been correctly declared.

In order to ship XK10 systems by airfreight in line with IATA regulations, lithium batteries used throughout the system need to be suitably declared. The table below gives full details of the batteries used for shipping declarations.

Due to the non-removable nature of the batteries within this product, care must be taken to ensure that the product does not become activated during transportation. This can be achieved by protecting the on/off switches from being contacted by any packaging material or other items within the product box. Shipping the XK10 product in the supplied product case will prevent any accidental activation of the product during transportation.

Component	Battery	Weight	Quantity	Purpose/description	Link to manufacturer's data sheet
Launch unit	VARTA LONGLIFE LR14 (C) (non-rechargeable)	67.8 g	1	Power for the alignment laser launch unit	
Display unit	Samsung INR18650-29E Rechargeable Li-Ion Cell, 3.65 V, 10.4 Wh, 2900 mAh	48 g	1	Rechargeable internal (non-customer accessible) power source for the display unit	**https://www.samsungsdi.com/lithium-ion-battery/power-devices/power-tool.html**
M unit	VARTA LPP 443441 S Li-Ion, 3.7 V, 2.4 Wh, 680 mAh	Approx. 13 g	1	Internal (non-customer accessible) lithium-ion battery	**https://www.varta-ag.com/en/industry/product-solutions/lithium-ion-battery-packs/cellpac-blox**
S unit	VARTA LPP 443441 S Li-Ion, 3.7 V, 2.4 Wh, 680 mAh	Approx. 13 g	1	Internal (non-customer accessible) lithium-ion battery	**https://www.varta-ag.com/en/industry/product-solutions/lithium-ion-battery-packs/cellpac-blox**

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XK10 hardware

Principles of measurement

XK10 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
- Squareness
- Flatness
- Level
- Coaxiality (spindle direction)
- Spindle direction

System components

XK10 alignment laser system kit

1	Launch unit
2	S unit
3	M unit
4	Wireless modules × 2
5	Display unit

6	Magnetic base
7	Magnetic base with rotating head
8	Measuring tape
9	Spindle brackets × 2
10	Base pin – short

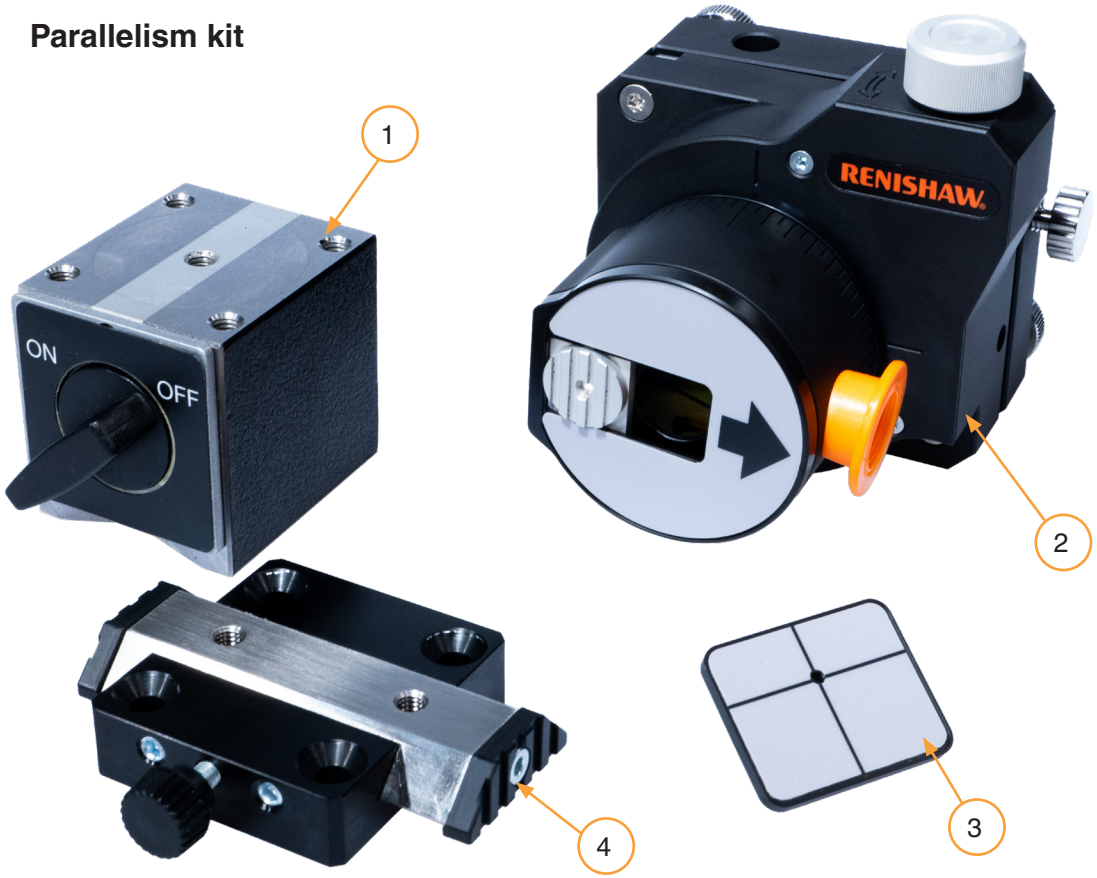
11	Base pin – long
12	90 degree bracket
13	M6 pillars × 8

System accessories

Tripod adaptor

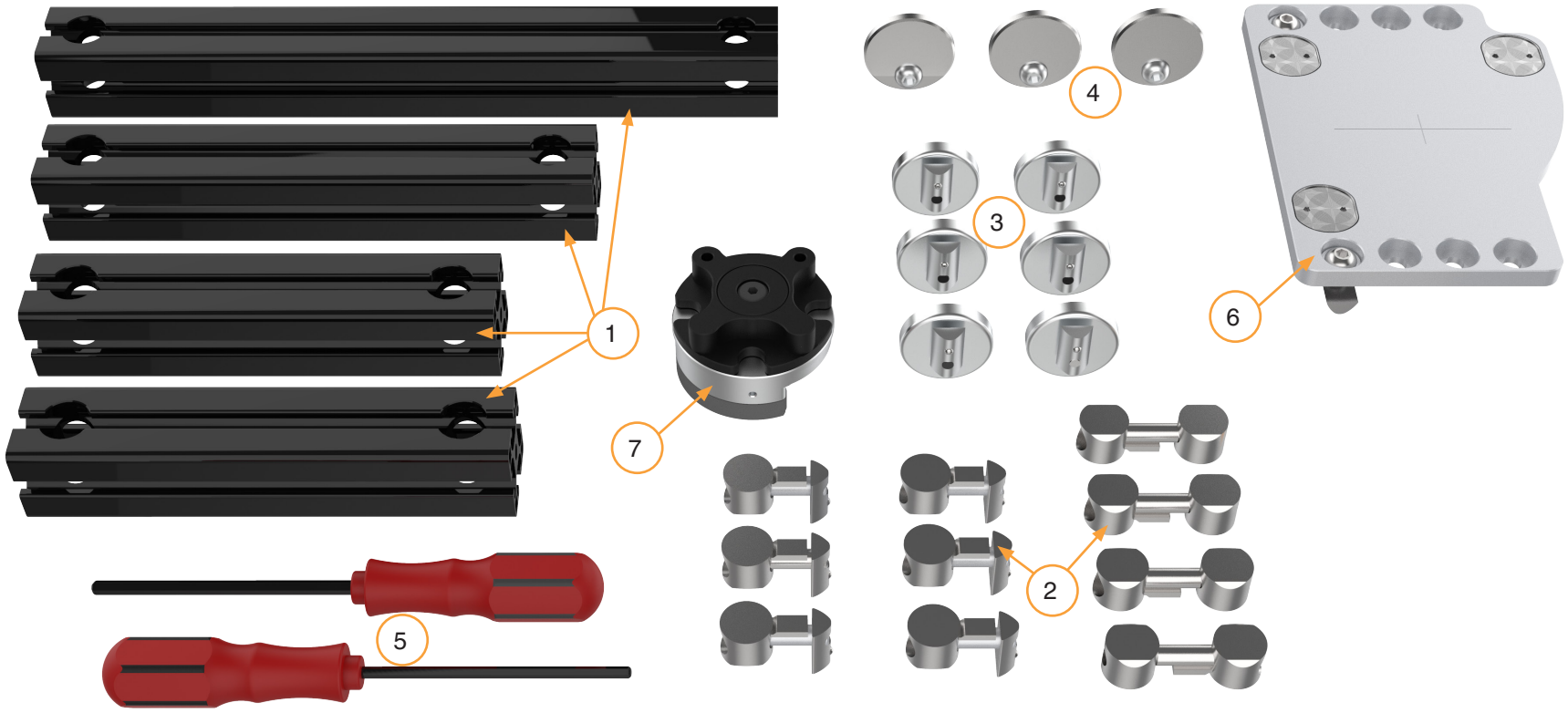
1	Tripod adaptor

Parallelism kit



1	Magnetic base
2	Pentaprism/parallelism optic
3	Target
4	Parallelism stage

XK10 fixturing kit



1	350 mm extrusion, 250 mm extrusion, 200 mm extrusion × 2
2	Extrusion connectors × 10
3	Magnets × 6
4	Position discs × 3

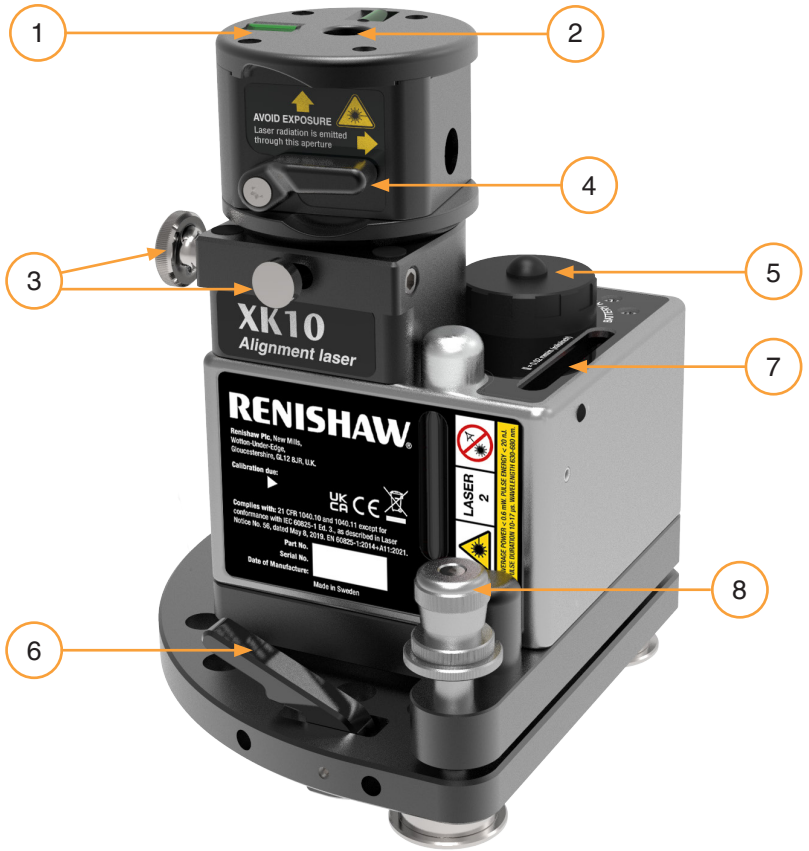
5	Hex drivers (4 mm, 5 mm)
6	Launch unit extrusion mount
7	Magnetic reference mount

Launch unit

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

The output is directed into a pentaprism mounted in the rotatable head which provides a beam that can be switched between two orientations.

The two beams exit the head perpendicularly and can be used as the reference for a variety of measurements.



1	Coarse bubble levels
2	Fixed beam output aperture
3	Head locking mechanism
4	Beam output switch
5	LR14 (C) battery cap
6	Magnetic break-out lever
7	Precision bubble levels
8	Level adjustment screw

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.

Power is provided by an internal lithium-ion battery. For extended long-term testing, ports on the side of the device allow for a 'wired connection' (**see details on page 22**).

NOTE: It is recommended that the M unit and S unit should be charged after every use to maintain the battery.

1	Adjuster wheels
2	Clamp screw
3	Position sensitive diode
4	Laser output
5	Charging and wireless connector ports

Wireless module

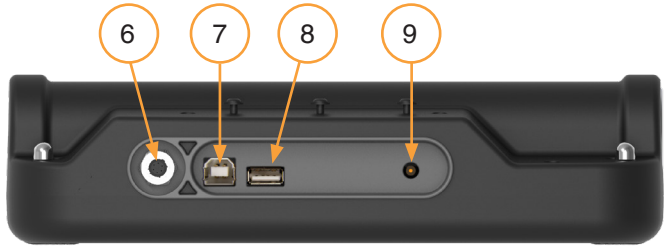
This module is required to use the system in wireless mode, and can be connected to the S unit or M unit instead of the communications cable.

1	Connector

Display unit

The display unit is used to set up and capture data, as well as to charge the S unit and M unit internal batteries.

The display unit contains a rechargeable lithium-ion battery. Additionally the display unit can be powered and recharged using the power supply **(see details on page 28)**.



1	Power on/off
2	Select key
3	Soft keys
4	Navigation keys
5	Keypad
6	Charged/wired output
7	USB B port
8	USB A port
9	Mains power input

Modes of operation

Wired and charging

The S unit and M unit are charged by the display unit when connected by the cable, as shown below.

Wireless operation

Wireless modules will only connect when a measurement program is active. The wireless module serves as an on/off switch for the S unit and M unit.

Diagnostics and troubleshooting

Display unit LED

The display unit has two LED indicators: Display status LED and Charge status LED.

Display status LED	Command
Flashing green	Display unit starting up
Solid green	Internal battery fully charged
Flashing blue	Searching for units
Solid blue	Unit connection established
Flashing red	Warning (for example, low battery)
Flashing light blue	Power saving mode. Press any button to activate the display unit.
Red/blue	System reprogramming

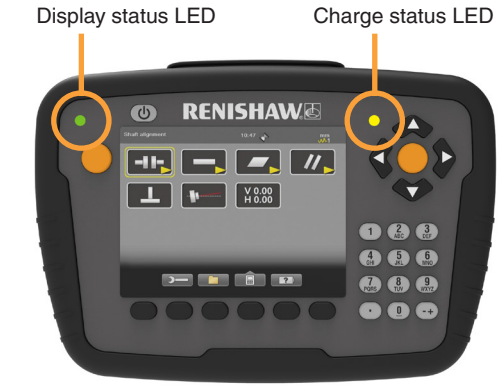
Charge status LED	Command
Flashing yellow	Internal battery charging

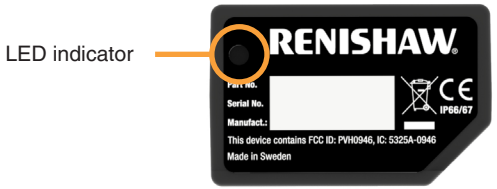
NOTE: If wireless module LEDs do not light up, the S unit or M unit may have fully discharged, and will require an overnight charge.

Wireless module LED

The wireless module has one LED indicator.

LED display	Command
Solid yellow	Searching for unit
Flashing blue	Unit connection established





System specifications

XK10 system	
Specified accuracy range	10 °C to 40 °C
Recommended recalibration period	2 years

Launch unit	
Beam measurement range	30 m
Laser output	Class 2
Dimensions	139 mm × 185 mm × 142 mm
Weight	2.65 kg
Power	1 × LR14 (C) battery
Operating time	~24 hours
Warm-up time	30 minutes
Spirit vial resolution	20 µm/m

M unit and S unit	
Beam measurement range	20 m
Laser output	Class 2
Dimensions	60 mm × 60 mm × 44 mm
Weight	0.2 kg
Power	Lithium-ion (2.4 Wh) internal battery
Operating time	~5 hours
Warm-up time	30 minutes

Display unit	
Dimensions	250 mm × 175 mm × 63 mm
Weight	1 kg
Power	Internal battery: Lithium-ion (43 Wh)
Operating time	~30 hours (internal battery only)
Screen size	5.7 in
Wireless range	30 m

System storage and transportation environment

Storage and transportation	
Temperature	–20 °C to +50 °C
Pressure	Normal atmospheric (550 mbar to 1200 mbar)
Humidity	0 % to 95% RH (non-condensing)

Performance specifications

Straightness (Launch unit and M unit)	
Range	±5 mm
Accuracy	±0.01A ±1 µm
Resolution	0.1 µm

A = displayed straightness reading (µm)

Squareness	
Range	±5 mm
Accuracy*	±0.01A/M ±2/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)

Flatness		
Range	±5 mm	
Accuracy	±0.01A ±1 ±(1+1.1M) µm	Over a 90° sweep
Resolution	0.1 µm	

A = displayed straightness reading (µm)
M = distance to the furthest point (m)

NOTE: To achieve the specified performance, the launch unit should only be used with the S unit and M unit that it was originally paired with. This information can be found on the calibration certificate which is supplied with the XK10 system.

Performance specifications continued

Parallelism	
Range	±5 mm
Accuracy (i)	±0.01A/M ±2/M ±4 µm/m*
Accuracy (ii)	±0.01A ±2 ±4M µm*
Resolution	0.1 µm

* laser to pentaprism distance > 0.3 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

Spindle direction	
Range	±5 mm
Accuracy (vertical)	±3 µm / 300 mm
Accuracy (horizontal)	±1.5 µm / 300 mm
Resolution	0.1 µm

Coaxiality	
Range	±5 mm
Accuracy (angle)	±1 µm / 100 mm
Accuracy (offset)	±1 µm
Resolution	0.1 µm

NOTE: To achieve the specified performance, the launch unit should only be used with the S unit and M unit that it was originally paired with. This information can be found on the calibration certificate which is supplied with the XK10 system.

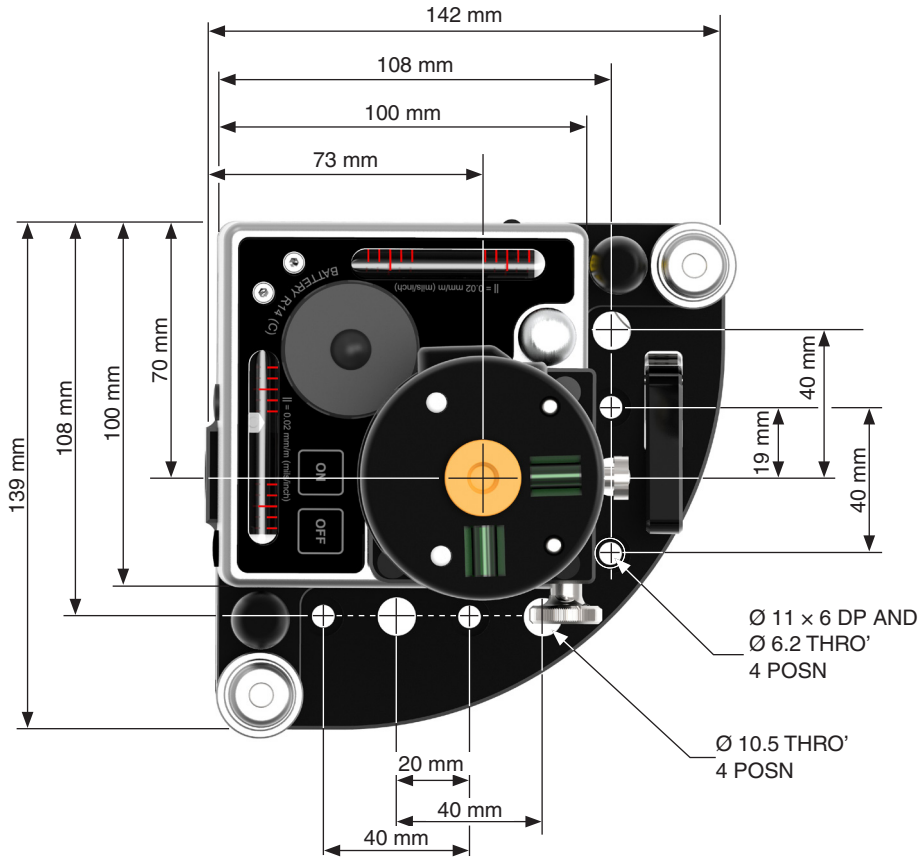
Power supply (display unit)

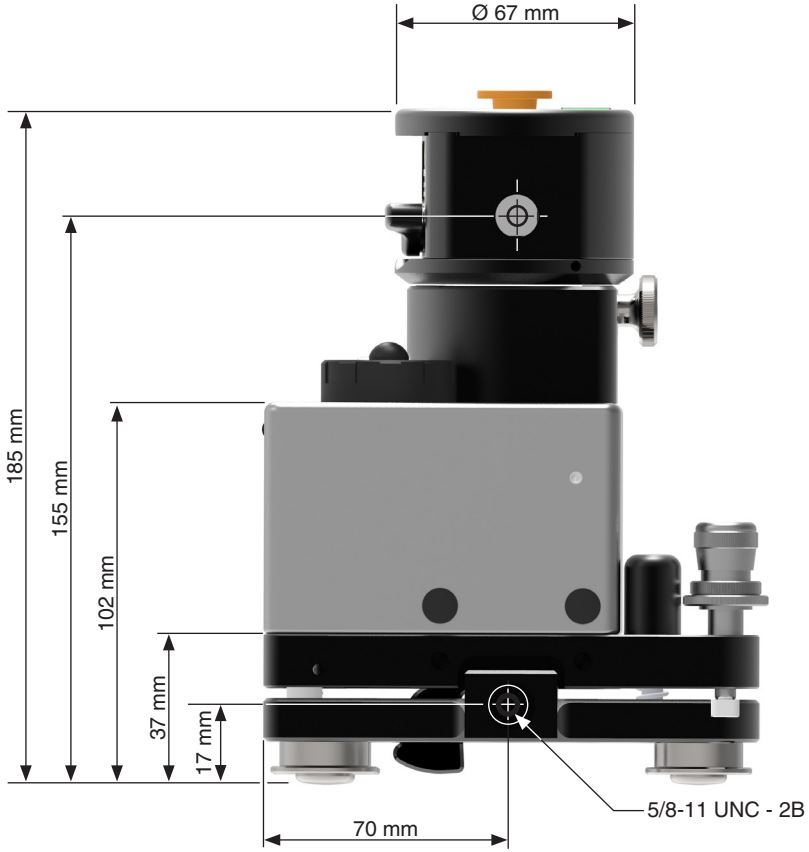
Power supply (display unit)	
Input voltage	100 V to 240 V
Input frequency	~50/60 Hz
Maximum input current	0.75 A
Output voltage	12 V
Maximum output current	2 A
Safety standard	EN 62368

Weights and dimensions

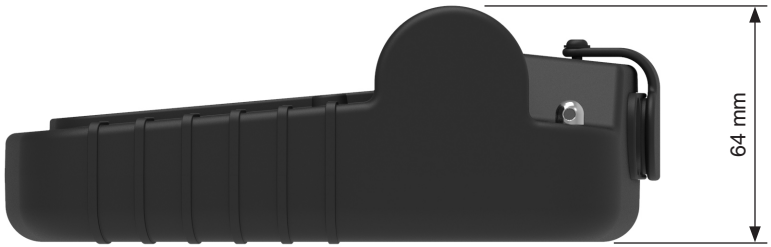
Item	Weight (approximately)
XK10 system	16 kg (including case) 23 kg (including fixturing)
Launch unit	2.65 kg
Display unit	1.1 kg
M unit	0.2 kg
S unit	0.2 kg

Launch unit

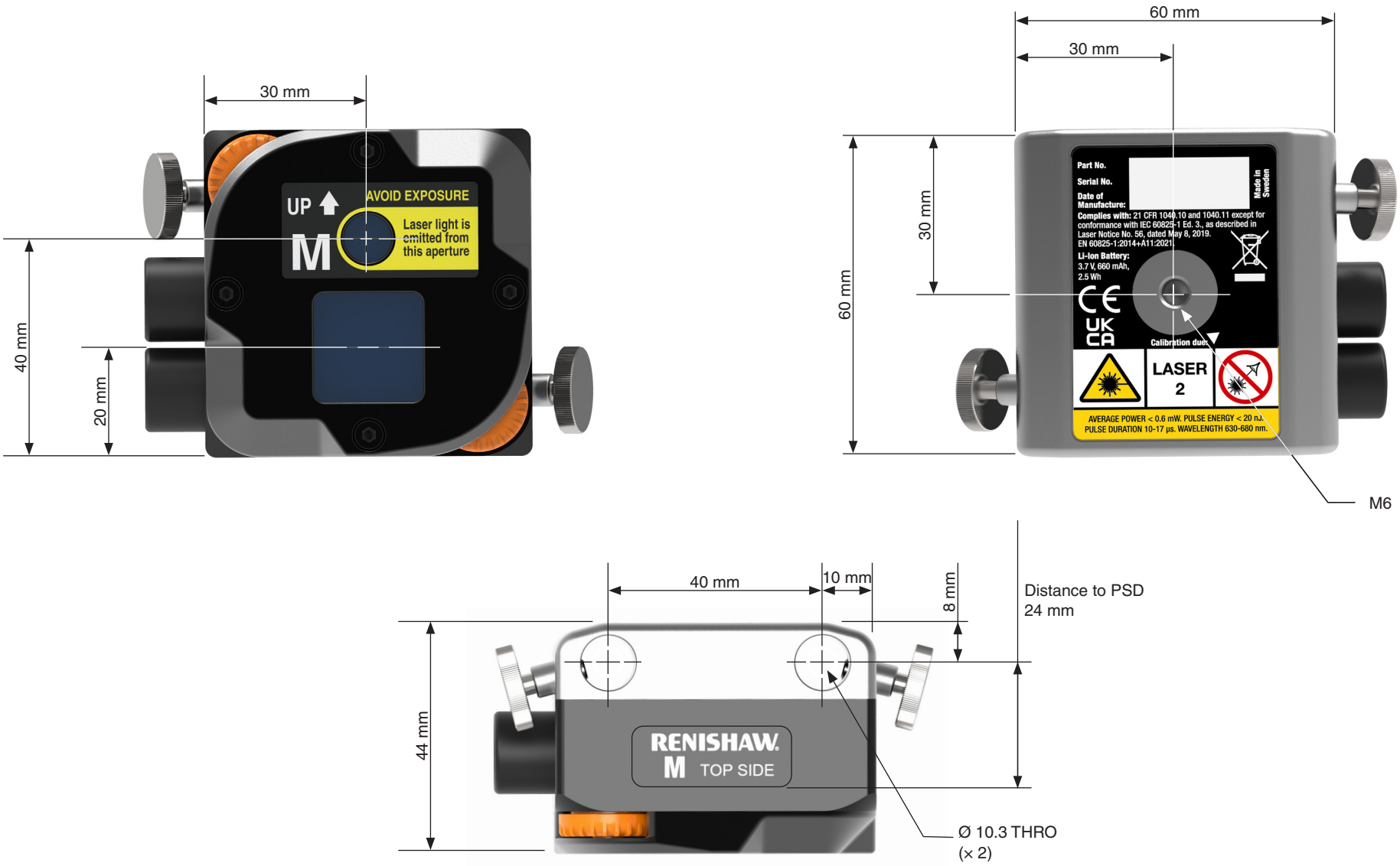

142 mm
108 mm
100 mm
73 mm
139 mm
108 mm
100 mm
70 mm
40 mm
19 mm
40 mm
Ø 11 × 6 DP AND
Ø 6.2 THRO'
4 POSN
Ø 10.5 THRO'
4 POSN
20 mm
40 mm
40 mm
ON
OFF


Ø 67 mm
185 mm
155 mm
102 mm
37 mm
17 mm
5/8-11 UNC - 2B
70 mm

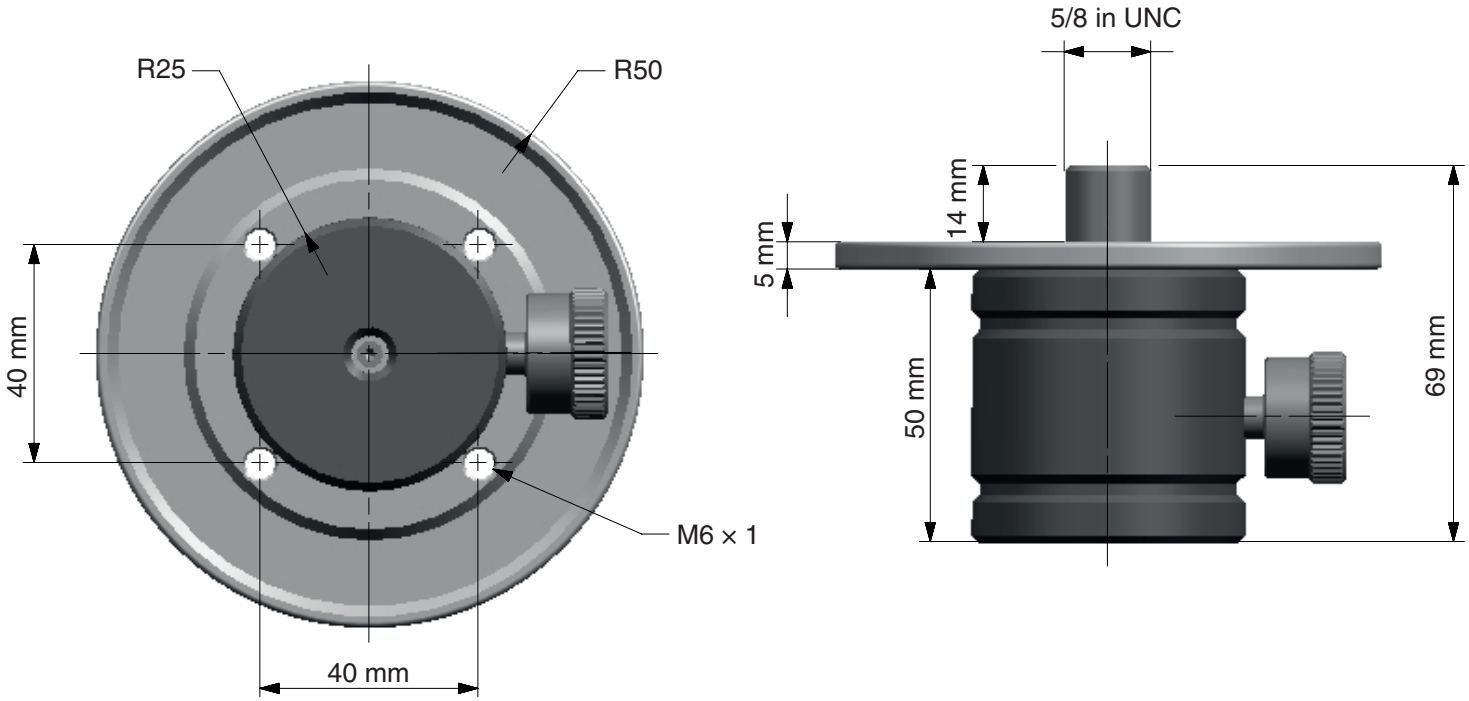
Display unit



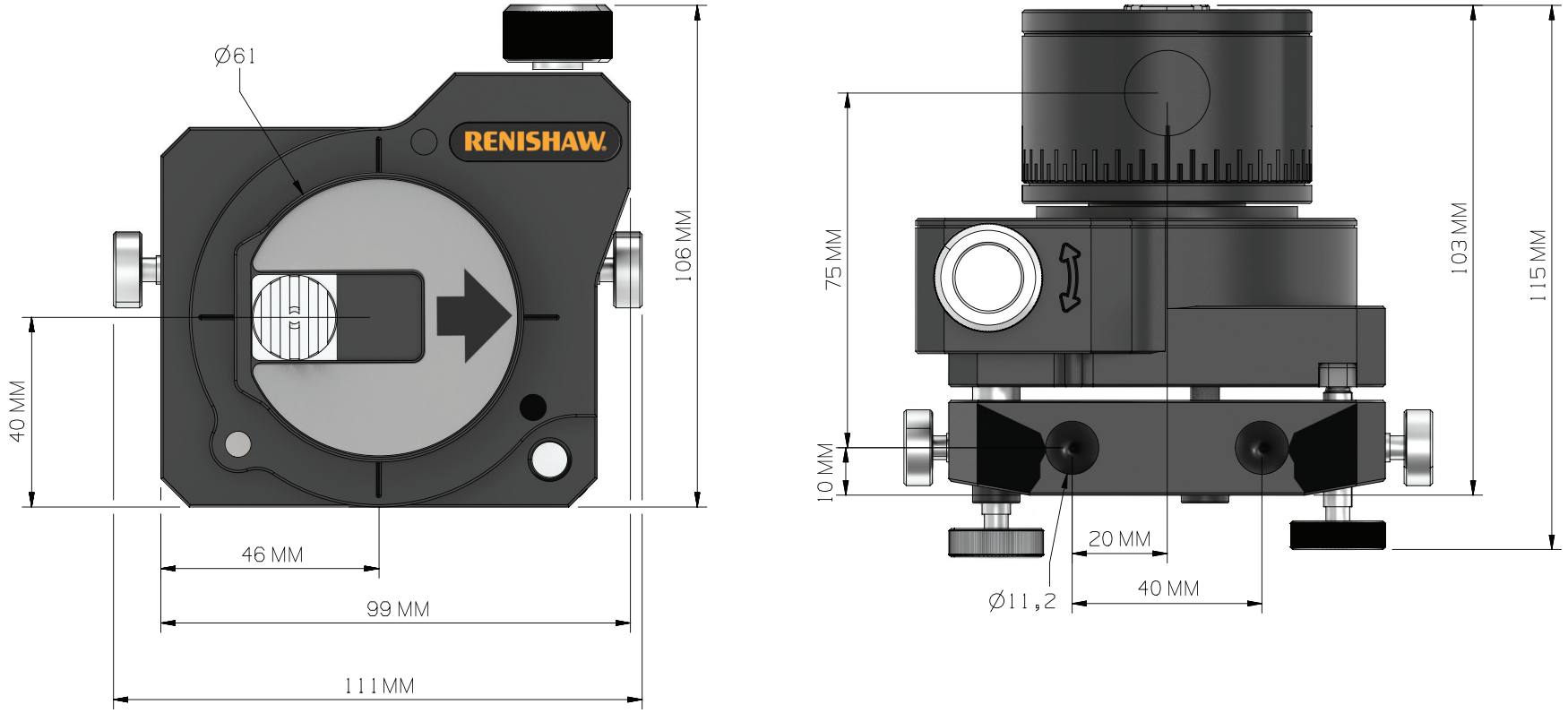
M unit and S unit



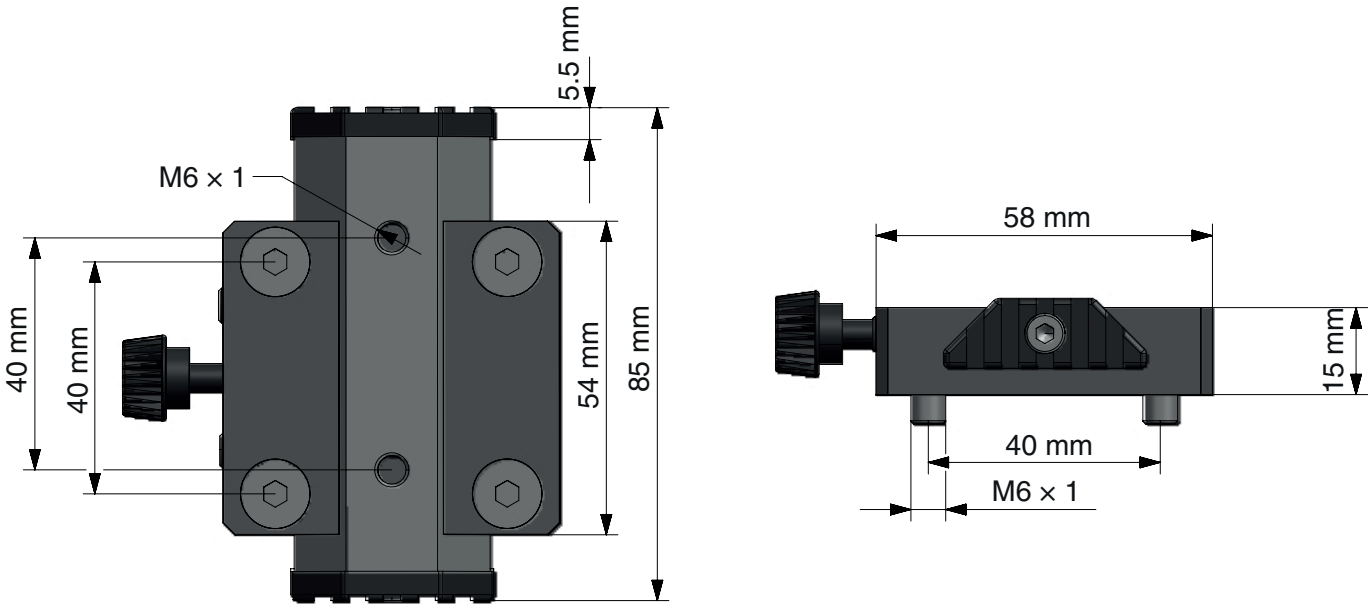
Tripod adaptor



Parallelism optic



Parallelism stage



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XK10 software

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Display unit overview

Status bar

The status bar contains additional information and warning icons.

Navigation

The navigation keys are used to move between icons.
The selected position is highlighted with a yellow frame.

Selection

Either of the two orange *Select* keys can be used to confirm an option or capture data.

Soft keys

The function of the soft keys changes depending on the selected view.

Control panel
The control panel provides additional information and settings.

File manager
Use the file manager to review measurement data.

Calculator
Use the calculator to perform calculations and unit conversions.

Battery level
The battery level page displays the charging status of each system device.

1	Status bar
2	Navigation
3	Selection
4	Soft keys
5	Control panel
6	File manager
7	Calculator
8	Battery level
9	Decimal point

Screenshot

To take a screenshot at any time, press and hold the decimal point for five seconds. Screenshots are saved automatically in the file manager.

Status bar icons

The table opposite provides a full description of all the status bar icons.

- The left side of the status bar gives information on the highlighted option.
- The right side shows various status bar icons.

Status bar icons	
	**WARNING!** Select the relevant function button for more information
	**WARNING!** Co-ordinate system has been rotated by 90 degrees
	Display unit is performing a task
	Display unit is charging
	Display unit battery is low
	Capturing data
	Selected averaging/filtering
	A peripheral device has been plugged in
	Wireless functionality is active
	Printing report
	Printing successful
	Printing error

Control panel

User

Add user profiles.

Language

Change language settings.

Date and time

Change date and time settings.

Backlight

Adjust backlight settings.

Automatic power off

Adjust sleep mode settings.

System update

View and install software updates.

Licence

View product software licence.

Detector value filter

The software can be used to filter data readings.

	Filter	Capture speed	Raw readings per point
1	Minimum	Fastest	Minimum
10	Maximum	Slowest	Maximum

Unit and resolution

Switch between metric and imperial units, and adjust measurement resolution.

Detector rotation

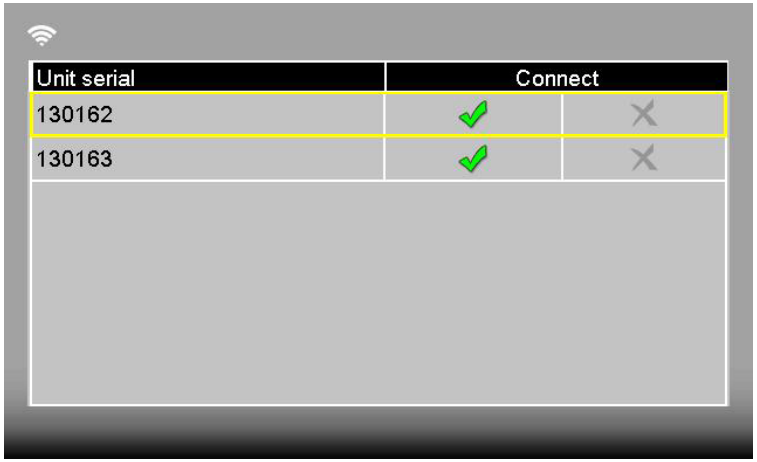
Allows rotation of the co-ordinate system by 90 degrees.

Wireless connections

Displays connected and previously connected wireless devices.

From this screen, the following functions are available:

- Search for devices
- Remove device
- Connect/disconnect



System information

Displays serial number and software versions.

File manager

Use the File manager to review measurement data.

- View data on the display unit
- Copy to USB (as .XML and .PDF)
- Import favourites from USB
- Open as template
- Create favourite
- Delete test

NOTE: Data can be sorted by date, name (A-Z), or test type.

NOTE: .PDF files are automatically generated when the test is saved.

Screen shot capture

To capture the image on the screen as a .jpg, hold down the decimal point button until the hourglass icon appears, then release. A .jpg file will be created in the File manager.

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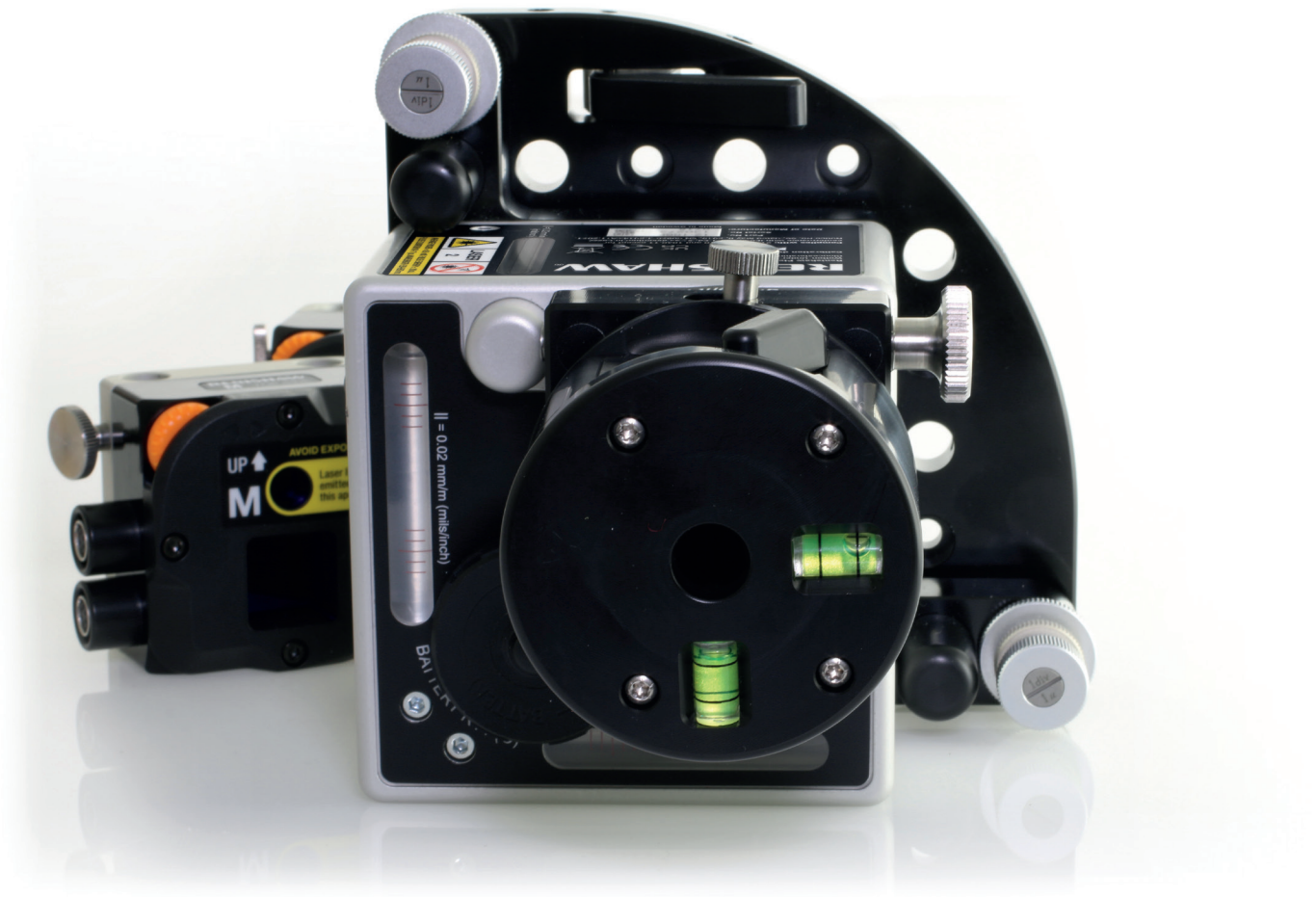
XK10 applications

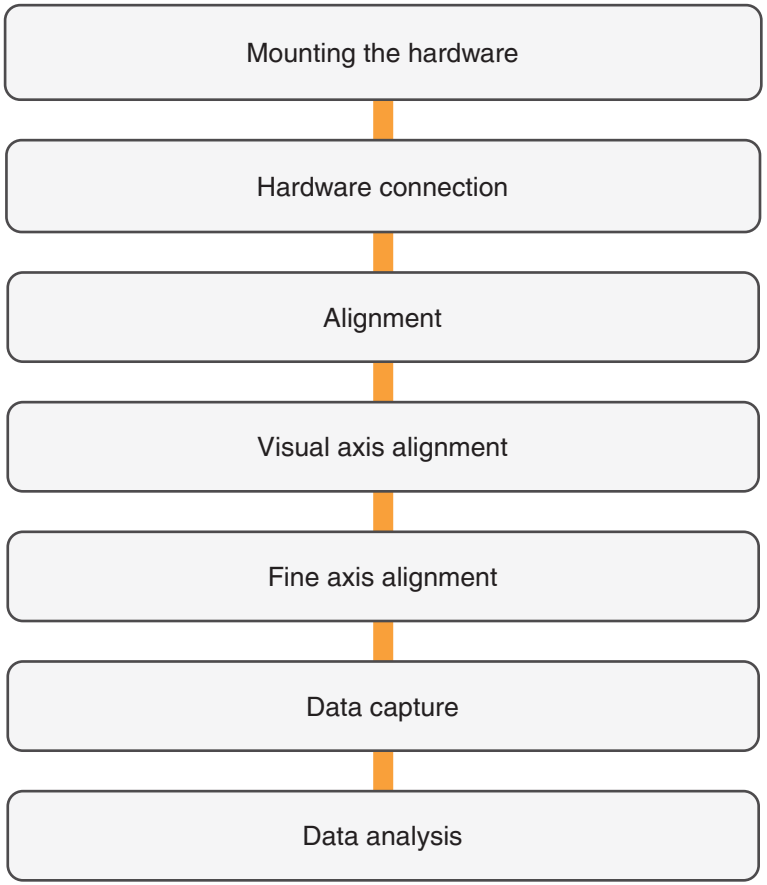


#renishaw

Introduction

Aims of the guide

- Provide the reader with the skills and confidence necessary to perform measurements using the XK10 system.
- Highlight the factors affecting measurements and methods of reducing or eliminating them.
- Define the best practices for each measurement.
- After reading this guide, the user will be able to take a range of measurements, evaluate the results and save measurement data.



Introduction

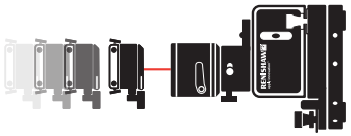
Measurement modes

This guide includes:

Straightness

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

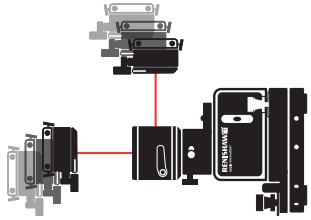
This is done by measuring the position of the launch beam when moving the M unit along the axis under test.



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.

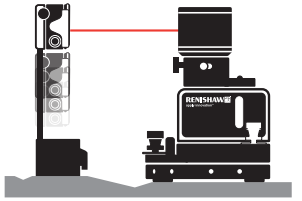
This consists of two straightness measurements done at 90 degrees to one another.



Flatness

Measures vertical deviation along a machine bed, rails, or other machine planes. A versatile mode that can measure continuous or interrupted planes, for example to measure height differences between fixtures or machine sub-assemblies.

This is done by measuring the position of the launch beam on the M unit at different points on a plane.



Continued overpage.

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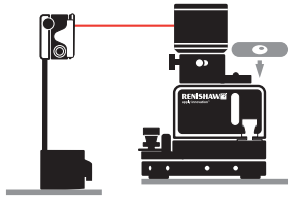
Measurement modes continued

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.

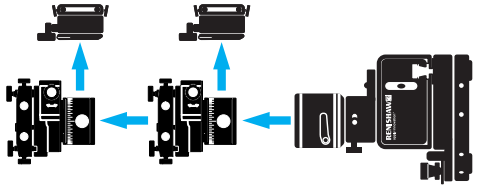
This is done by looking at the live changes in launch beam position on the M unit.



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.

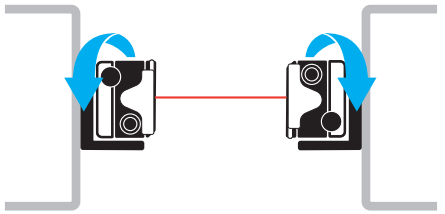
This is done by using the optional pentaprism optic to direct the beam along the axes, taking measurements with the M unit while keeping the launch unit as a fixed reference.



Coaxiality

Measures the deviation of one rotating centre from another. This is typically used for alignment of rotary spindles or chucks, for example when building a lathe.

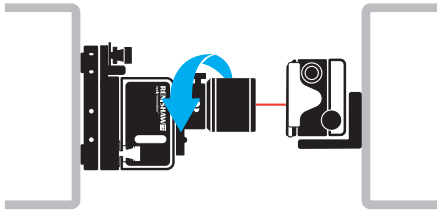
This is done by mounting the S unit and the M unit in opposing spindles and measuring the position of the beams as they are rotated.



Spindle direction

Measures the angle at which a spindle or chuck is pointing. This can be used for any spindle or chuck alignment, to ensure that it points in the same direction through a full 360° rotation.

This is done by mounting the launch unit and the M unit opposite each other, and measuring the beam position as the spindle(s) is/are rotated.



Measurement considerations

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.

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.

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.

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.

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 details on page 39)**

Alignment tolerances

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

Geometric tolerance
±100 µm* along the axis being measured.

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

* Environmental conditions permitting

Measurement considerations

Filtering

How to set filtering level

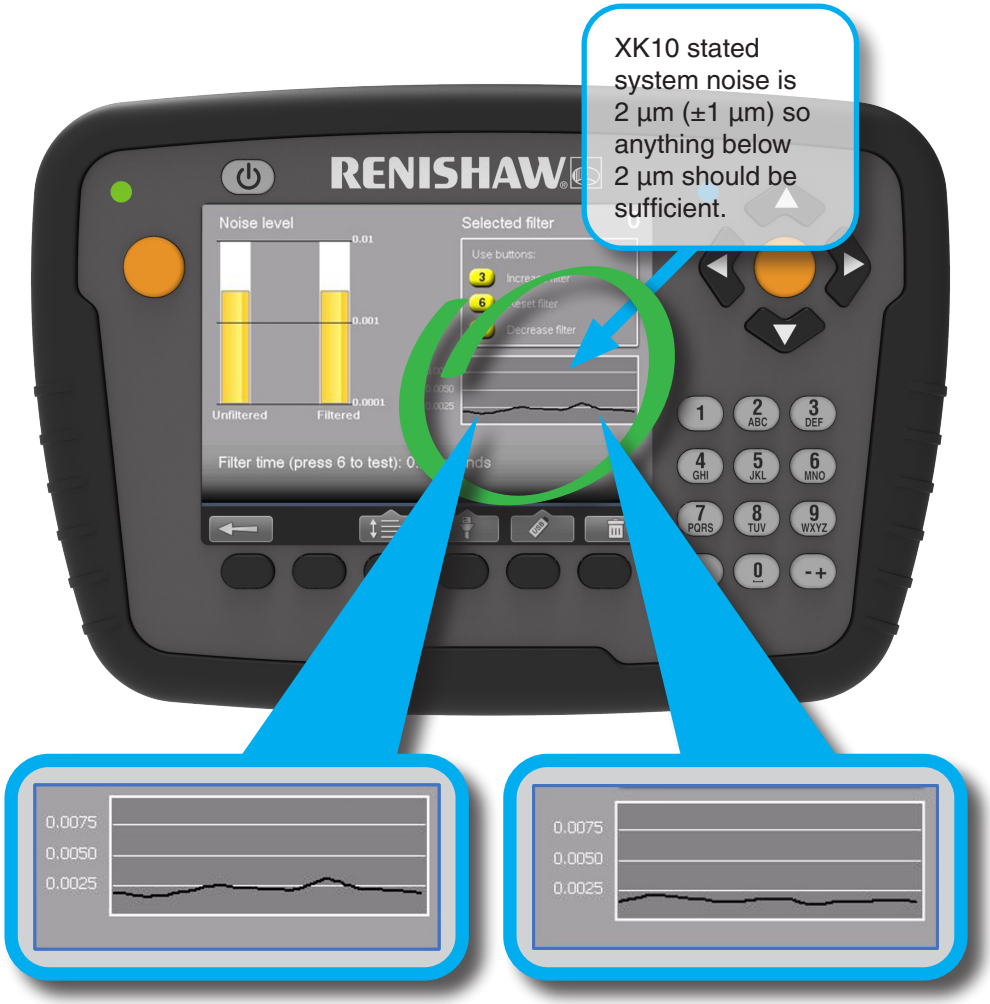
There is no fixed rule for setting the filtering level. You will need to evaluate the environment, reduce or remove any sources of heating or forced air (for example, close doors, switch off fans and air conditioning) and only then set a filtering level.

Steps

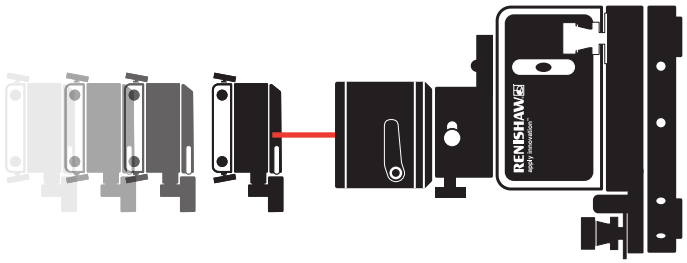
1. Set filtering to 0.
2. Move the M unit to the far position.
3. Look at the graph and press (3) to increase the filter until the filtered noise level is stable (the recommended level is below 2.5 µm).

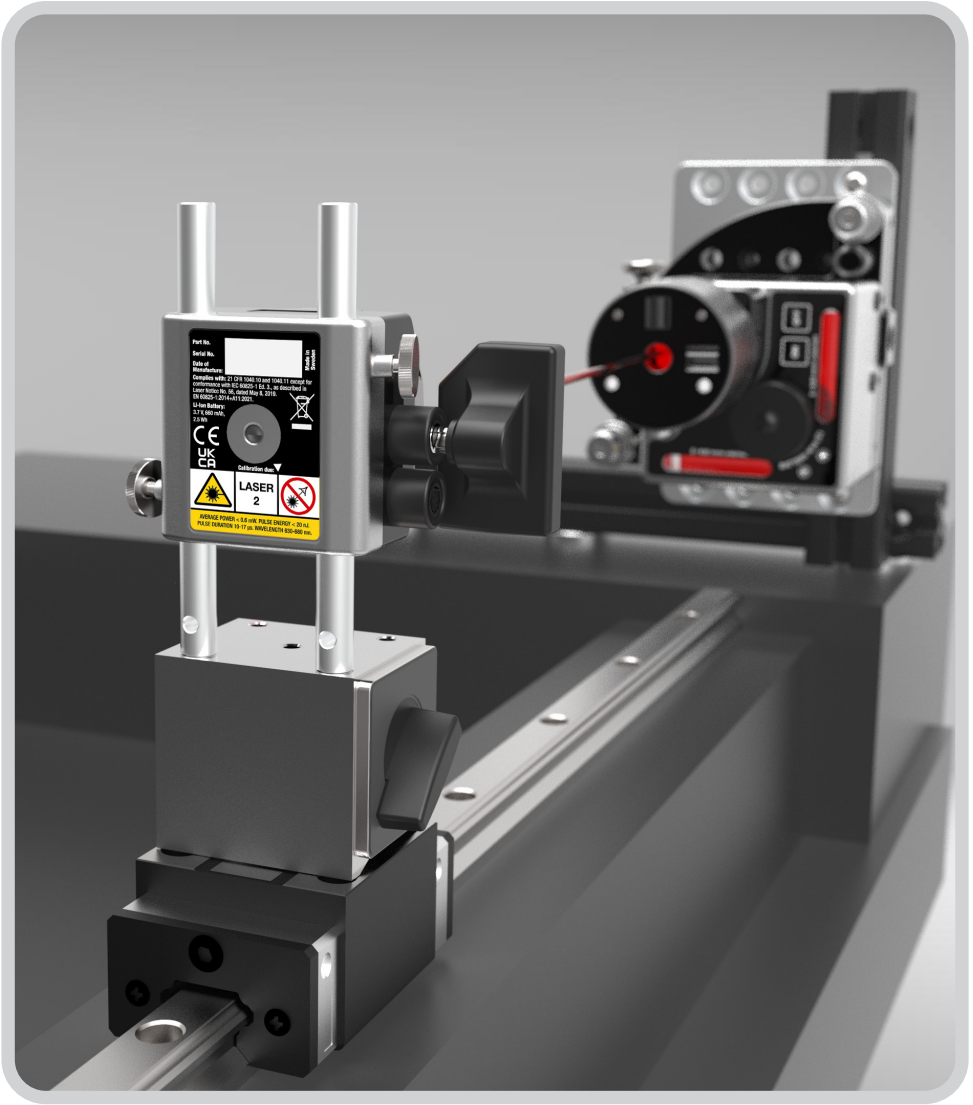
NOTE: The filtering level can be set from 1 to 10. For typical environments, filter level 4 should be sufficient. If your data is unstable above this filter value, this would suggest an unstable environment, which should be addressed.

For more information: go to **Appendix B – Filtering.**

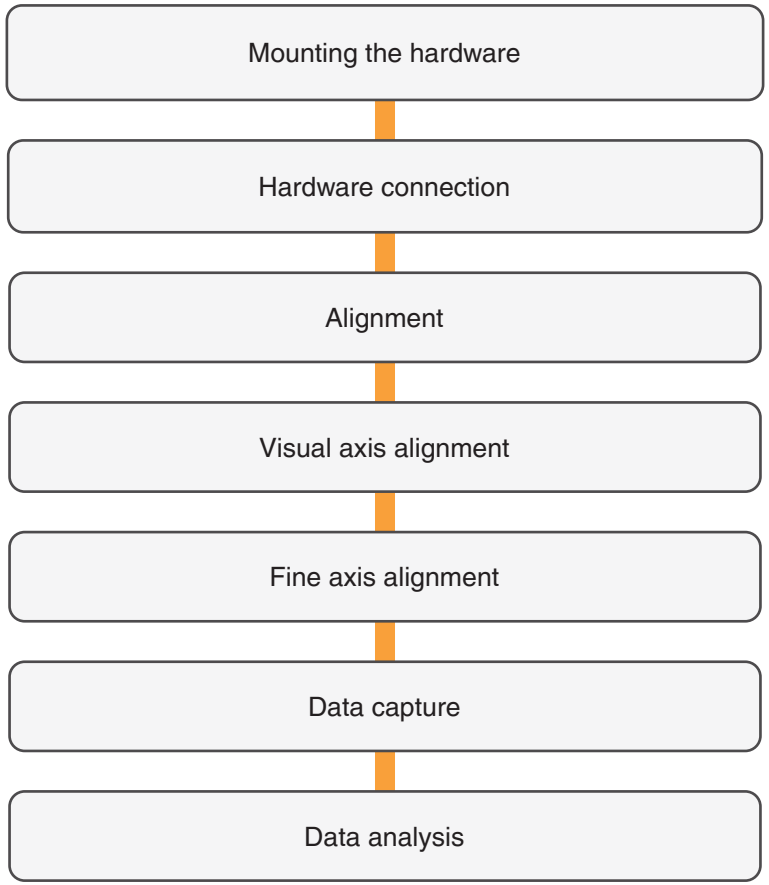


Straightness



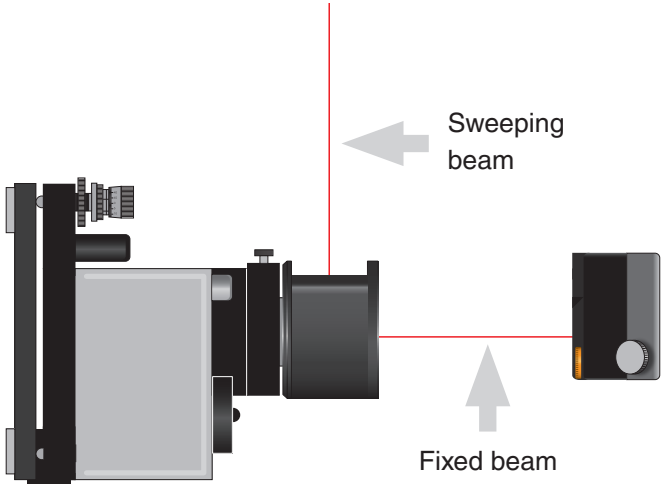


Overview


Mounting the hardware
Hardware connection
Alignment
Visual axis alignment
Fine axis alignment
Data capture
Data analysis

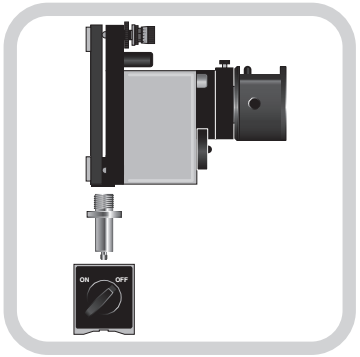
Mounting the hardware

- Straightness measurements are made with the launch unit and the M unit.
- It is recommended to use the fixed beam for straightness measurements, for ease of alignment.

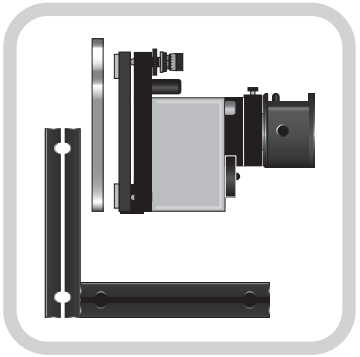


CAUTION: To avoid stripping the thread, do not put the full weight of the launch unit on the threads when screwing in the pin.

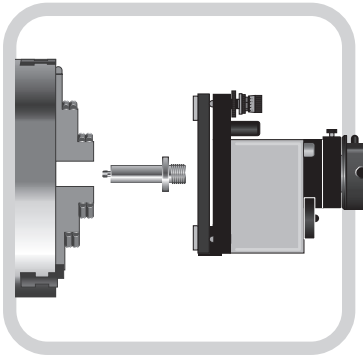
Launch unit



Mounted to a magnetic base.

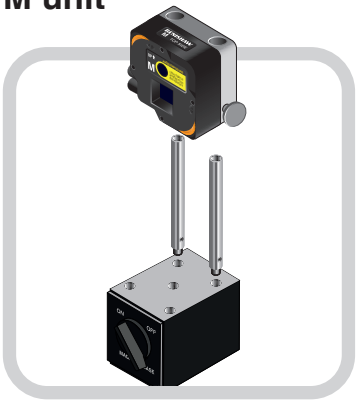


Mounted to the fixturing kit.



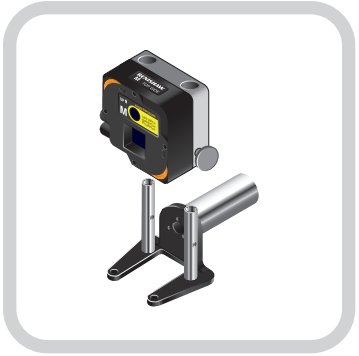
Mounted in the chuck.

M unit



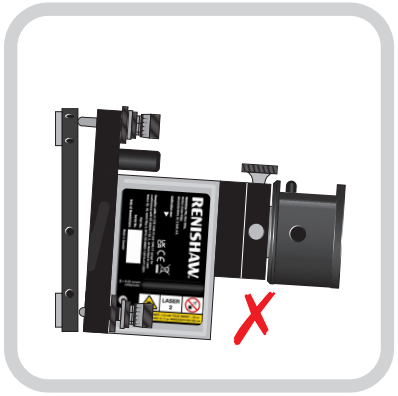
Mounted to a magnetic base.

Mounted to the reference mount.

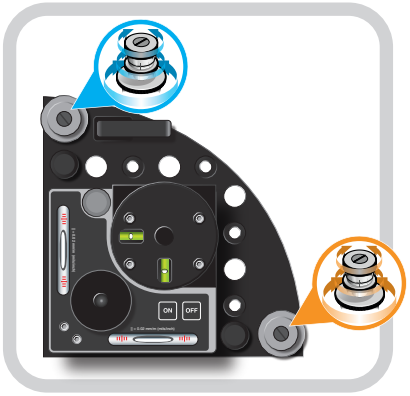


Mounted to the sub-spindle.

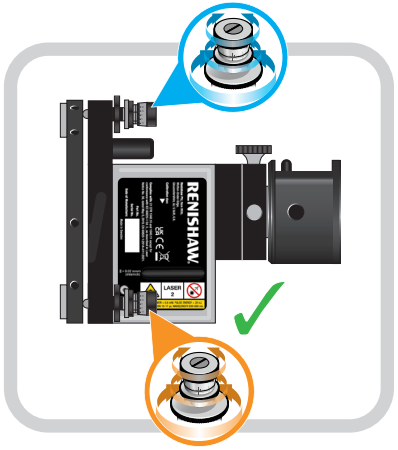
Mounting the hardware – best practice



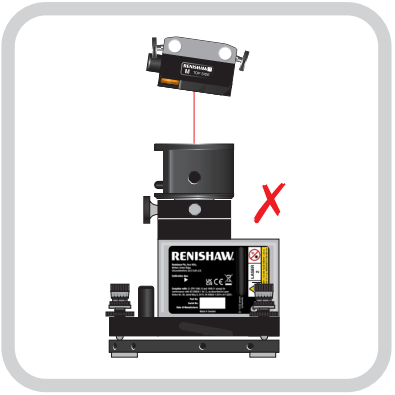
Check that the tilting plate is in the central position.



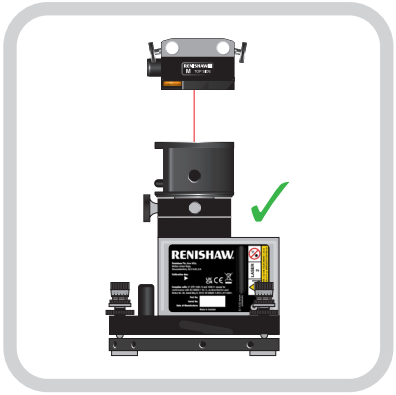
Adjustments can be made to the tilting plate using the pitch/ yaw adjusters.



Adjust until the tilting plate is in the nominal position.



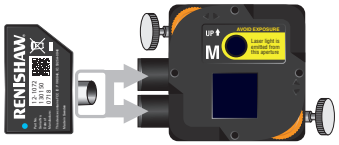
Check that the launch unit and receiver are square to each other.



Adjust the M unit until it is square with the launch unit.

Hardware connection

1



Insert the wireless module into the M unit.

2

Power on the display unit.

3

Select the 'Settings' icon.

4

Select the 'Wireless' icon.

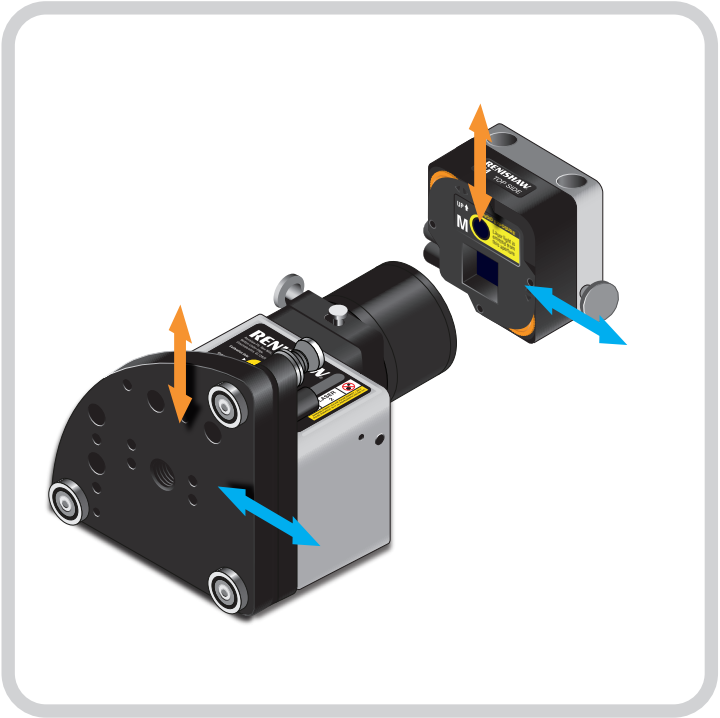
5

Enable the wireless device plugged into the M unit.

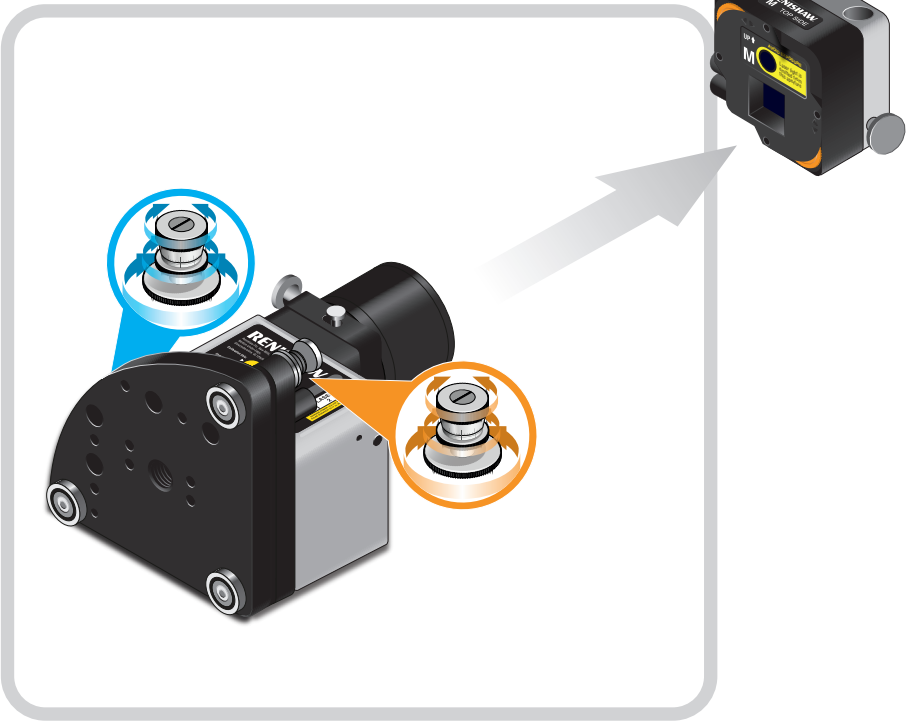
Alignment

This 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.

Basic rules of alignment



When the launch unit and receiver are close to each other = **translation adjustment**.

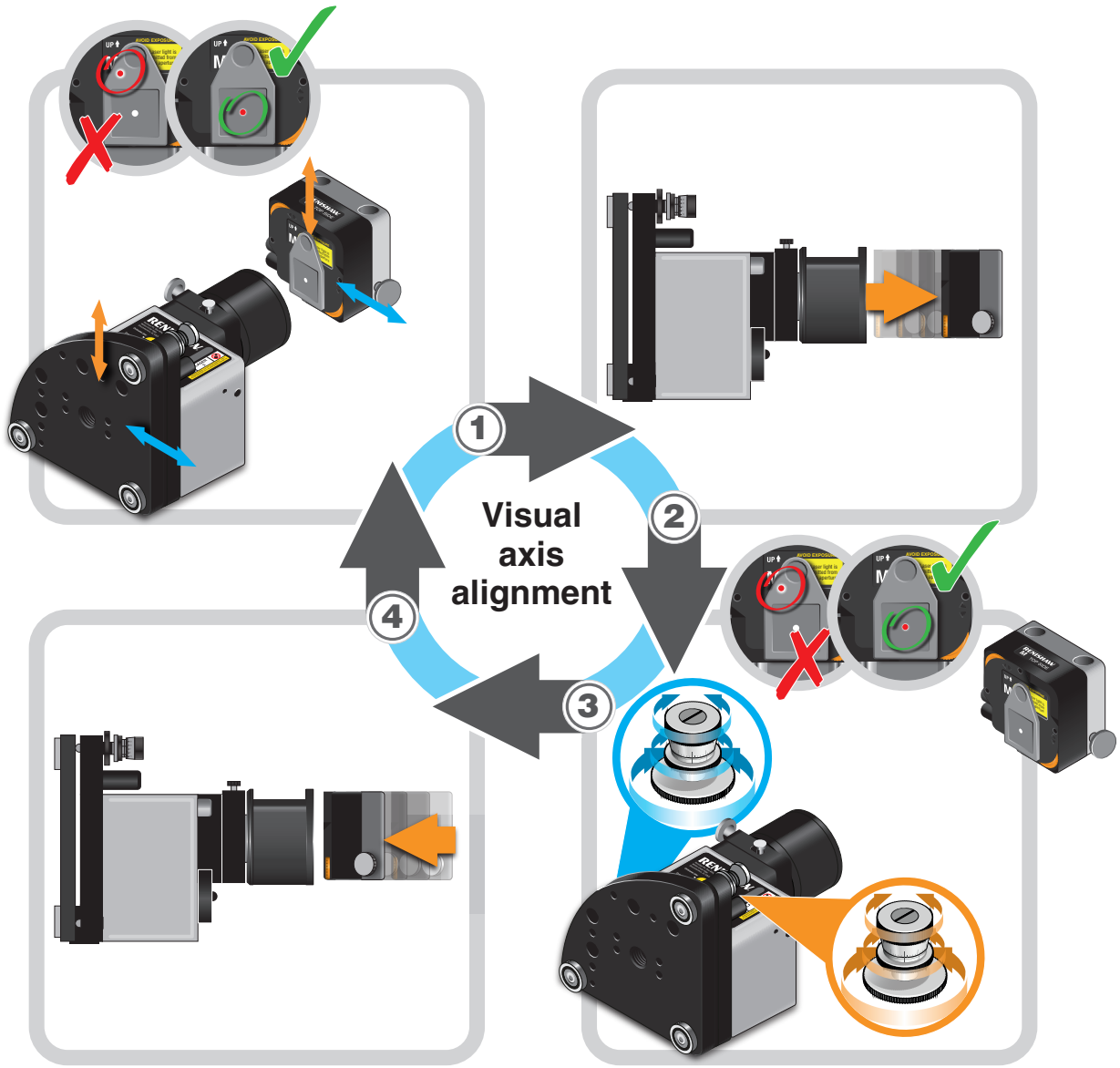


When the launch unit and receiver are far from each other = **rotation adjustment**.

Alignment

Visual axis alignment

Continue the illustrated process until the beam stays on the target along the full axis.



Alignment

Fine axis alignment

1

Remove the target from the M unit.

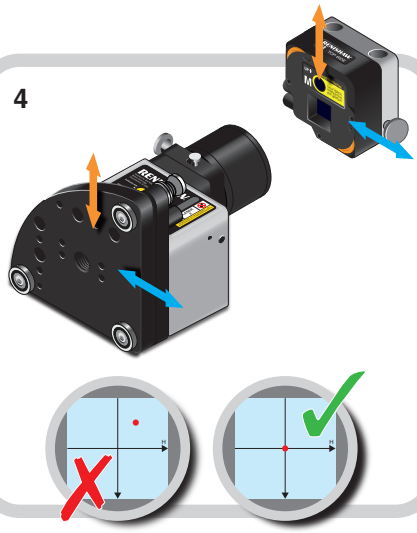
2

Select ‘Straightness’ on the display unit.

3

Select the ‘Show target’ function.

4

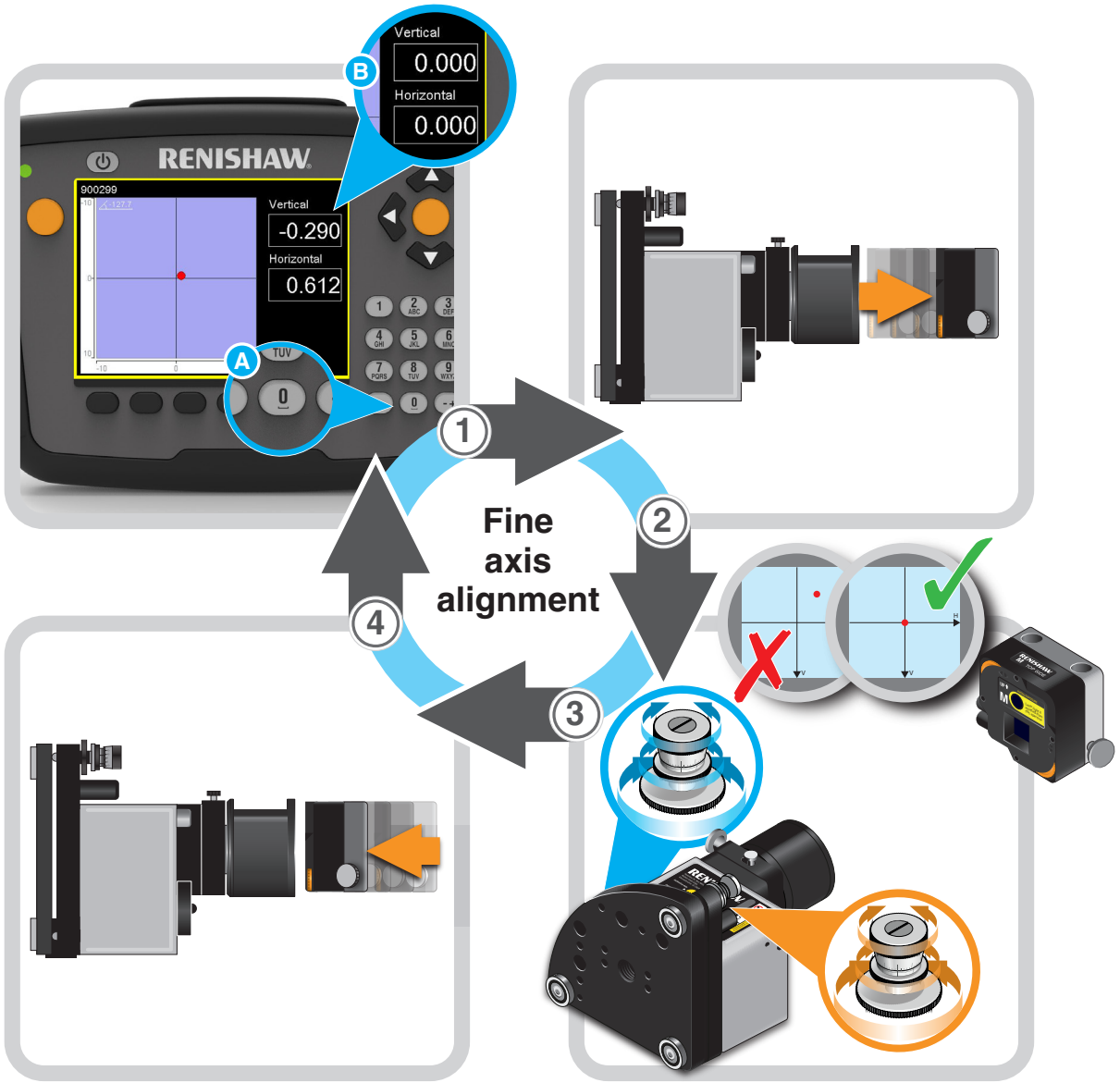


Translate either the launch unit or the M unit close to the centre of the PSD.

Alignment

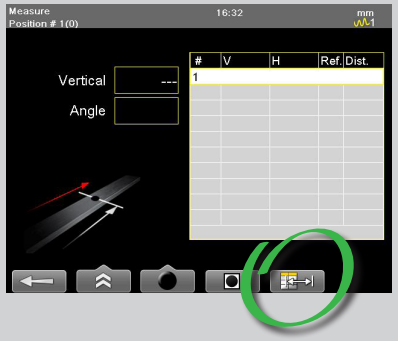
Fine axis alignment

Continue the process shown until the beam stays **within the alignment tolerance (value of ±100 µm)** over the measurement range.



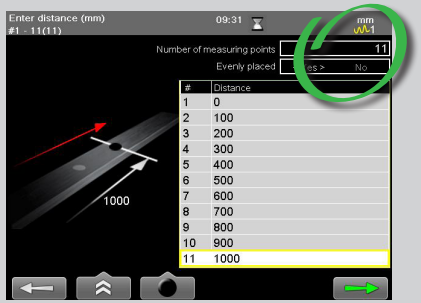
Data capture

1



Select the ‘Tables’ option to enter predefined measurement positions.

2



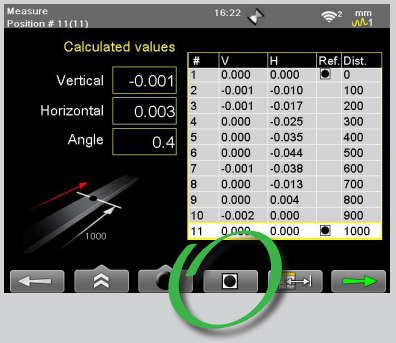
Insert the number of measurement points and spacing, then select the green arrow to proceed to measurement.

3

Capture data at each measurement position.

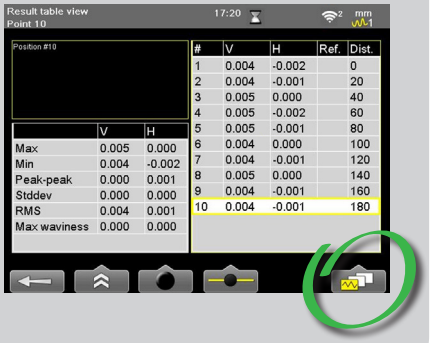
Data analysis

4



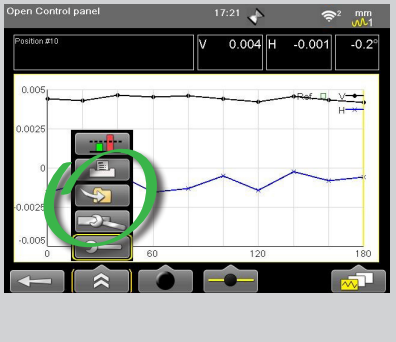
Data can be end point fitted **(see slope error, details on page 44)** by selecting two reference points. Press the green arrow to progress to data analysis.

5



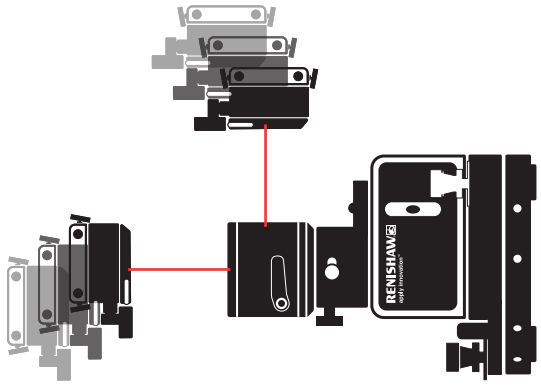
Select the 'Analysis' button to view the data in different formats.

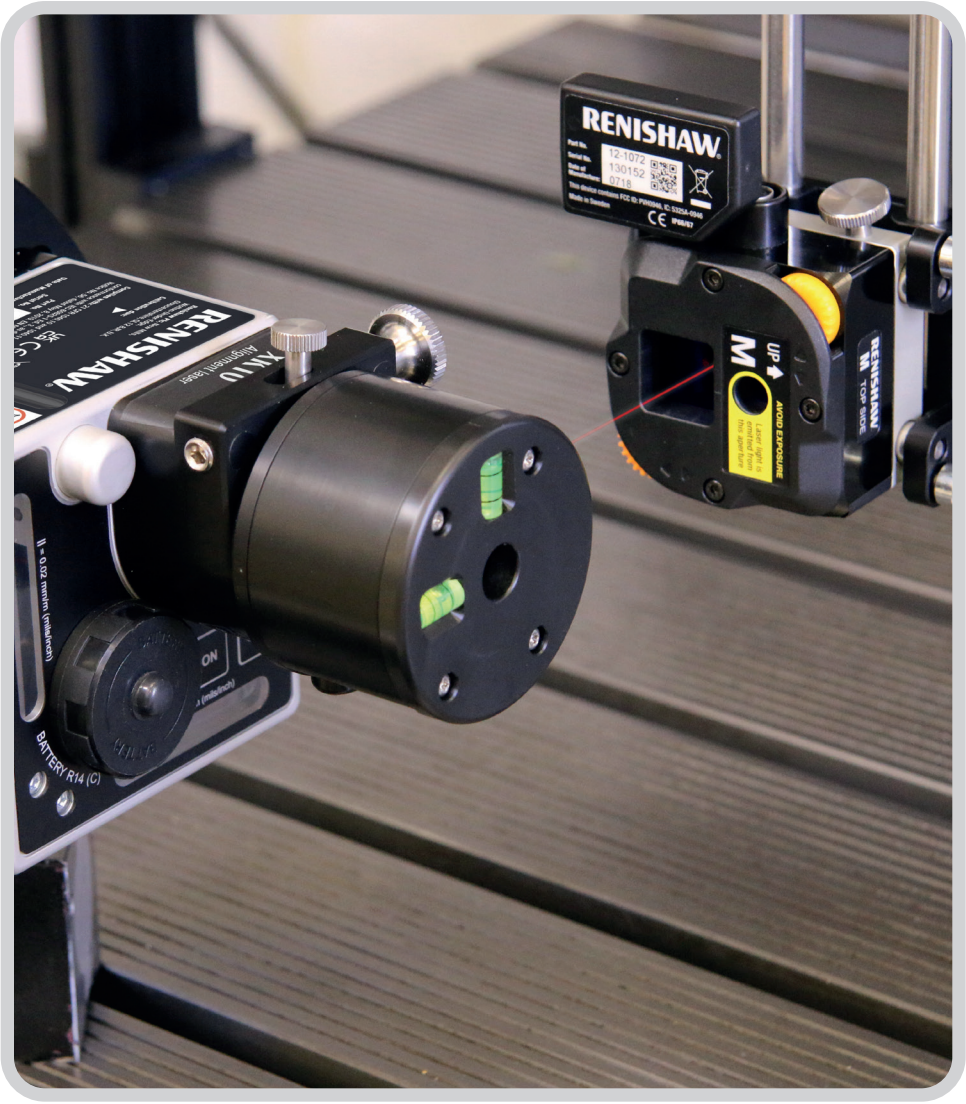
6



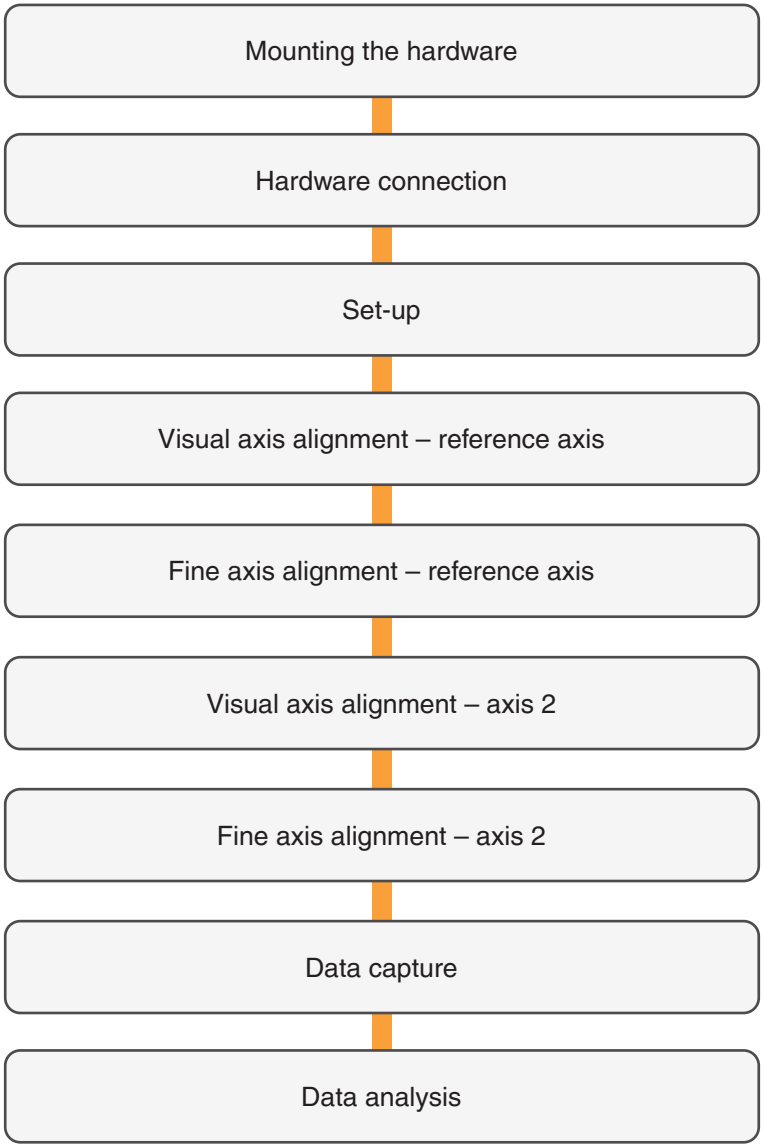
'Save' and assign a file name.

Squareness


RENISHAW

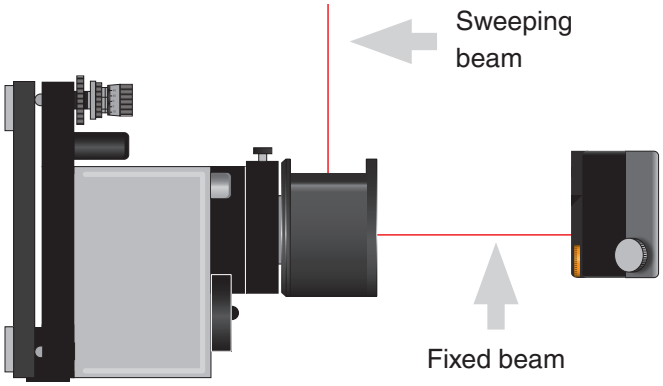

RENISHAW
XK10
Alignment laser
ON
BATTERY R14 (C)
RENISHAW
M
TOP SIDE
UP
AVOID EXPOSURE

Overview


Mounting the hardware
Hardware connection
Set-up
Visual axis alignment – reference axis
Fine axis alignment – reference axis
Visual axis alignment – axis 2
Fine axis alignment – axis 2
Data capture
Data analysis

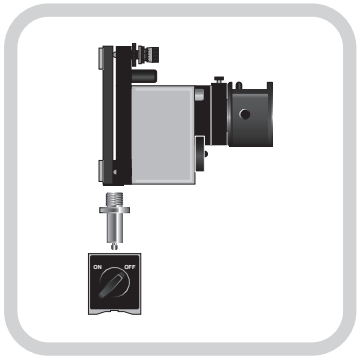
Mounting the hardware

- Squareness measurements are made with the launch and M unit.
- The fixed beam should be used for the first axis/ reference.
- The sweeping beam is used for the second axis.

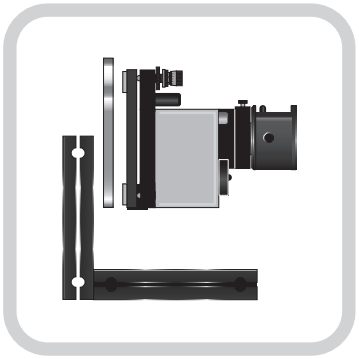


CAUTION: To avoid stripping the thread, do not put the full weight of the launch unit on the threads when screwing in the pin.

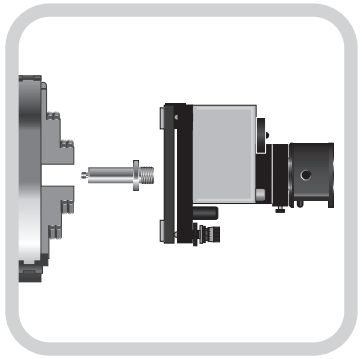
Launch unit



Mounted to a magnetic base.

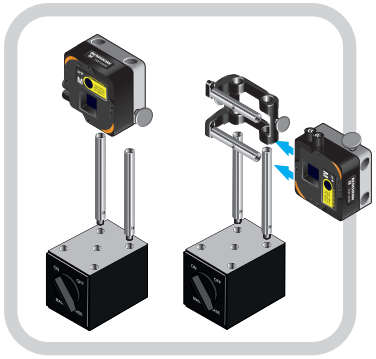


Mounted to the fixturing kit.



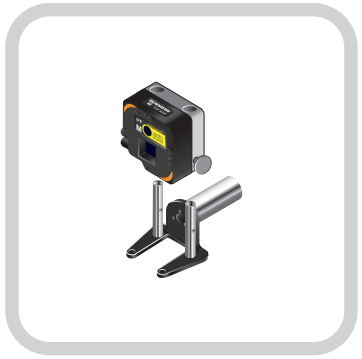
Mounted in the chuck.

M unit



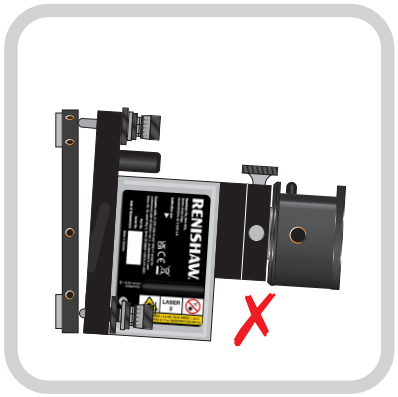
Mounted to a magnetic base.

Mounted to the reference mount.

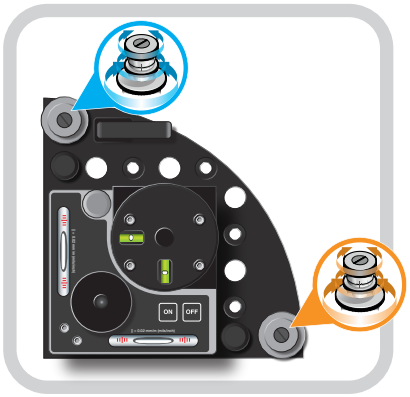


Mounted to the sub-spindle.

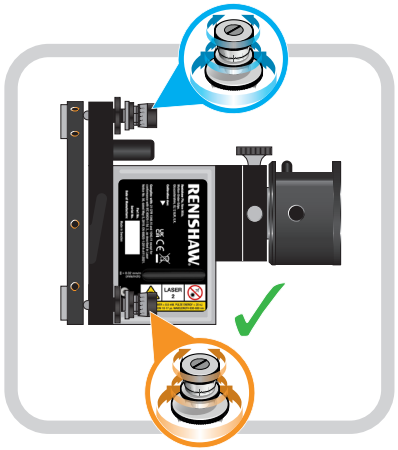
Mounting the hardware – best practice



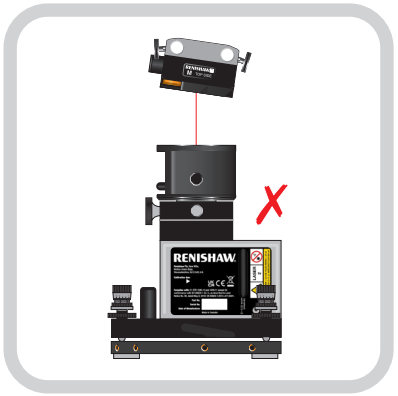
Check that the tilting plate is in the central position.



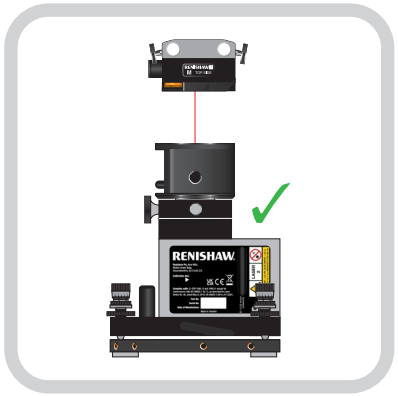
Adjustments can be made to the tilting plate using the pitch/ yaw adjusters.



Adjust until the tilting plate is in the nominal position.



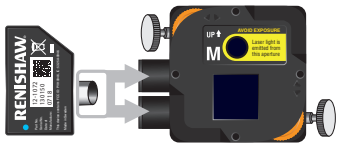
Check that the launch unit and receiver are square to each other.



Adjust the M unit until it is square with the launch unit.

Hardware connection

1



Insert the wireless module into the M unit.

2

Power on the display unit.

3

Select the 'Settings' icon.

4

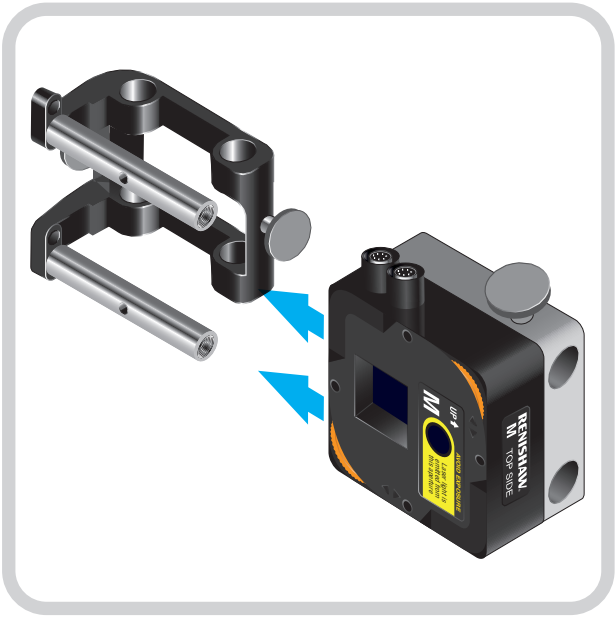
Select the 'Wireless' icon.

5

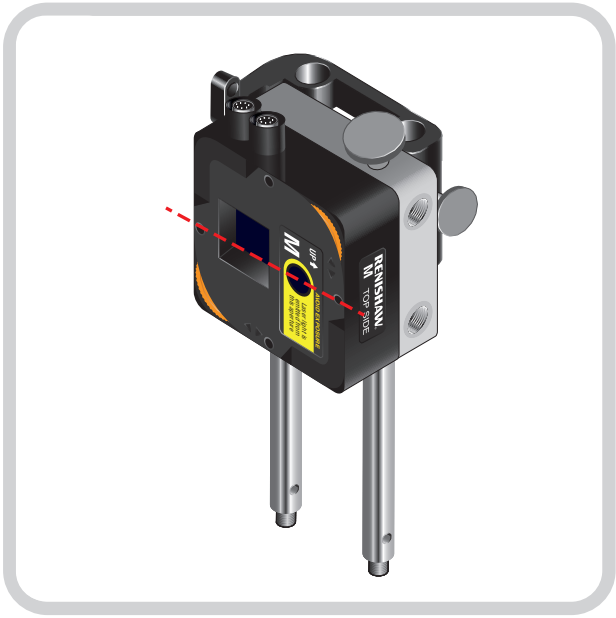
Enable the wireless device plugged into the M unit.

Set-up

The default setting in the squareness mode is to measure deviations along the vertical axis of the PSD. This guide follows that set-up.



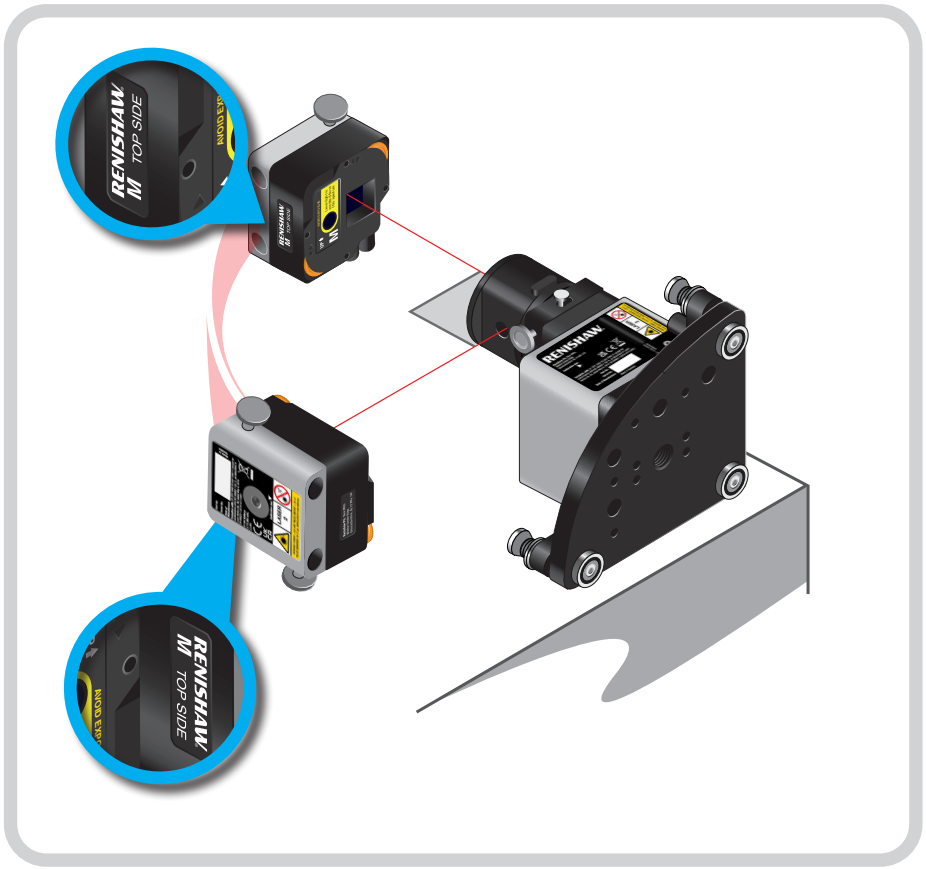
The supplied 90 degree bracket can be used to suitably orientate the M unit.



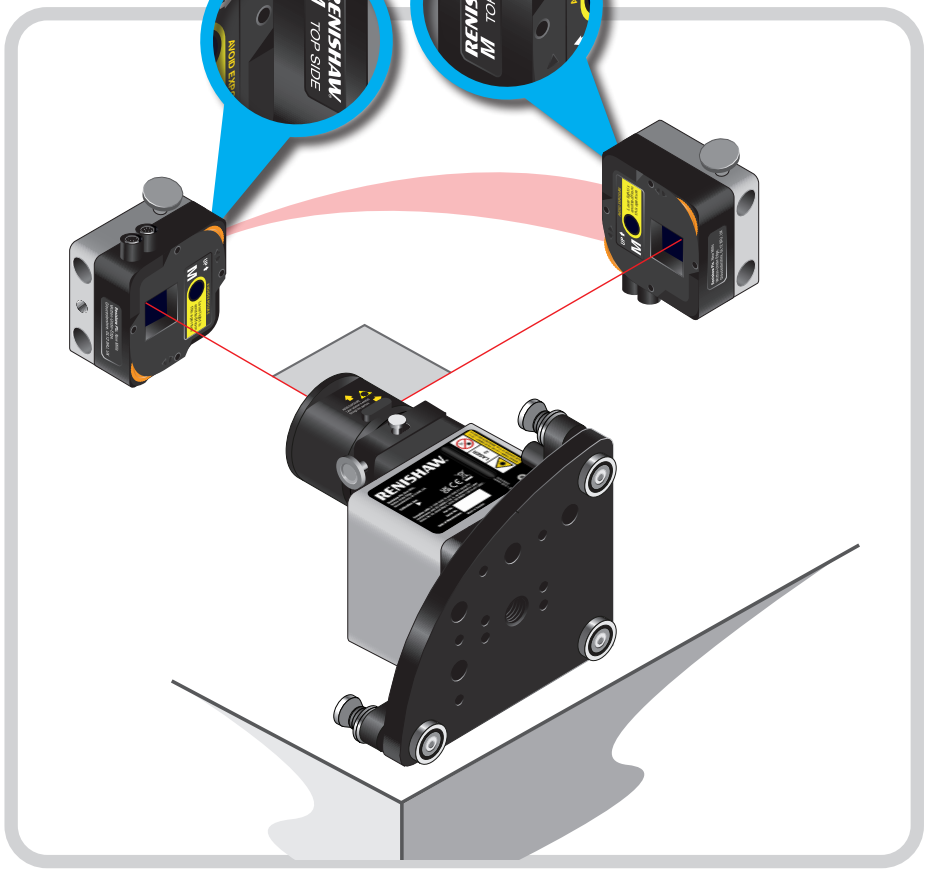
The 90 degree orientated set-up of the M unit. The red line indicates the direction of the unit.

Set-up requirements – horizontal

The M unit should be set up so that the **TOP SIDE** label faces **into** the angle.



Horizontal plane set-up 1

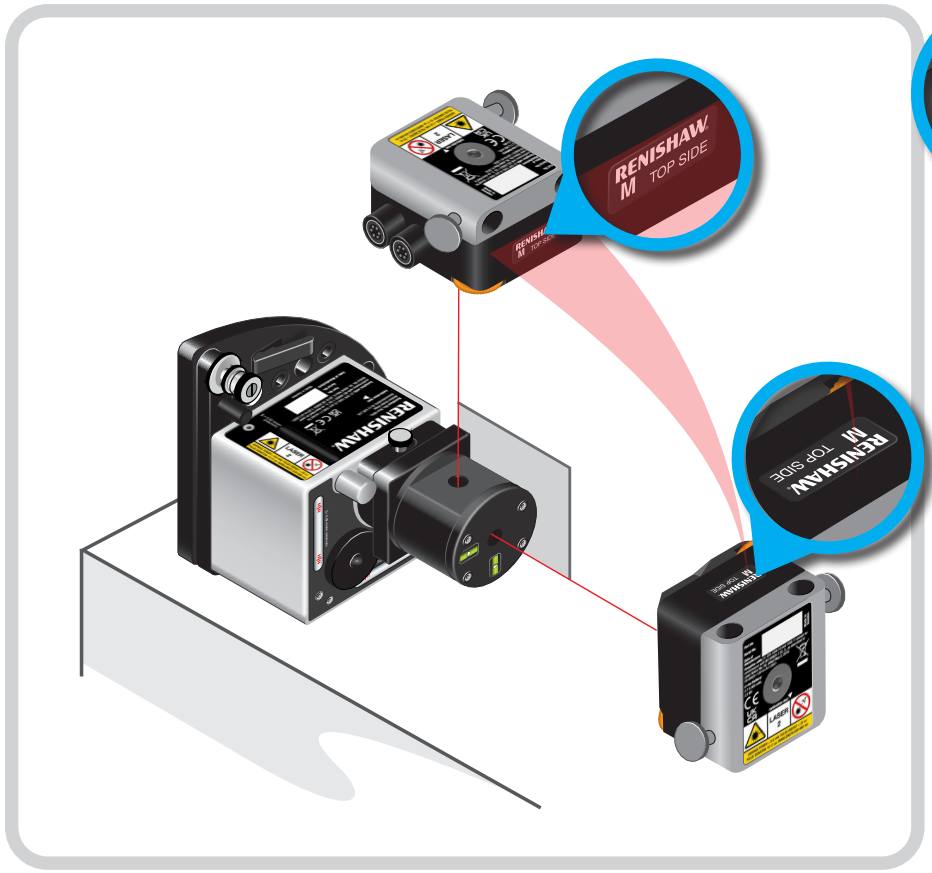


Horizontal plane set-up 2

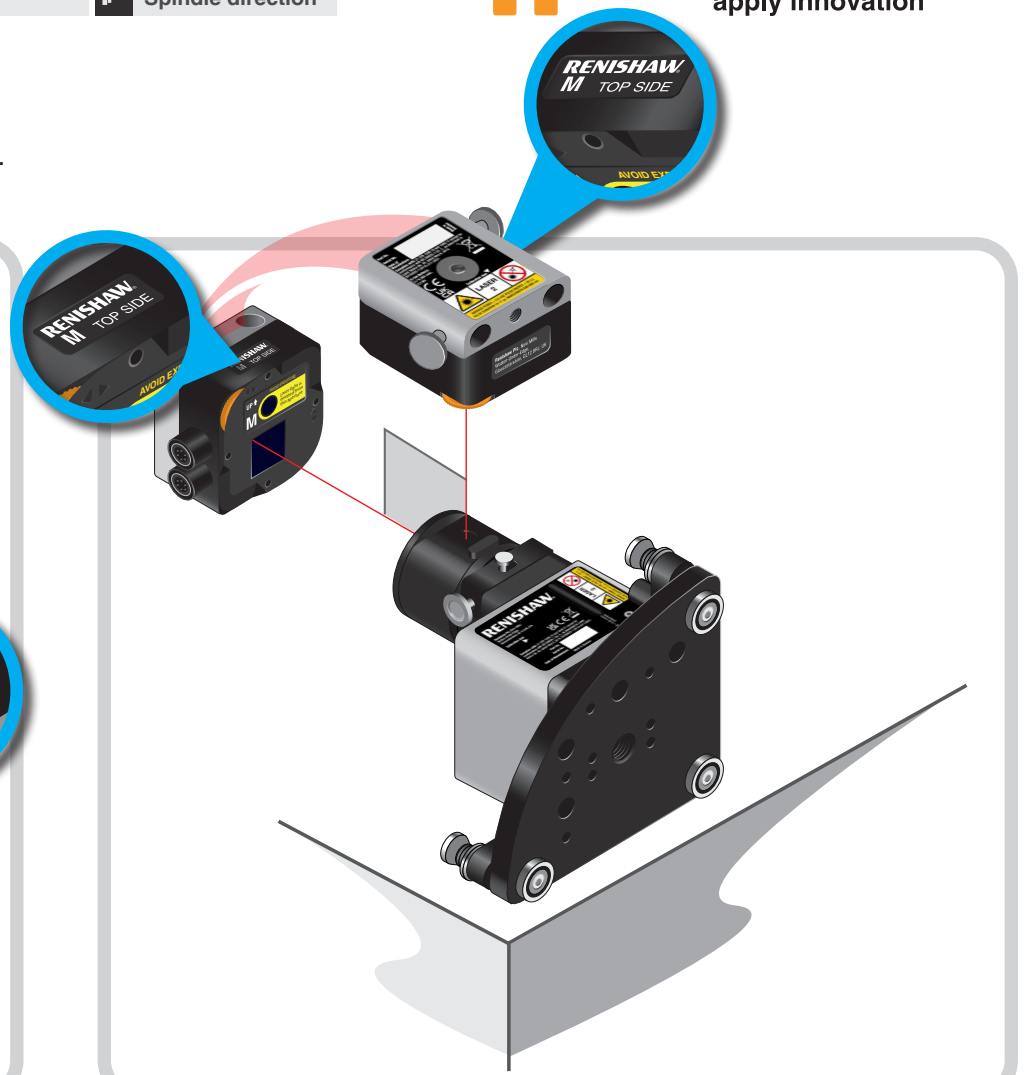
NOTE: If measuring using the H values of the PSD, the Bluetooth dongle should face into the angle.

Set-up requirements – vertical

The M unit should be set up so that the **TOP SIDE** label faces into the angle.



Vertical plane set-up 1

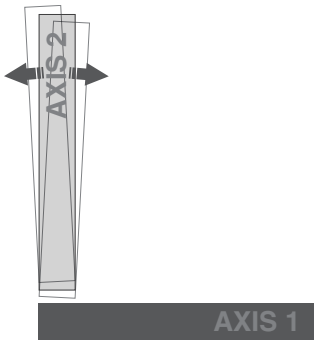


Vertical plane set-up 2

NOTE: If measuring using the H values of the PSD, the Bluetooth dongle should face into the angle.

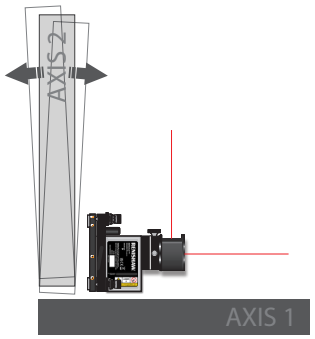
Set-up

1



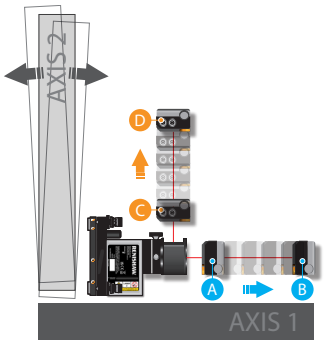
If making adjustments to machine squareness, identify which axis can be adjusted. This would be axis 2 in the software.

2



Mount the launch unit so that the fixed beam travels along the reference axis (axis 1) and the sweeping beam travels along axis 2.

3

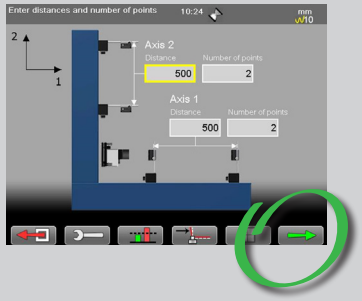


Using the supplied tape measure, measure the distance between the first and last measurement positions for A to B and C to D.

4

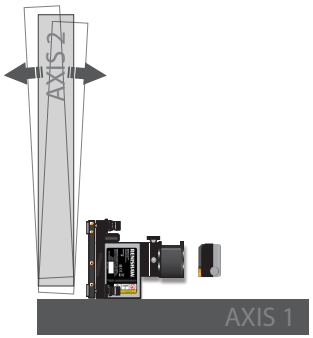
Select the 'Squareness' mode on the display unit.

5



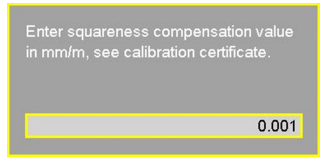
Input the distances for A to B and C to D. Select the green arrow.

6



Mount the M unit at the first measurement position for axis 1.

NOTE: When first using the 'Squareness' mode, a prompt to input the 'Squareness compensation value' will appear. Refer to the calibration certificate for this value.

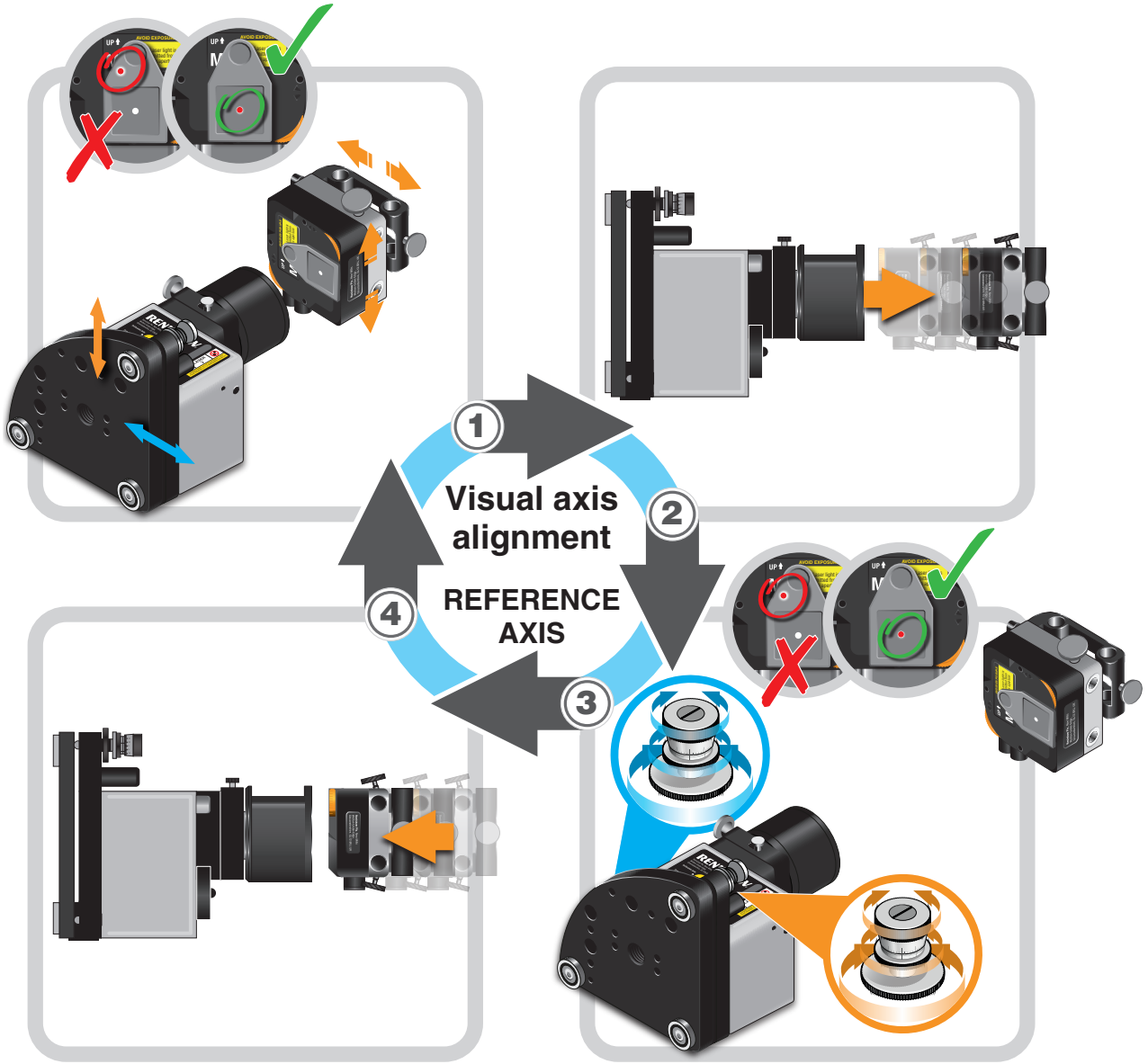


Alignment

Visual axis alignment – reference axis

Continue the process shown until the fixed beam stays on the target along the full length of axis 1.

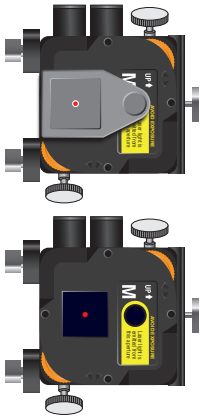
NOTE: M unit orientation will vary according to test set-up.



Alignment

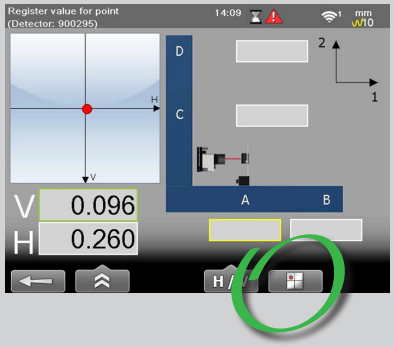
Fine axis alignment – reference axis

1



With the M unit at the first measurement position, remove the target cap from the M unit.

2



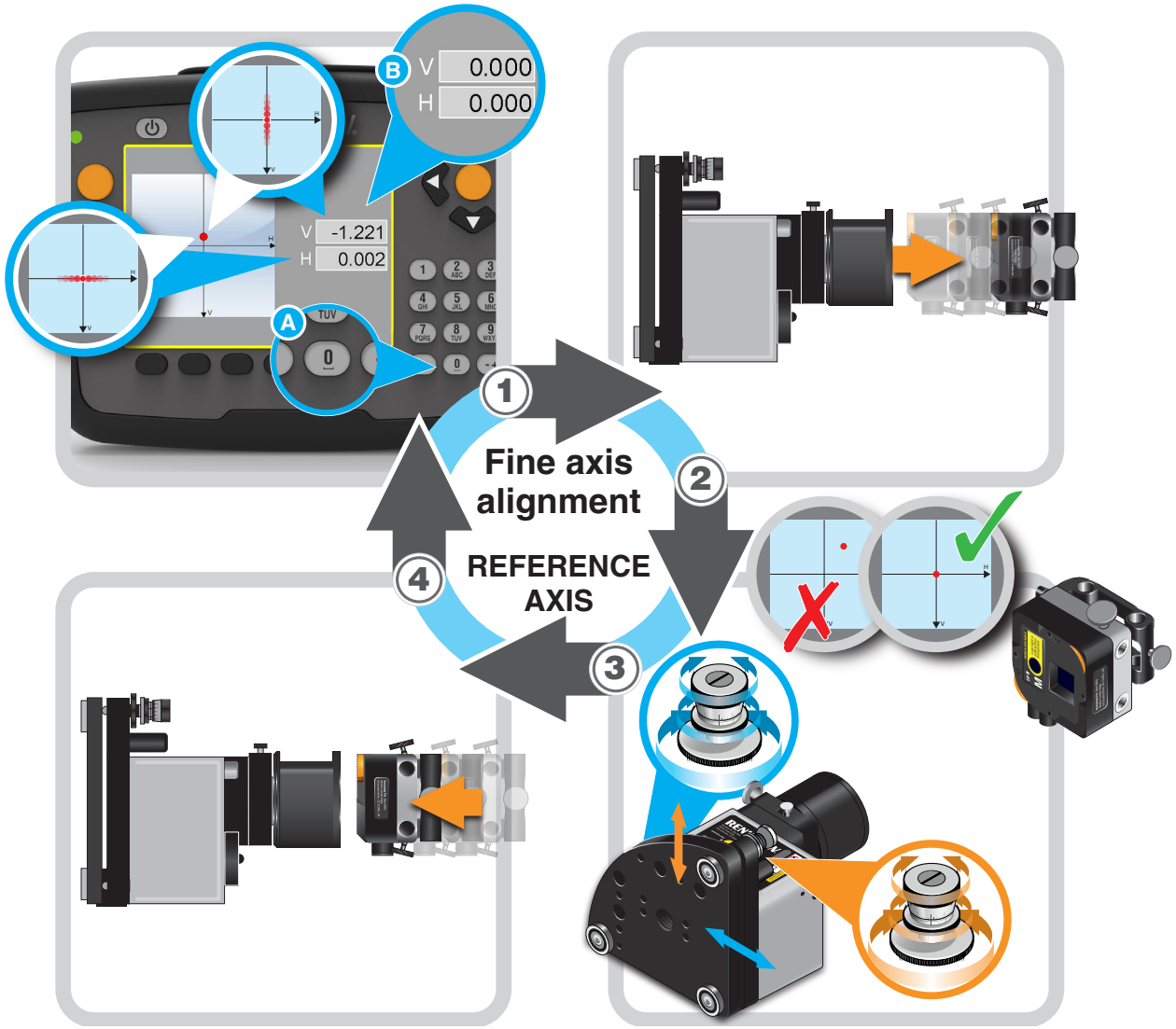
Select the 'Show target' view from within squareness mode.

NOTE: The PSD axis can be selected by pressing the H/V button.

Alignment

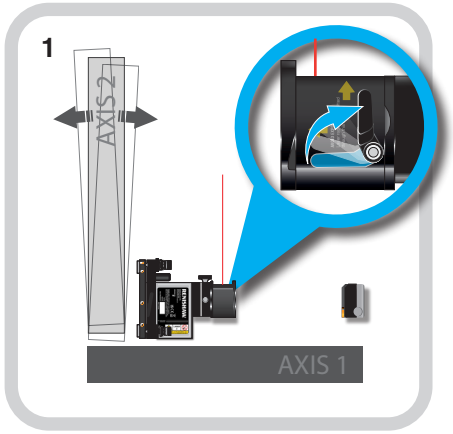
Fine axis alignment – reference axis

Continue the process shown until the beam stays **within the alignment tolerance (value of ±100 µm)** over the measurement range.

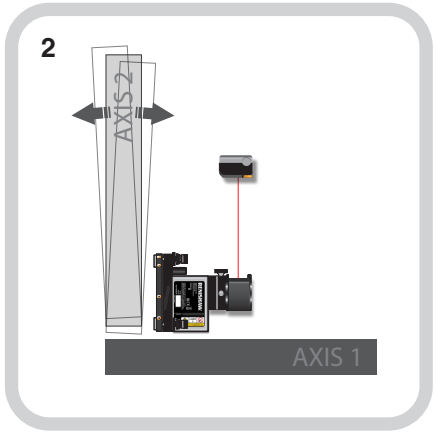


Alignment

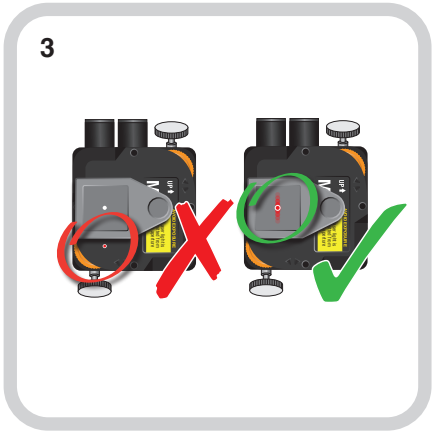
Visual axis alignment – axis 2



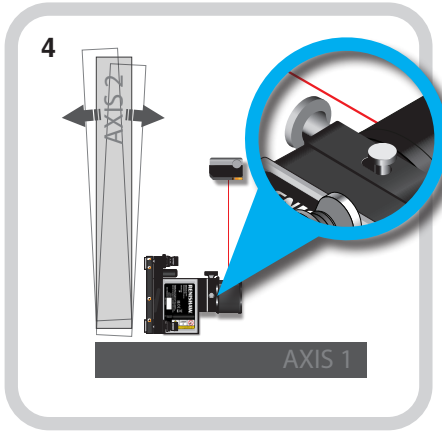
Flip the pentaprism.



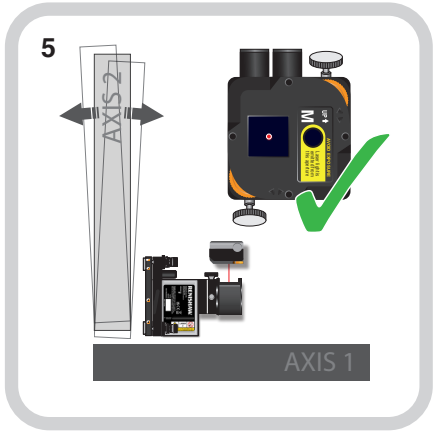
Move the M unit to the last measurement position of axis 2.



Add a target to the M unit and rotate the sweeping beam onto the centre of the target.



Lock the sweeping beam in place using the thumbscrew.

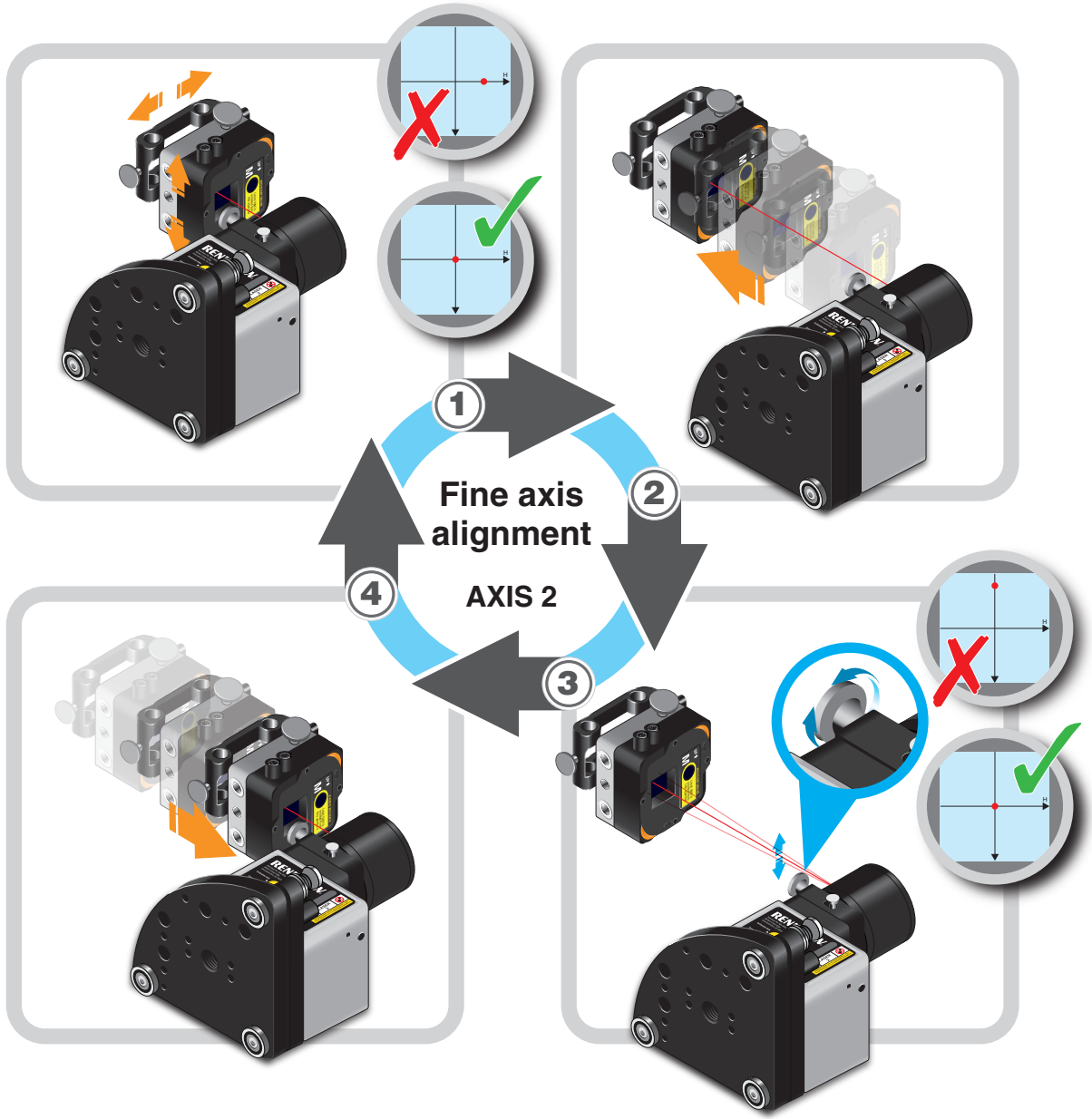


Move the M unit to the first measurement position of axis 2 and remove the target.

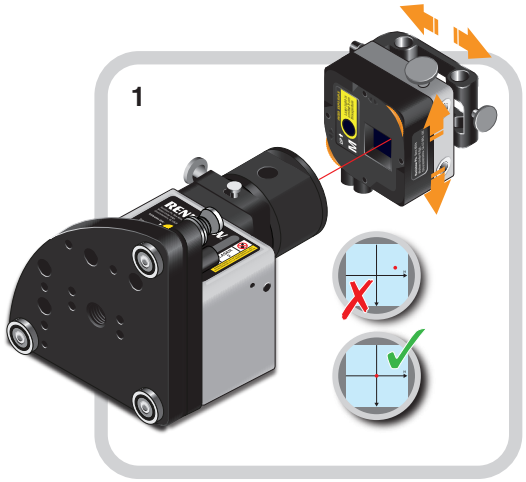
Alignment

Fine axis alignment – axis 2

Continue the process shown until the sweeping beam is **within the alignment tolerance (value of ±100 µm)** along the full length of axis 2.

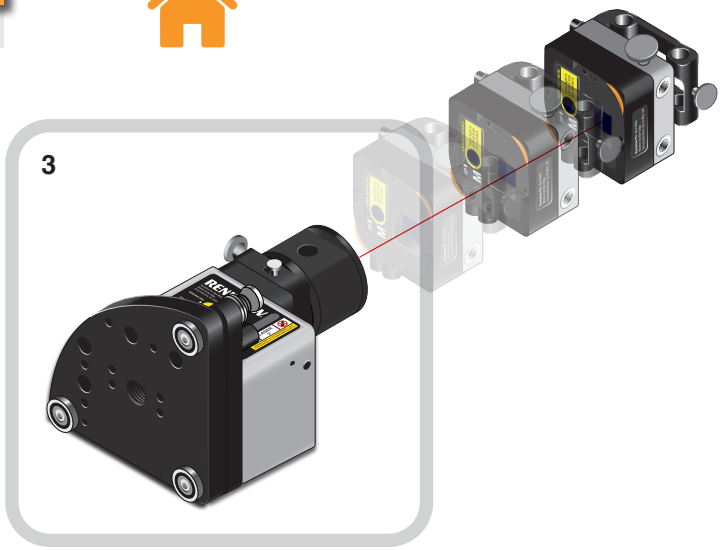


Data capture



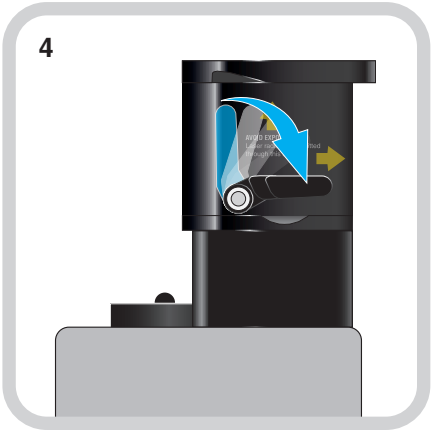
Move the M unit to measurement position A. Switch to the fixed beam and translate the M unit to within ±1 mm of the centre of the PSD.

Capture data by pressing the orange button on the display unit.

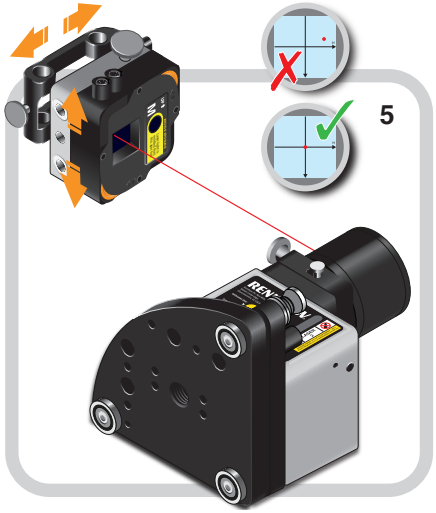


Move to position B and capture data.

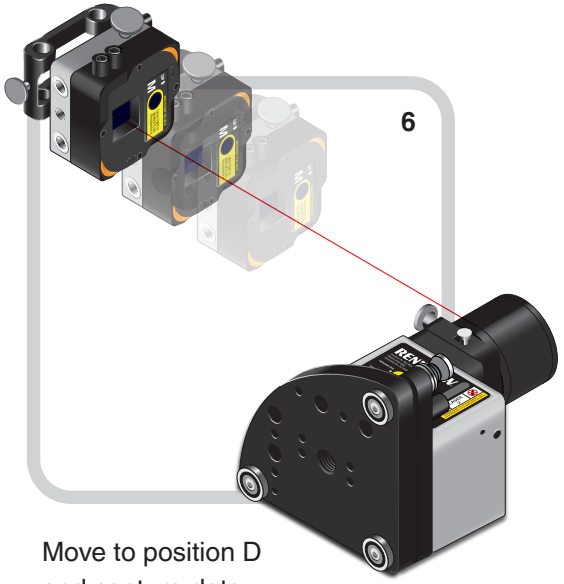
NOTE: See **page 72** for the axis diagram.



Switch to the sweeping beam.

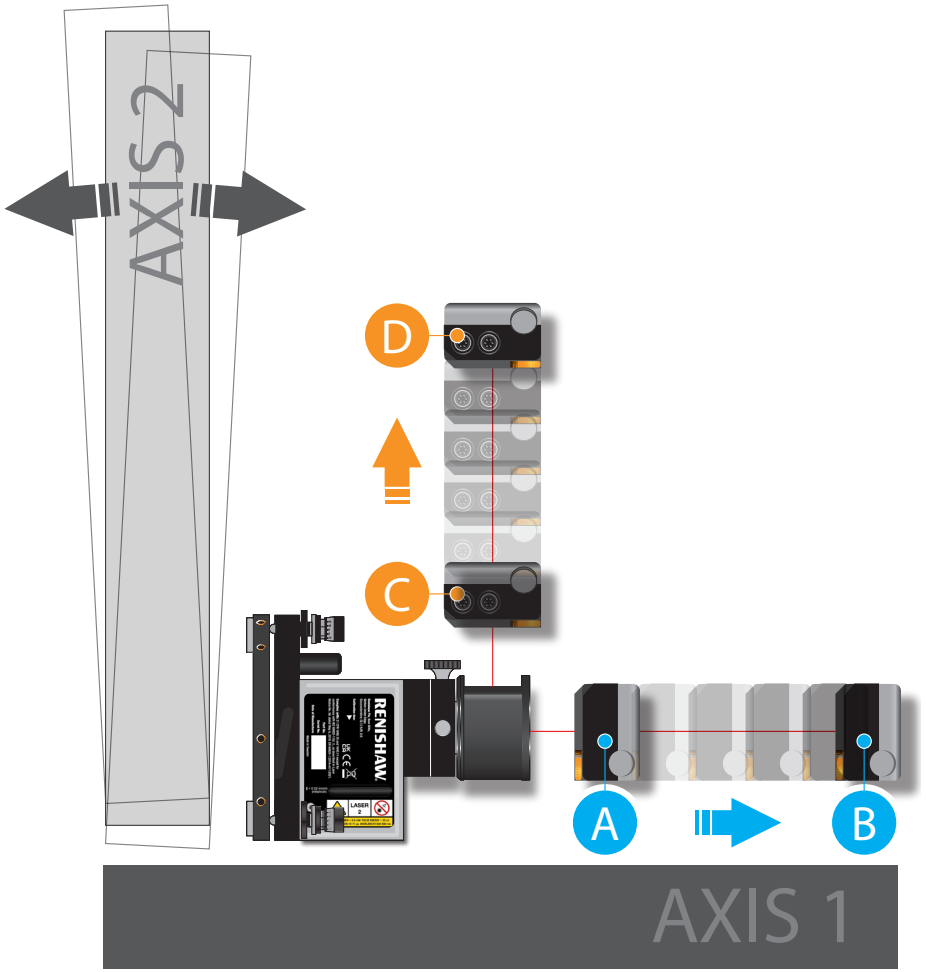


Move the M unit to position C and translate it to within ±1 mm of the centre of the PSD. Capture data.



Move to position D and capture data.

Axis diagram



Data analysis

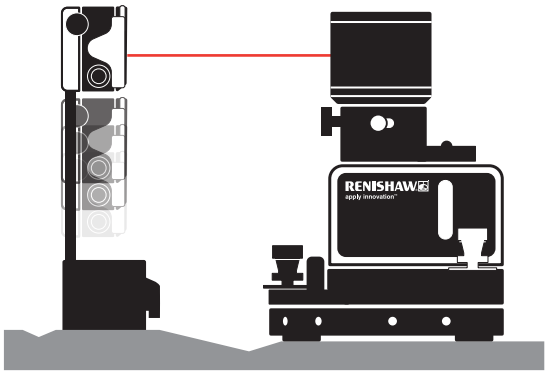
7

After completing measurements, results will be automatically displayed.

8

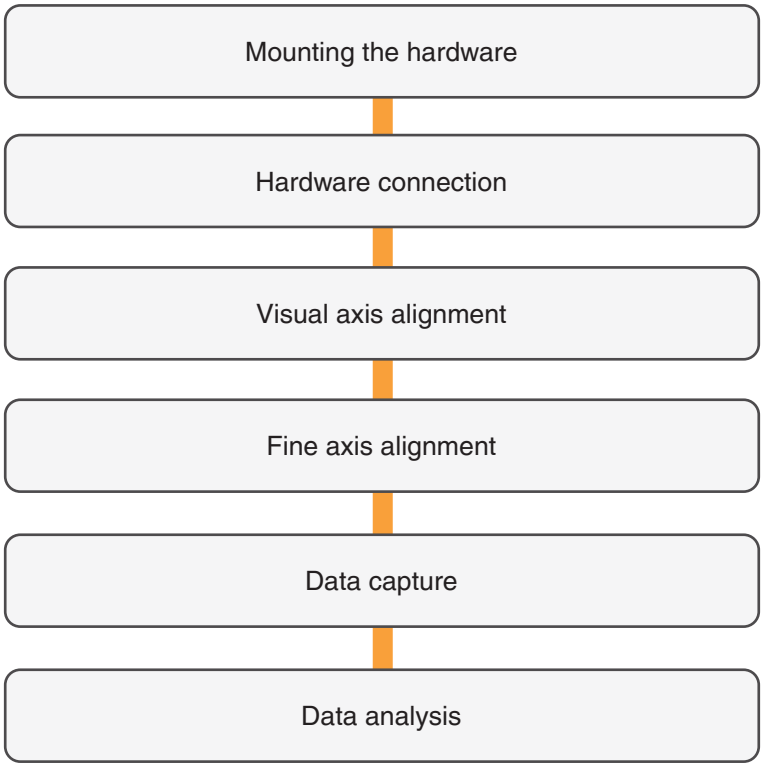
Data can now be saved.

Flatness


RENISHAW
apply innovation™

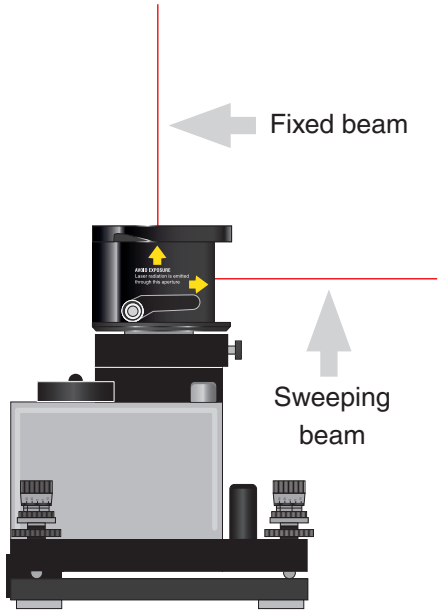

AVOID EXPOSURE
Laser radiation is emitted through this aperture
XK10
Alignment laser
RENISHAW
LASER 2
UP
M
AVOID EXPOSURE

Overview


Mounting the hardware
Hardware connection
Visual axis alignment
Fine axis alignment
Data capture
Data analysis

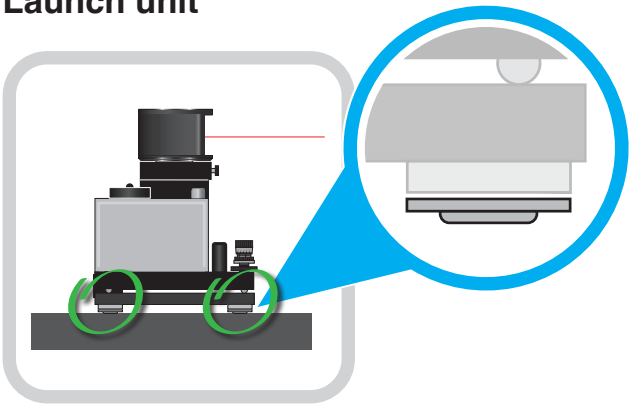
Mounting the hardware

- Flatness measurements are made with the launch unit and the M unit.
- The sweeping beam is used for flatness measurements.



CAUTION: To avoid stripping the thread, do not put the full weight of the launch on the threads when screwing in the pin.

Launch unit



Non-magnetic feet can be used on non-ferrous surfaces, for example, granite tables.

Mounted to the surface of measurement.

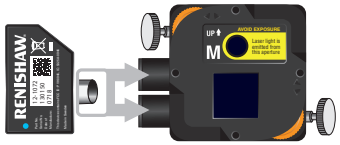
M unit

Mounted on the rotational magnetic base.

Mounted to the reference mount, on the rotational element.

Hardware connection

1



Insert the wireless module into the M unit.

2

Power on the display unit.

3

Select the 'Settings' icon.

4

Select the 'Wireless' icon.

5

Enable the wireless device plugged into the M unit.

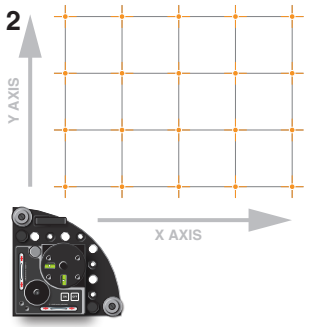
Alignment

Visual axis alignment

1

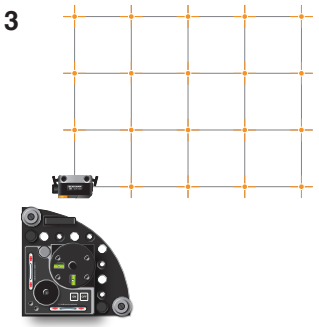
Position the laser launch in one corner of the surface.

2



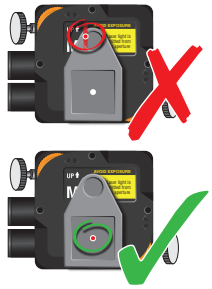
Mark out your grid on the surface to be measured.

3



Move the M unit to X1 Y1.

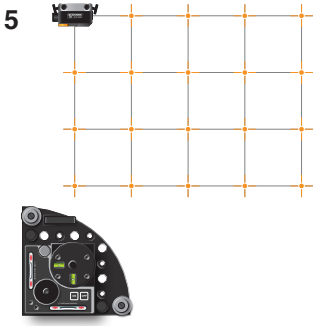
4



Adjust the height of the M unit on the pillars so that the beam aligns with the centre of the target.

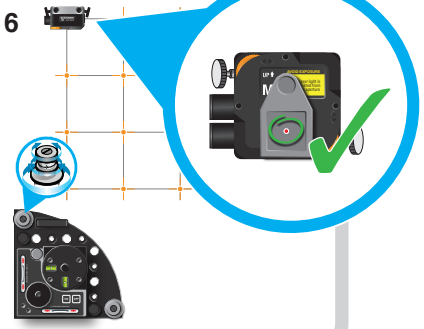
Repeat **steps 3-8** until beam remains on the centre of the target in all locations

5



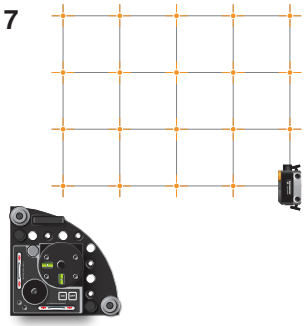
Move the M unit to X1 YMAX.

6



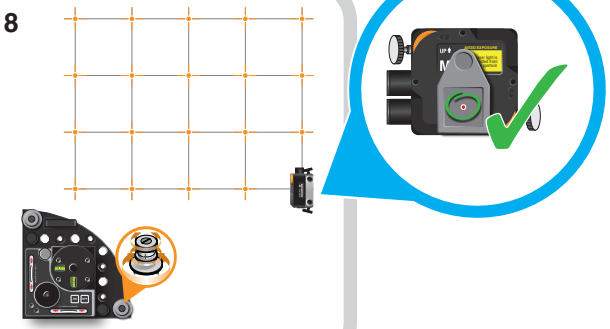
Align the beam onto the centre of the target by rotating the sweeping beam for horizontal alignment and use the pitch/ yaw adjusters for vertical alignment.

7



Move the M unit to XMAX Y1.

8



Align the beam onto the centre of the target by rotating the sweeping beam for horizontal alignment and use the pitch/ yaw adjusters for vertical alignment.

Alignment

Fine axis alignment

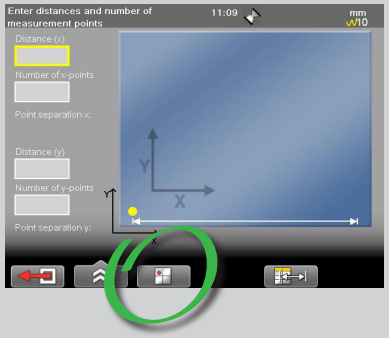
1

With the M unit at X1 Y1, remove the target.

2

Select 'Flatness'.

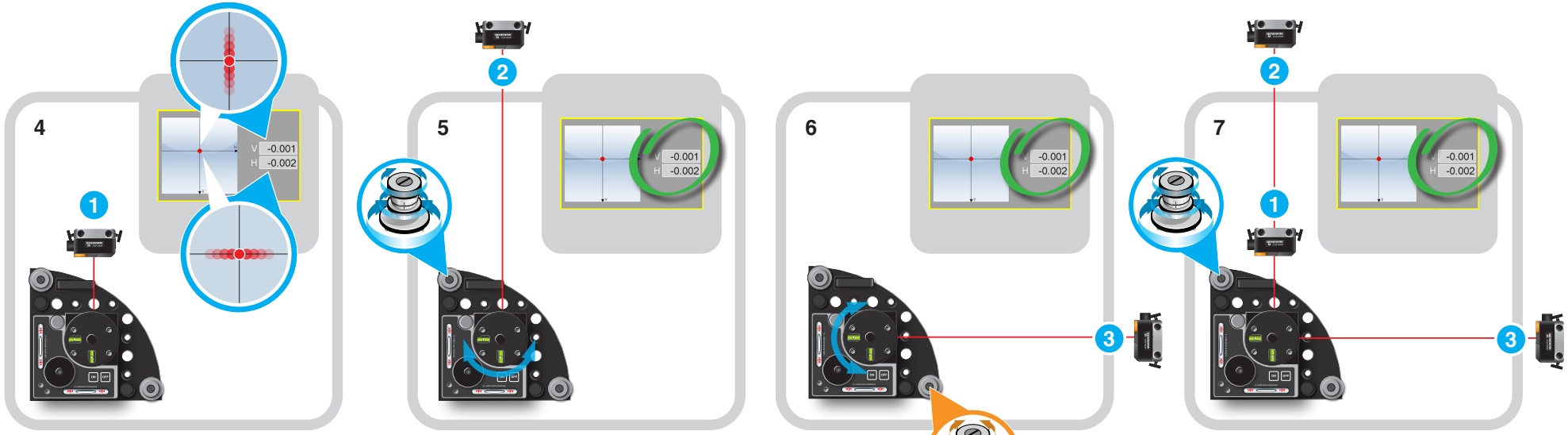
3



Select 'Show target'.

Alignment

Fine axis alignment



Press 'Zero' to datum at X1 Y1.

Move the M unit to X1 YMAX. Rotate the sweeping beam so that the H value is ±1 mm. **Adjust the V value within alignment tolerance*.**

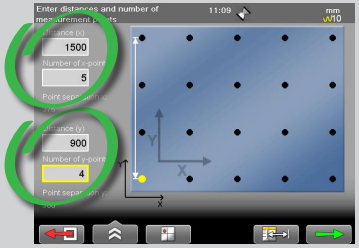
Move the M unit to XMAX Y1. Rotate sweeping beam so that the H value is ±1 mm. **Adjust V value within the alignment tolerance*.**

Repeat the alignment process until the vertical alignment at all three points is **within the alignment tolerance*.**

NOTE: *value of ±100 µm

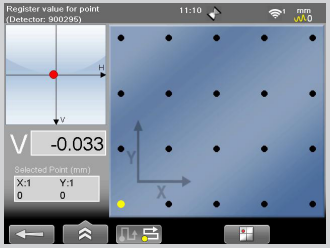
Data capture

1



Enter the grid size and the number of points in each axis.

2

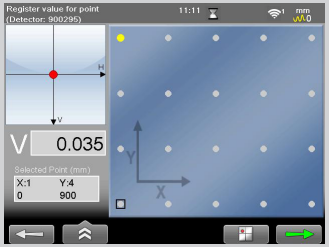


Move the detector to the highlighted position and rotate the sweeping beam to within ±1 mm of the centre of the PSD.

3

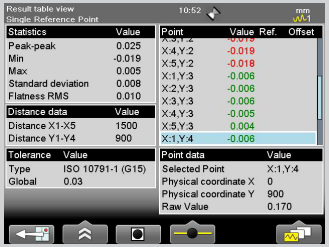
Capture data.

4



Repeat for each position on the grid.

5



Results are displayed after all points have been captured.

NOTE: The order of the captured positions can be changed by using the navigation arrows.

Data analysis

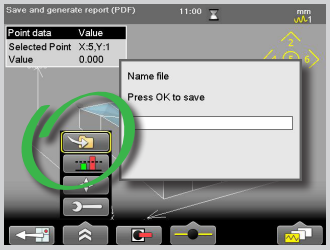
6

The results can be viewed in different formats.

7

A datum plane can be created by selecting three reference points.

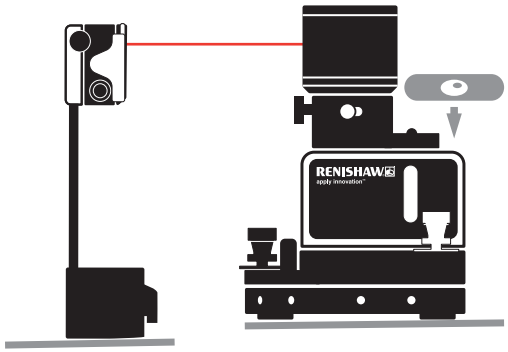
8



'Save' and assign a file name.

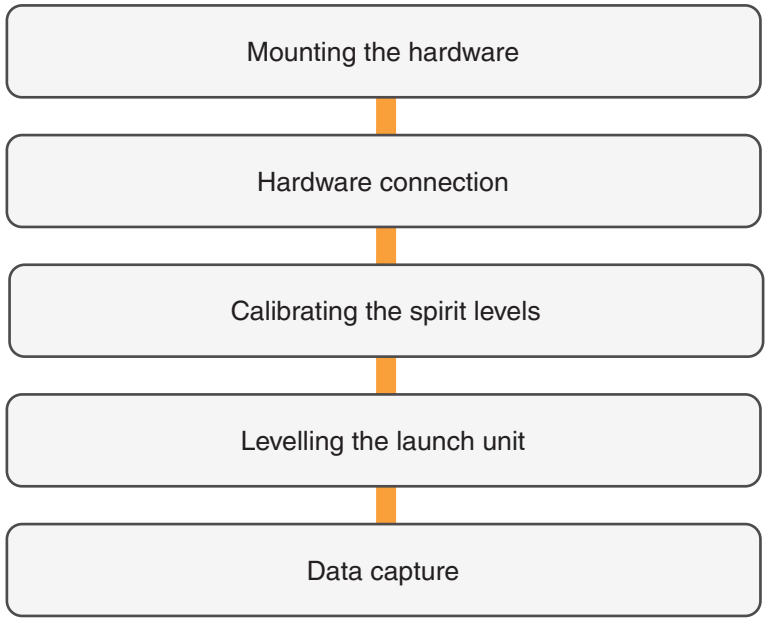
NOTE: It is advised to use the three points as used in the alignment process.

Level

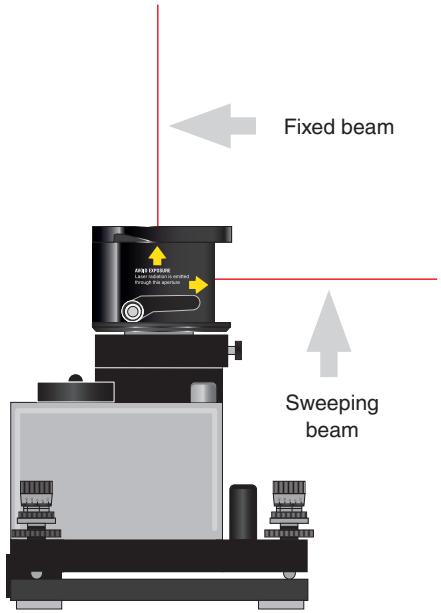

RENISHAW


AVOID EXPOSURE
Laser radiation is emitted through this aperture
XK10
Alignment laser
RENISHAW
Renishaw Plc, New Mills, Wotton-Under-Edge, Gloucestershire, GL12 8JR, U.K.
Calibration due:
Complies with: 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019. EN 60825-1:2014+A11:2021.
Part No.
Serial No.
Date of Manufacture:
Made in Sweden
LASER 2
RENISHAW
UP
M
AVOID EXPOSURE
Laser light is emitted from this aperture

Overview

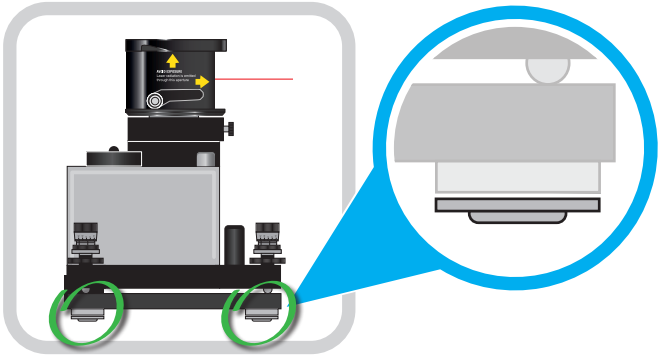

Mounting the hardware
Hardware connection
Calibrating the spirit levels
Levelling the launch unit
Data capture

Mounting the hardware



CAUTION: To avoid stripping the thread, do not put the full weight of the launch on the threads when screwing in the pin.

Launch



Non-magnetic feet can be used on non-ferrous surfaces, for example, granite tables.

Mounted on a stable surface separate to the part being levelled.

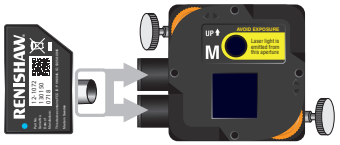
M unit

Mounted on a rotational magnetic base.

Mounted to a reference mount, on a rotational element.

Hardware connection

1



Insert the wireless module into the M unit.

2

Power on the display unit.

3

Select the 'Settings' icon.

4

Select the 'Wireless' icon.

6

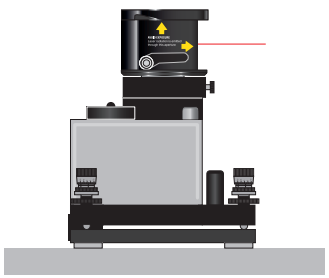
Enable the wireless device plugged into the M unit.

Calibrating the spirit levels

When levelling a point of interest to gravity, it is recommended to follow the process of calibrating the levels before measuring.

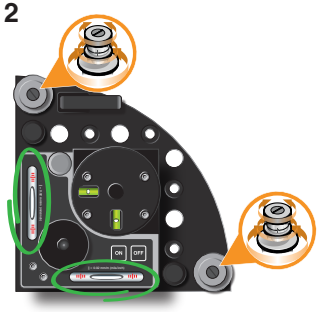
If not levelling to gravity, calibrating the spirit levels is not necessary **(refer to 'levelling', details on page 90)**.

1



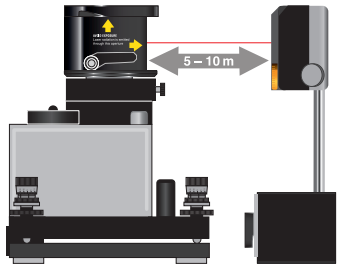
Place launch on a stable, flat surface.

2



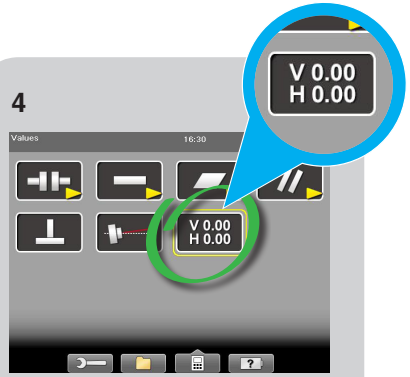
Using the adjuster screws (orange), level the launch unit according to the large spirit levels (green).

3



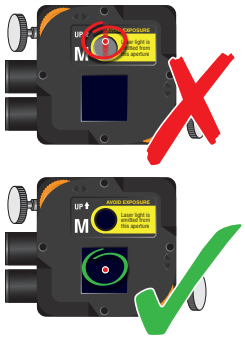
Place the M unit 5 m to 10 m away from the launch unit.

4



Open ‘Values’.

5

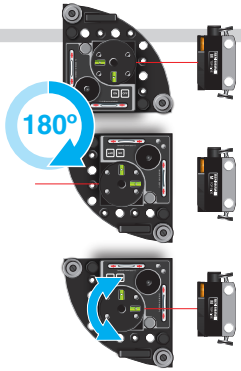


Adjust the height of the M unit on the pillars so that the beam aligns with the centre of the PSD.

6

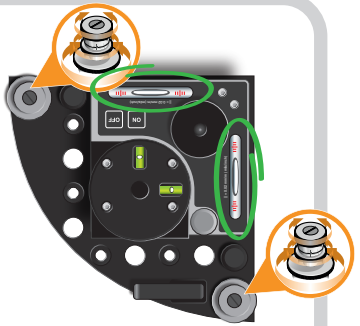
Select ‘0’ to zero the laser reading.

7



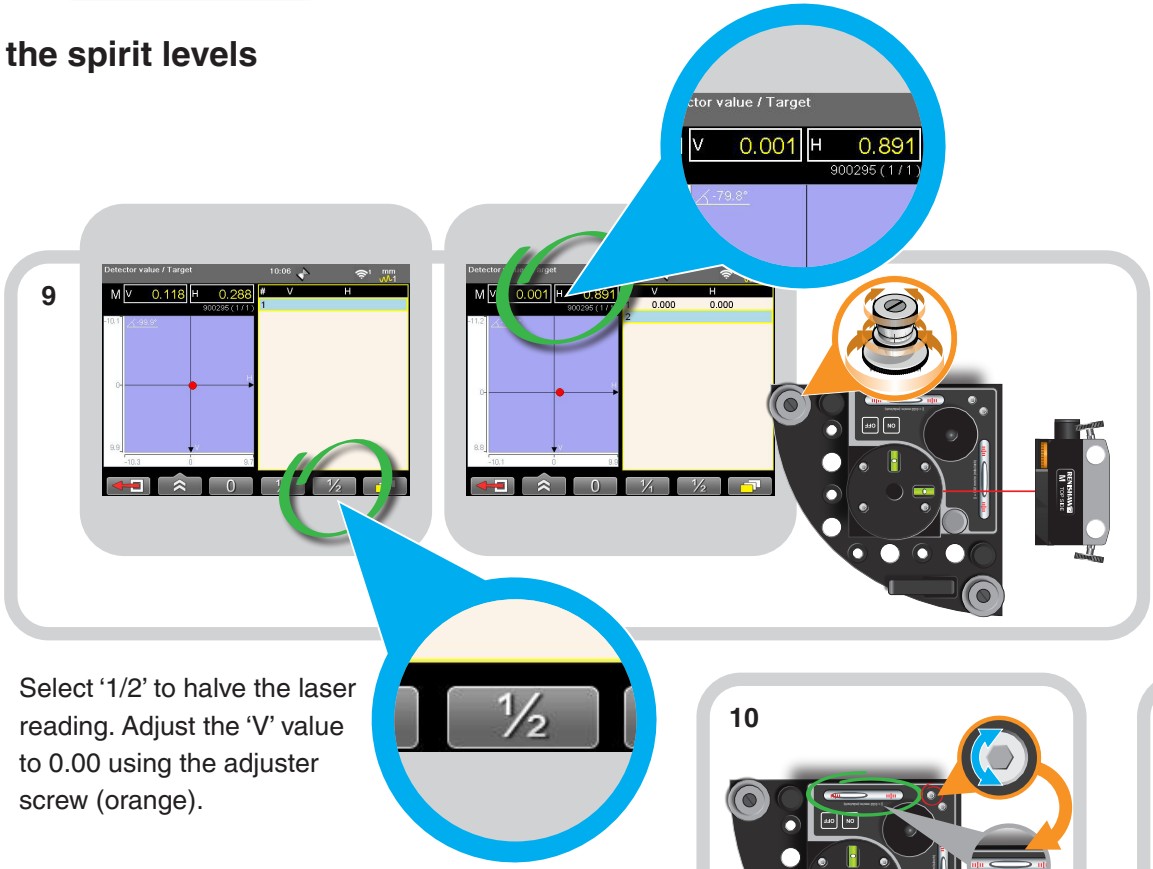
Rotate the launch unit 180 degrees and turn the sweeping beam towards the centre of the M unit.

8

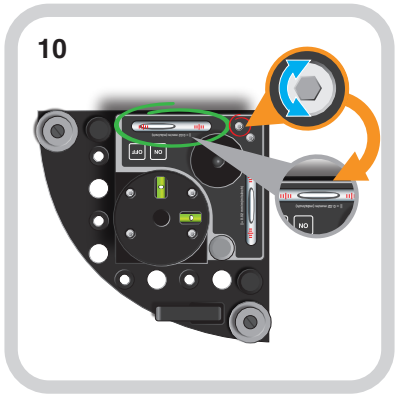


Using the adjuster screws (orange), level the launch unit according to the large spirit levels (green).

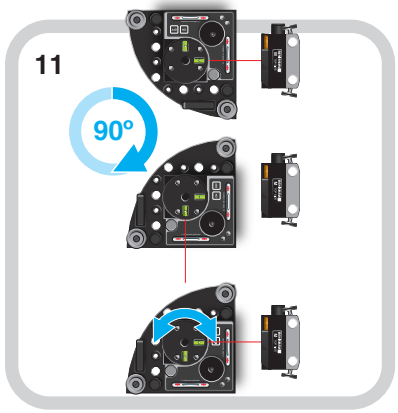
Calibrating the spirit levels



Select ‘1/2’ to halve the laser reading. Adjust the ‘V’ value to 0.00 using the adjuster screw (orange).



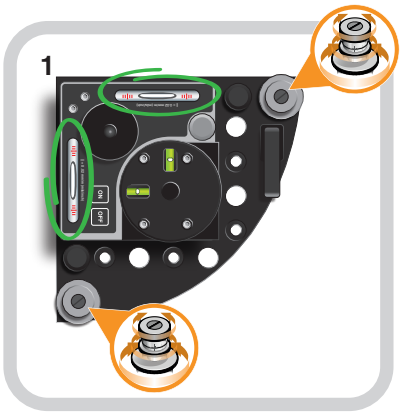
Using a hex key, adjust the spirit level to the centre of the range. Repeat **steps 6 to 9** until the ‘V’ value is < 20 µm/m.



After successfully calibrating the first spirit level, turn the launch unit 90 degrees to start the process of calibrating second spirit level.

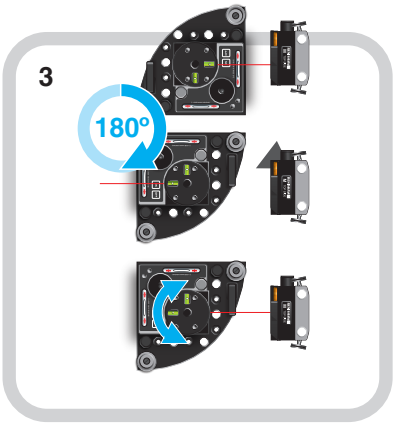
Calibrating the spirit levels

Second spirit level



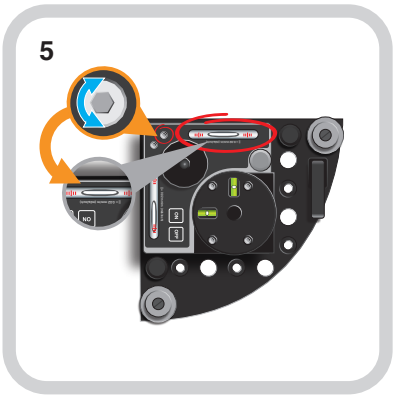
Using the adjuster screws (orange), level the launch unit according to the large spirit levels (green).

Select ‘0’ to zero the laser reading.



Rotate the launch the 180 degrees and turn the sweeping beam towards the centre of the M unit.

Select ‘1/2’ to halve the laser reading. Adjust the ‘V’ value to 0.00 using the adjuster screw (orange).



Using a hex key, adjust the spirit level to the centre of the range.

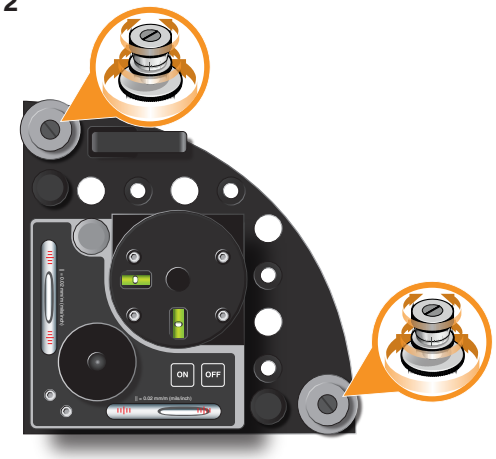
Repeat **steps 3 to 6** until the ‘V’ value is < 20 µm/m.

Levelling the launch unit

1

Place the launch unit on a stable, flat surface.

2



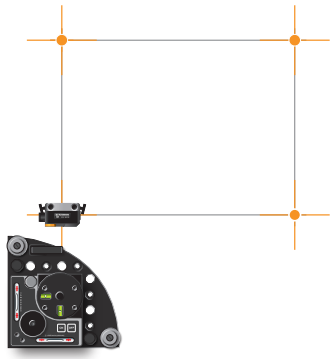
Using the adjuster screws (orange), level the launch unit according to the large spirit levels (red).

Data capture

1

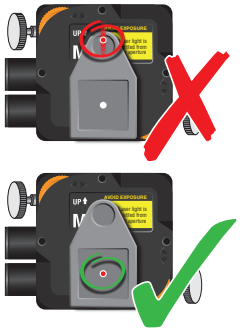
Select 'Values'.

2



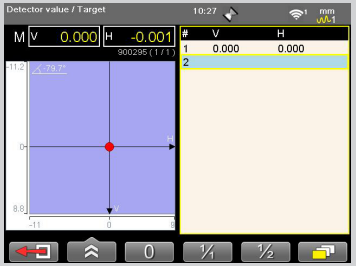
Mount the M unit at first measurement position.

3



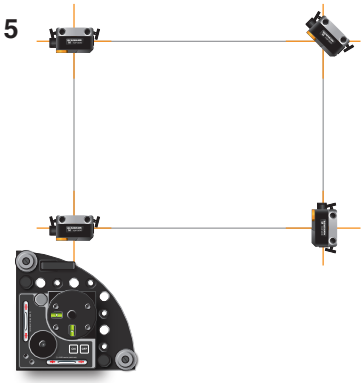
Adjust the height of the M unit on the pillars so that the beam aligns with the centre of the target.

4



Remove the target from the M unit, zero the laser reading and capture the first point. This is now the reference.

5

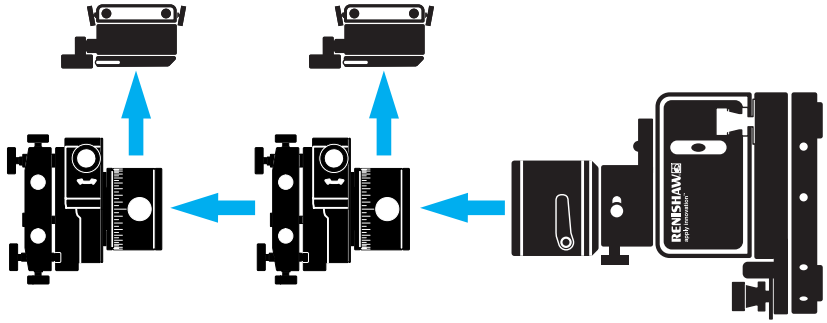


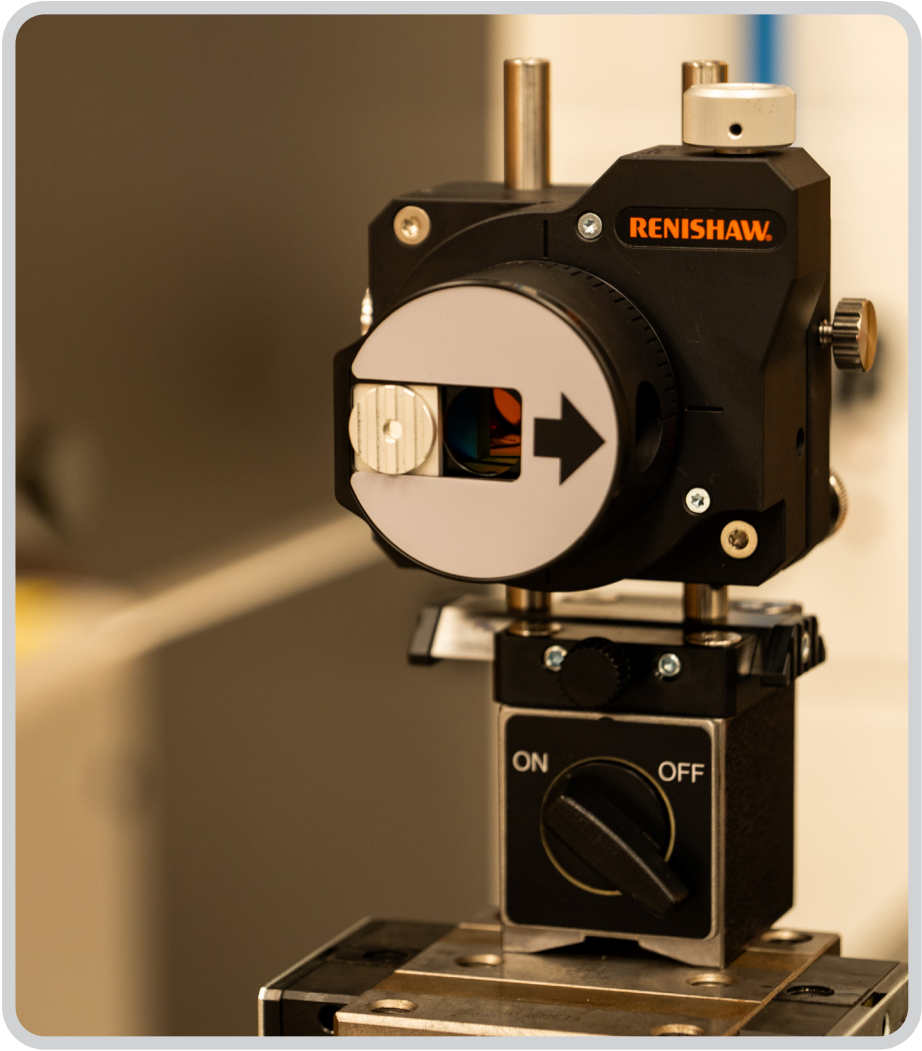
Move to all positions of interest and capture points.

NOTE: Use the live readings from the software to adjust the machine level where required.

NOTE: The V values are the difference between the measured position and the reference.

Parallelism (horizontal)



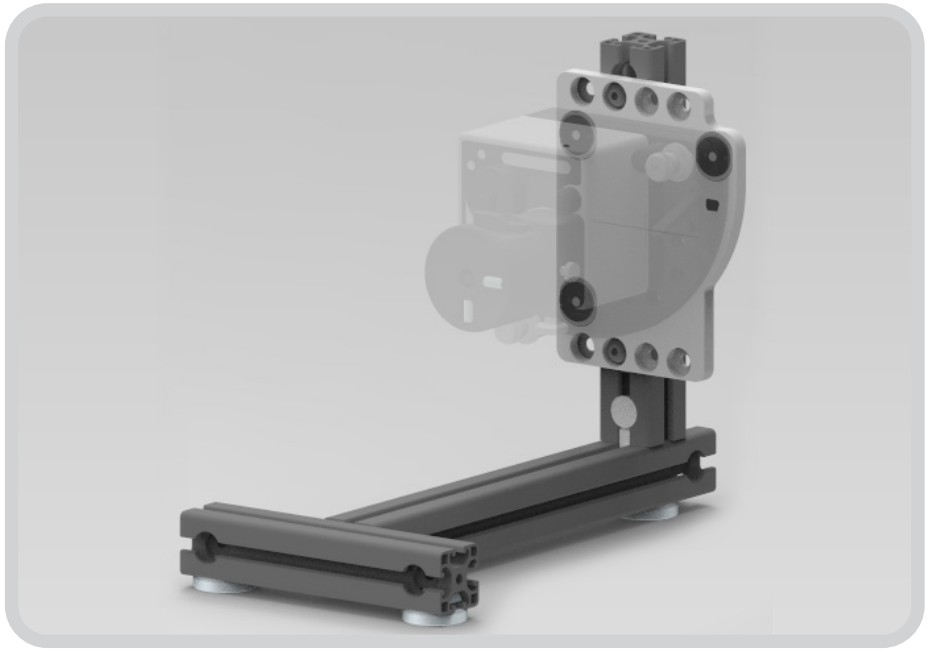


Overview

- Mounting the hardware
- Positioning the launch unit
- Levelling the launch unit to the casting
- Mounting the hardware
- Positioning the pentaprism
- Align the pentaprism to the launch unit
- Mounting the M unit
- Visual alignment of the launch unit to the reference rail
- Fine alignment of the launch unit to the reference rail
- Measure the reference rail
- Pentaprism set-up for measurement rail
- Align the pentaprism to the launch unit (measurement rail)
- Fine alignment of pentaprism to the M unit
- Measure the measurement rail

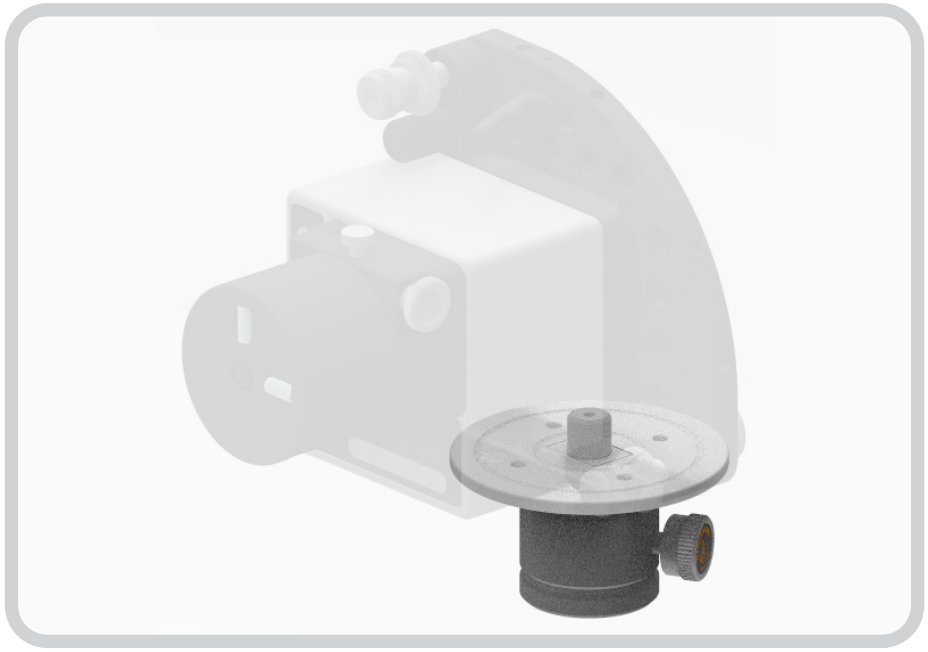
Mounting the hardware

Fixture kit



The launch unit can be mounted directly to the casting using the fixture kit ...

Tripod mount

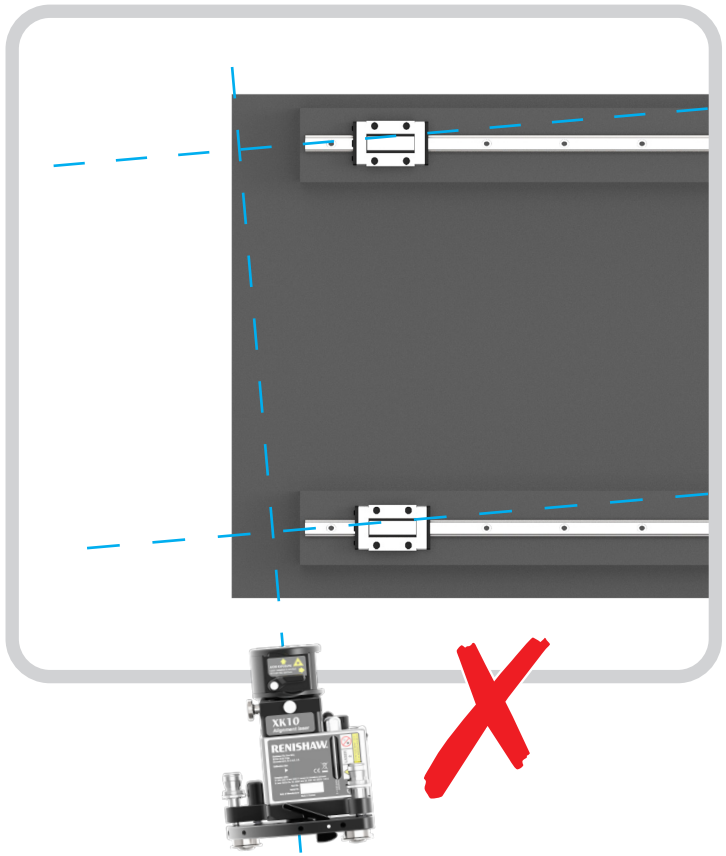


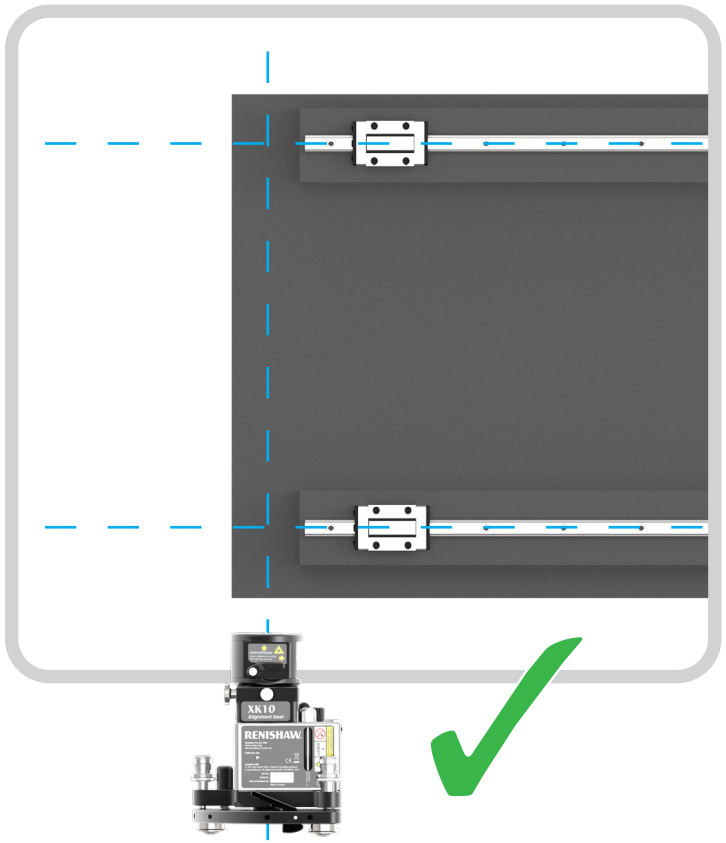
... or using the tripod mount on a suitable tripod.

NOTE: The tripod should only be used where it is not possible to suitably fixture the launch unit to the machine structure. The launch unit is the reference, and as such, any instability in the tripod will impact the accuracy of any testing.

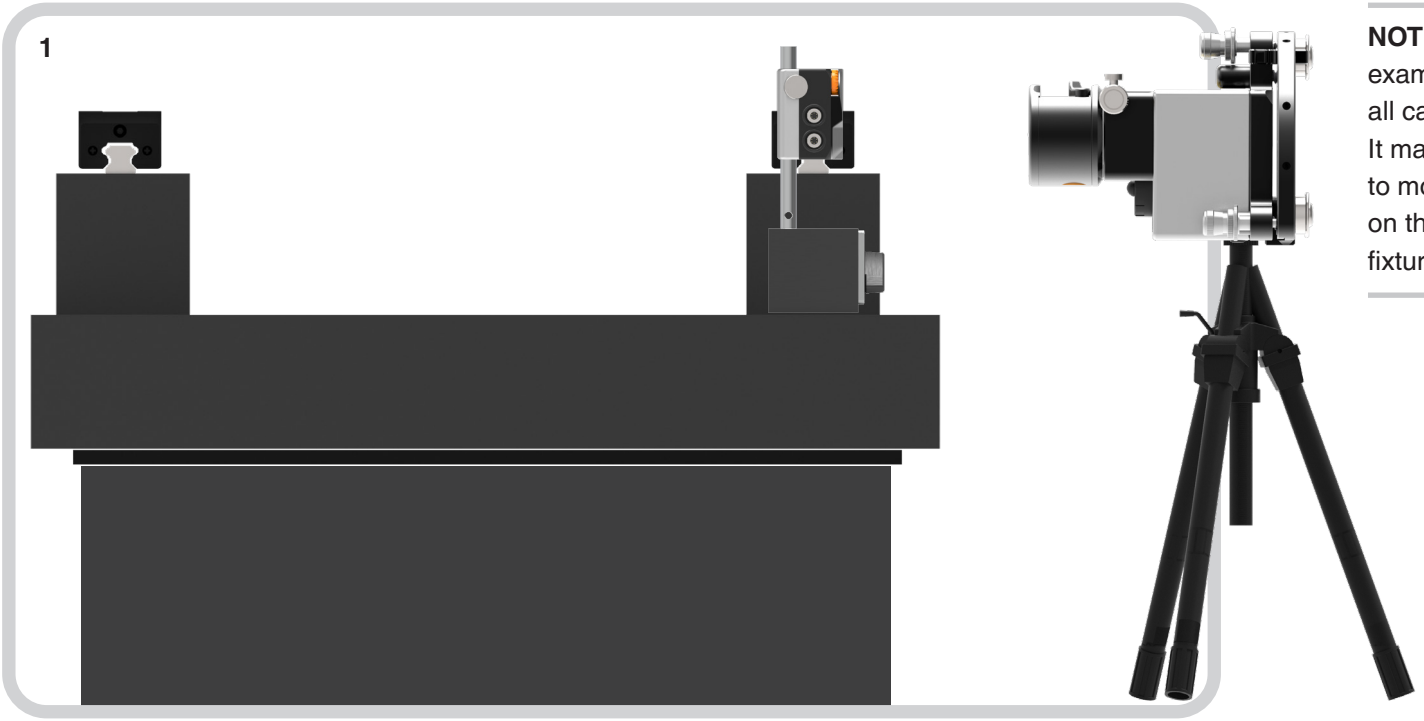
Positioning the launch unit

Visually position the **launch unit** perpendicular to the measurement rails. (It is good practice to approximately level the launch according to the spirit levels).





Levelling the launch unit to the casting



NOTE: This is an example set-up only, all castings are different. It may be necessary to mount optics directly on the rails or suitable fixturing.

Mount the M unit to a flat surface on the structure at a position closest to the launch unit. The M unit PSD should be facing the launch unit.

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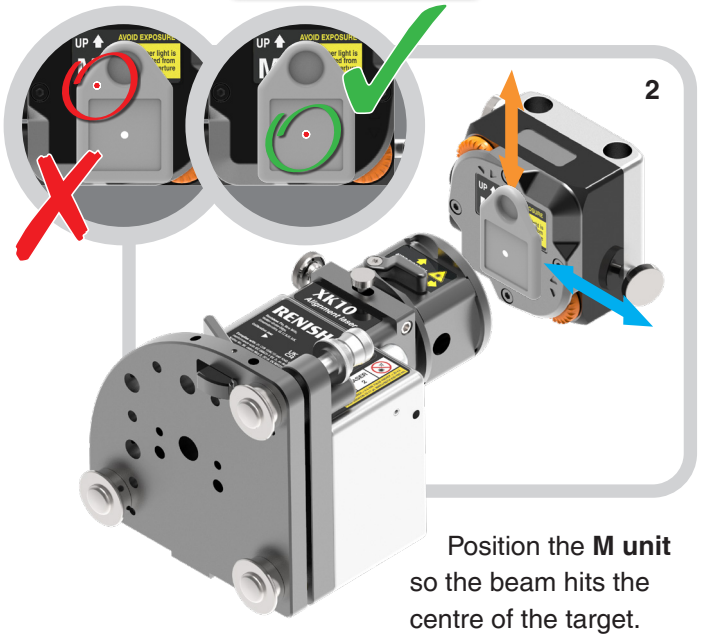
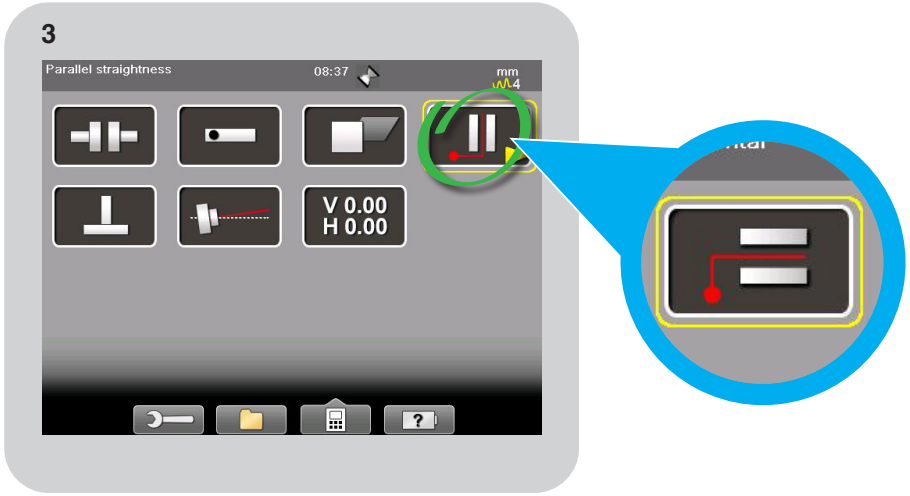
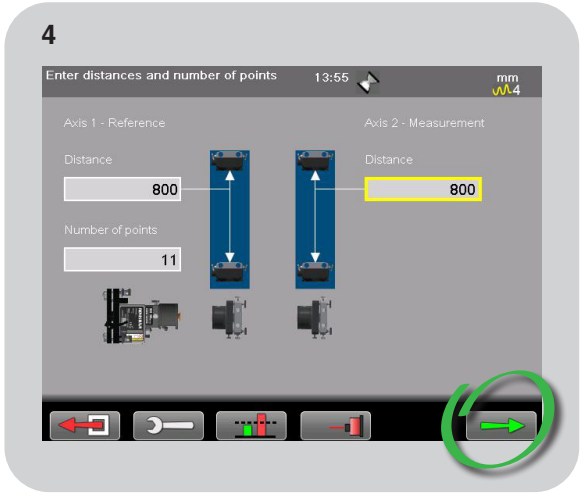
Levelling the launch unit to the casting



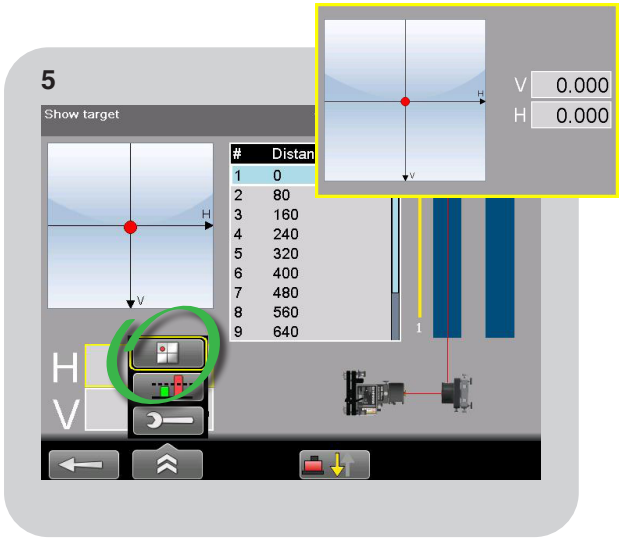
Position the **M unit** so the beam hits the centre of the target.



Load the 'Parallelism' option – select the 'Horizontal' mode.



Input the parameters for the test set-up. Select the green arrow.



Select the 'Show target' view, remove the target from the M unit and zero the laser reading.

NOTE: Select the 'Launch orientation' icon to change the reference rail/location of the launch unit.

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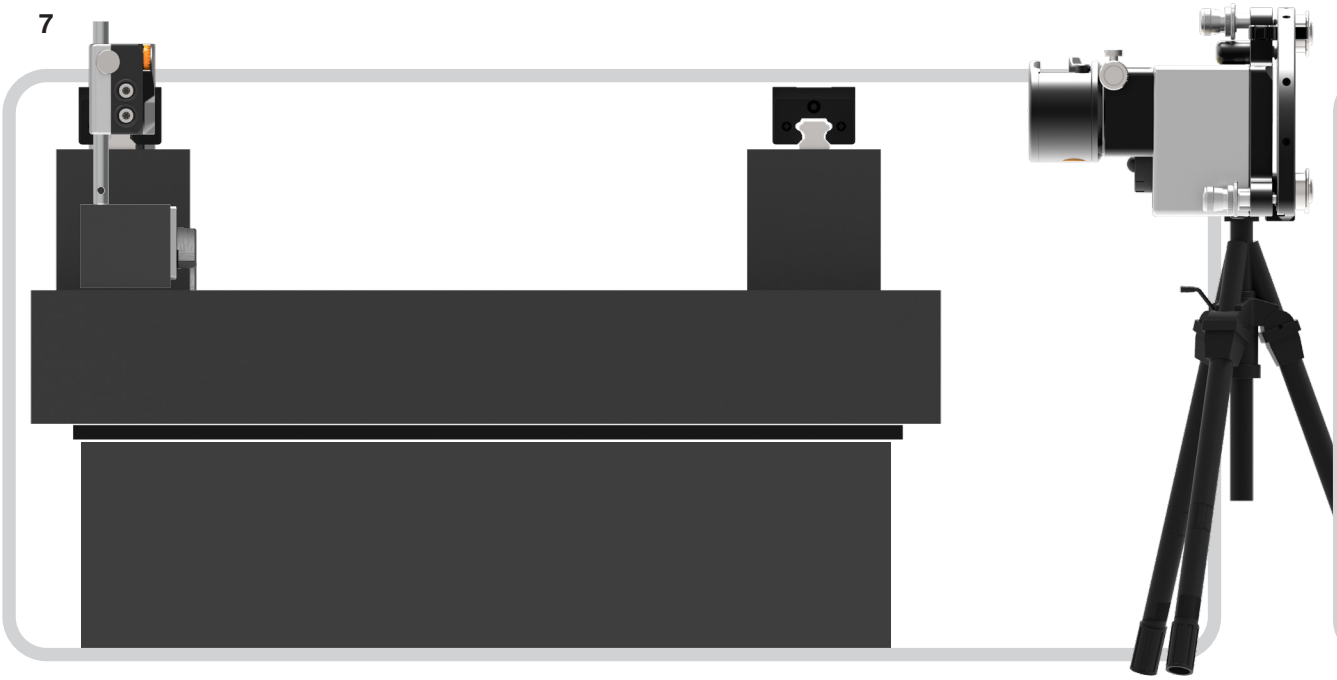
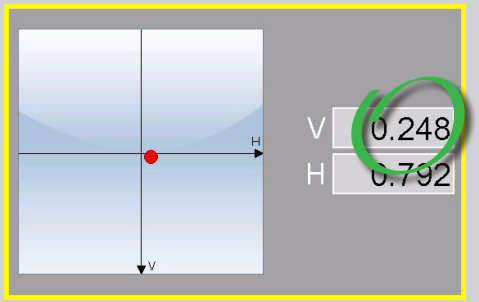
Levelling the launch unit to the casting

7



Move the **M unit** to the furthest position on the structure away from the launch unit.

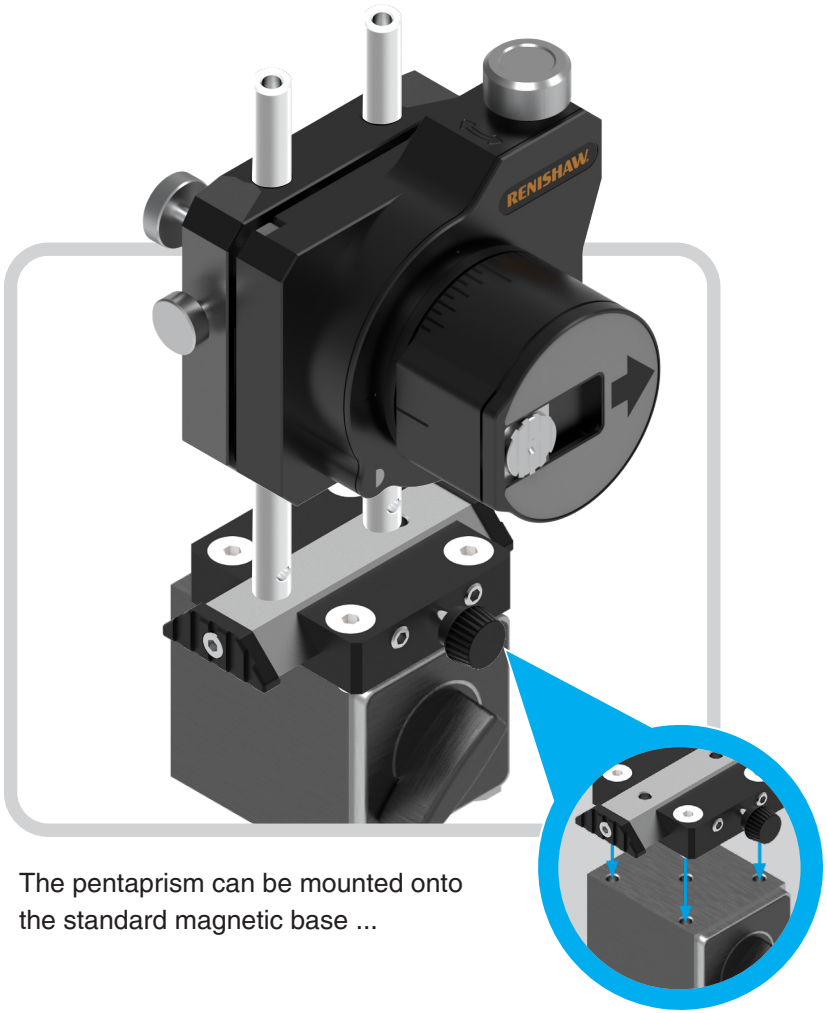
8 & 9



Adjust the **pitch of the launch unit** so that the V value is 0.

Repeat **steps 2 to 8** until the PSD reading is < 100 µm between the two positions.

Mounting the hardware



The pentaprism can be mounted onto the standard magnetic base ...

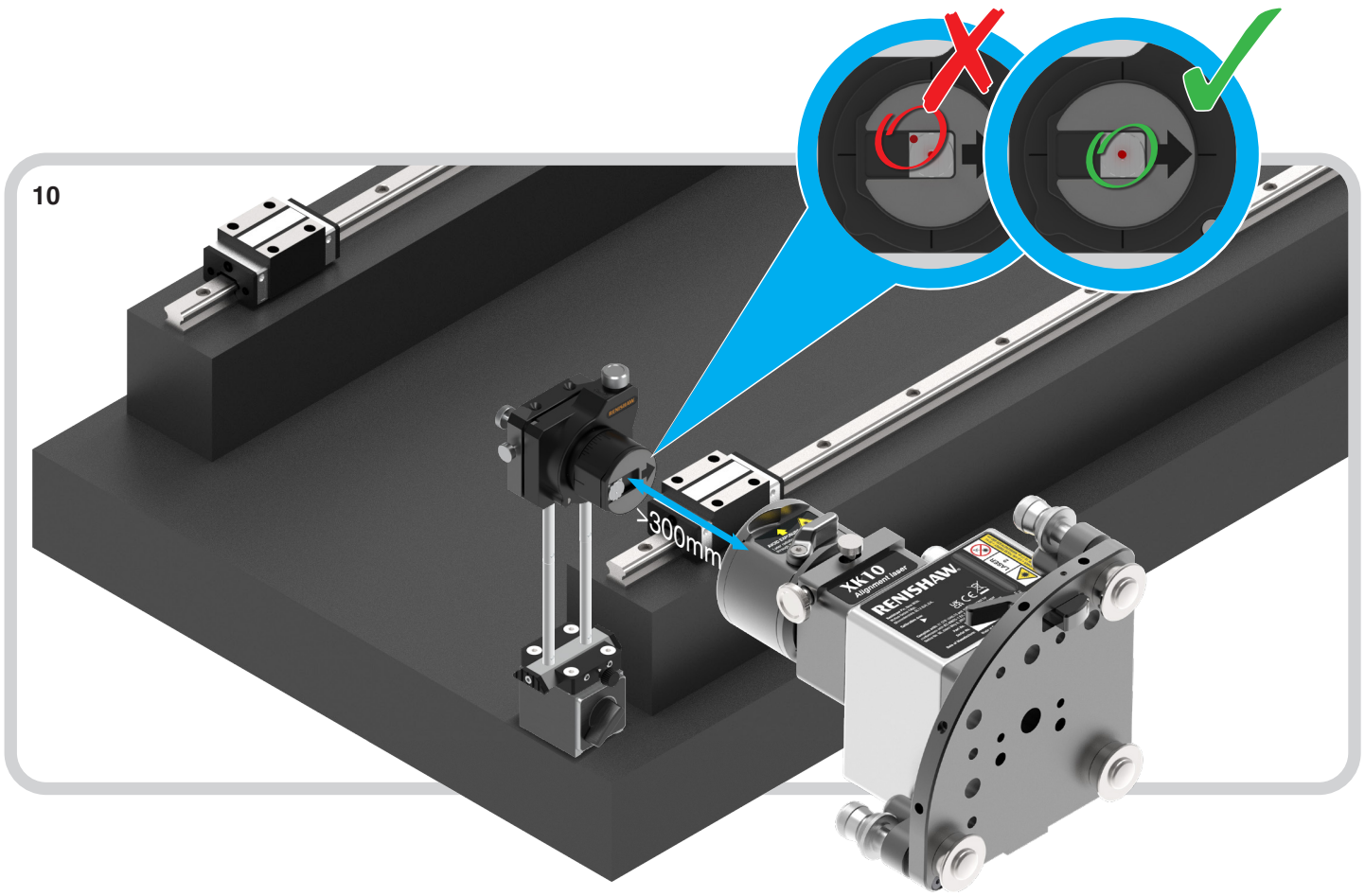
... or it can be mounted onto a tripod mount.

Positioning the pentaprism

Mount the pentaprism in a suitable position so that the output aperture is facing down the reference rail.

- The pentaprism should be > 300 mm from the output aperture of the launch unit.
- Visually align the pentaprism so it is square to the structure/ launch unit.
- Ensure the arrow on the front of the pentaprism is pointing down the axis of measurement.

Position the **pentaprism** so that the beam from the launch unit hits the centre of the mirror/target (with the mirror covering the input aperture of the pentaprism).



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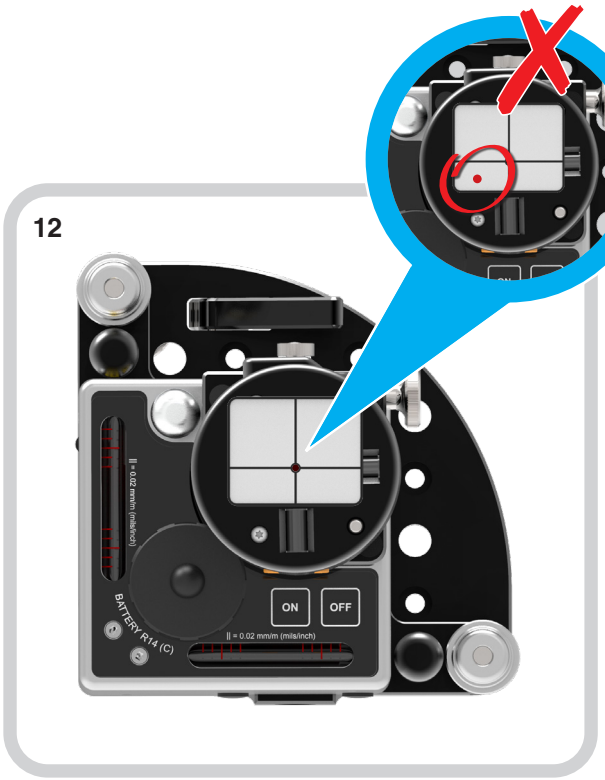
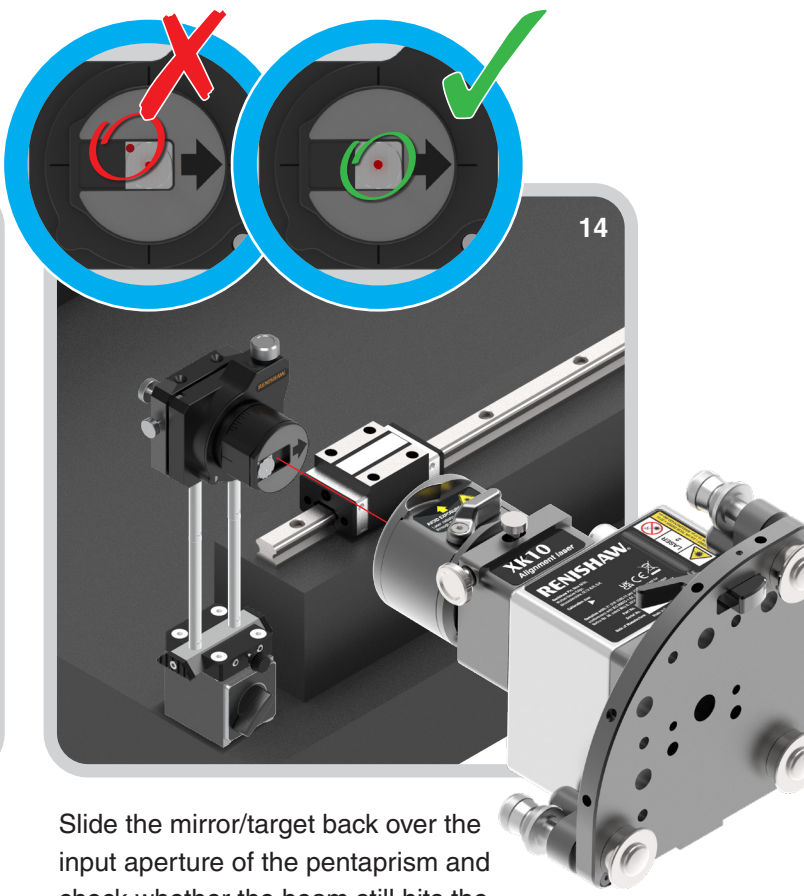
Align the pentaprism to the launch unit



Insert the beam reducer/target into the output aperture of the launch unit.

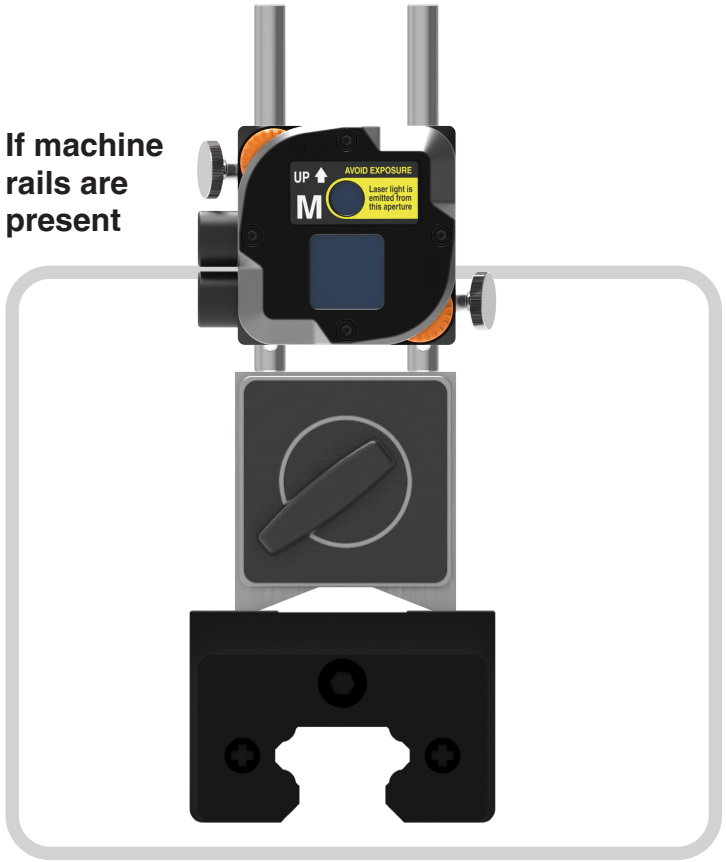
Check the back-reflection from the pentaprism mirror to the launch unit output aperture target. The back-reflection should hit the centre of the 2 mm hole. If it does not, adjust the pitch/yaw of the **pentaprism** using the thumbscrew adjuster.



Slide the mirror/target back over the input aperture of the pentaprism and check whether the beam still hits the centre of the target. If it does not, translate the **pentaprism** until the beam is back on centre.

Mounting the M unit

If machine rails are present



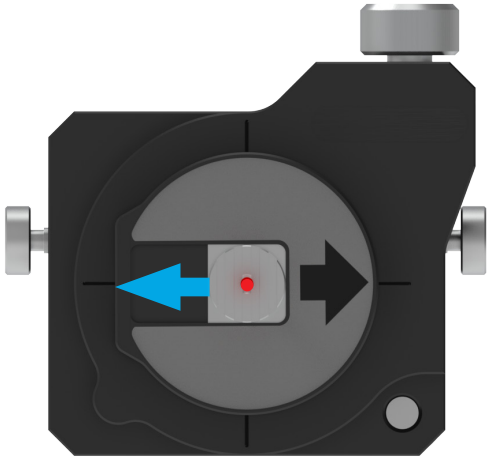
Mount the M unit to the carriage using the standard magnetic base.

If machine rails are not present

Mount the M unit to the casting using the reference mount.

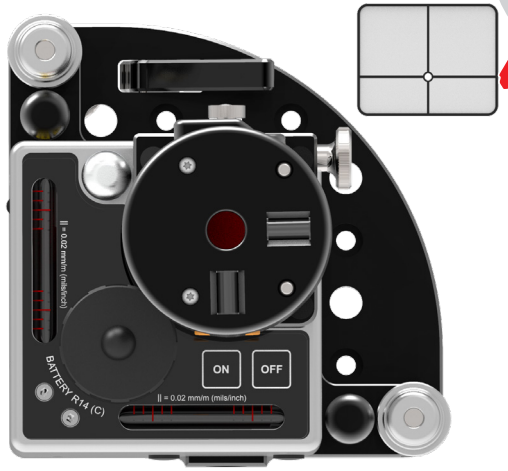
Visual alignment of the launch unit to the reference rail

15



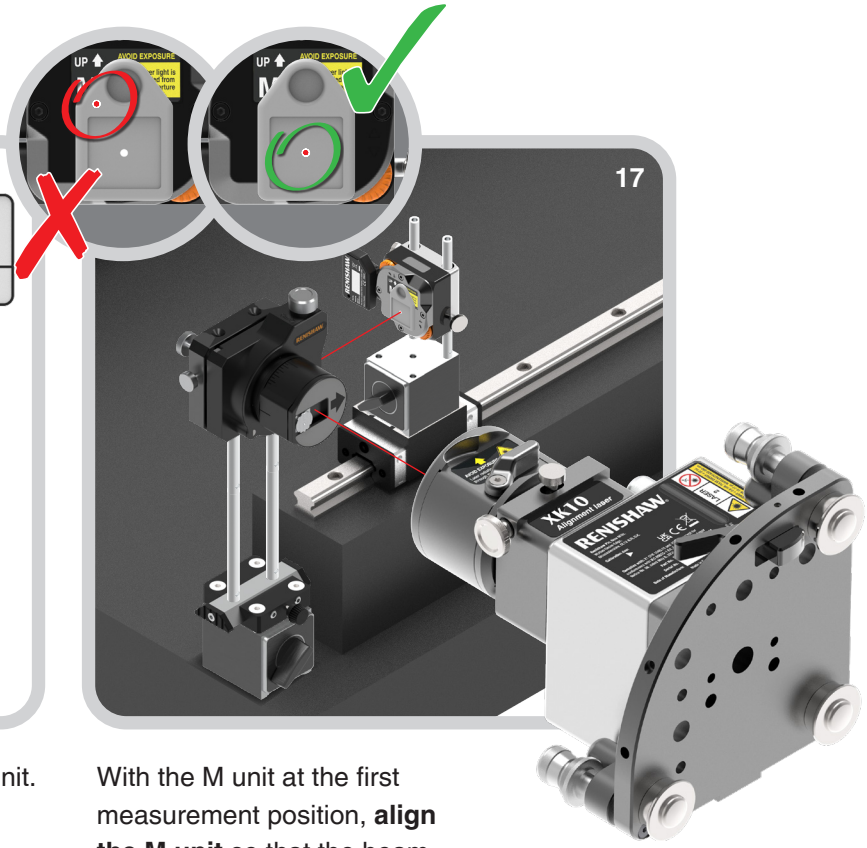
Slide the mirror/target away from the input aperture of the pentaprism.

16



Carefully remove the target from the launch unit.

17

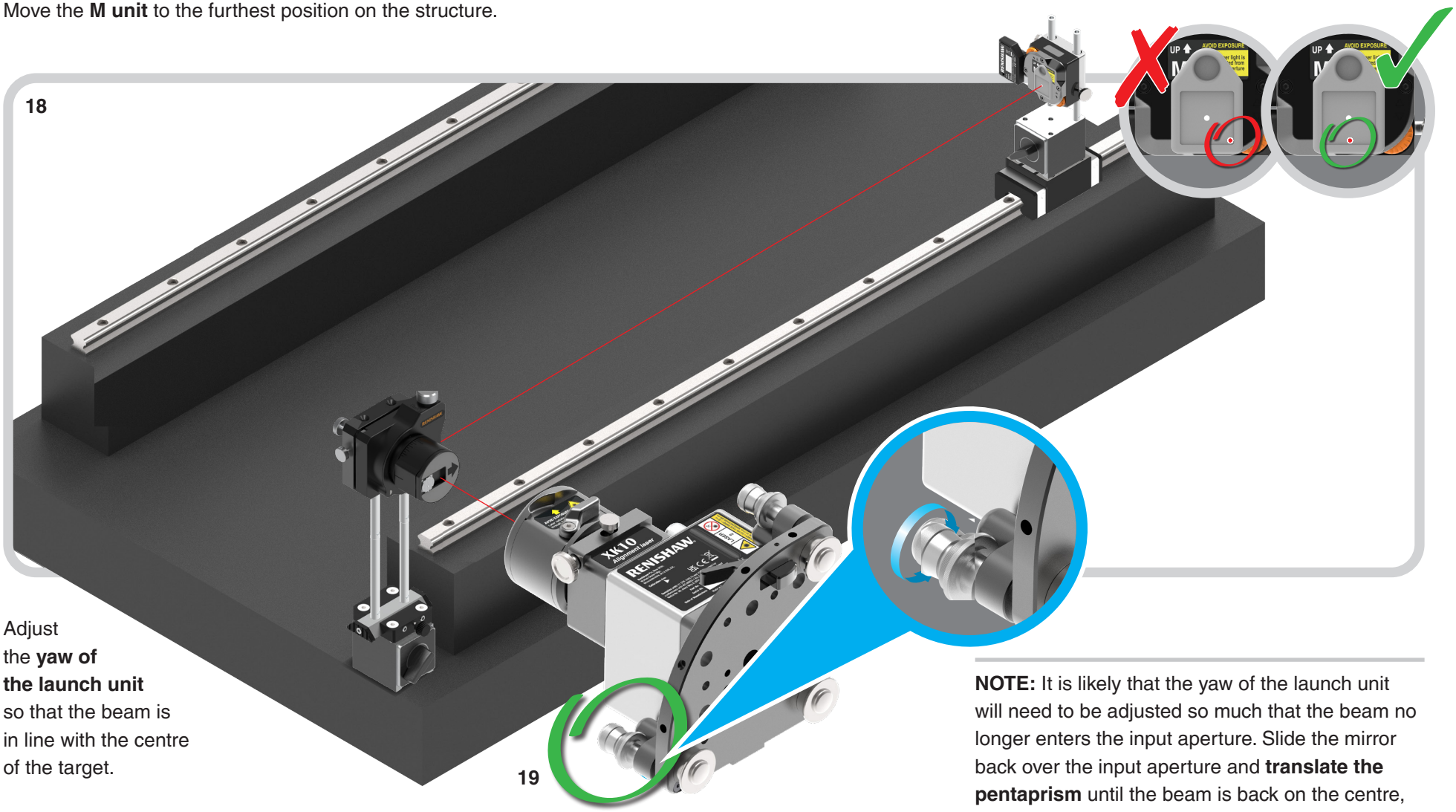


With the M unit at the first measurement position, **align the M unit** so that the beam exiting the pentaprism hits the centre of the target.

Visual alignment of the launch unit to the reference rail

Move the **M unit** to the furthest position on the structure.

18



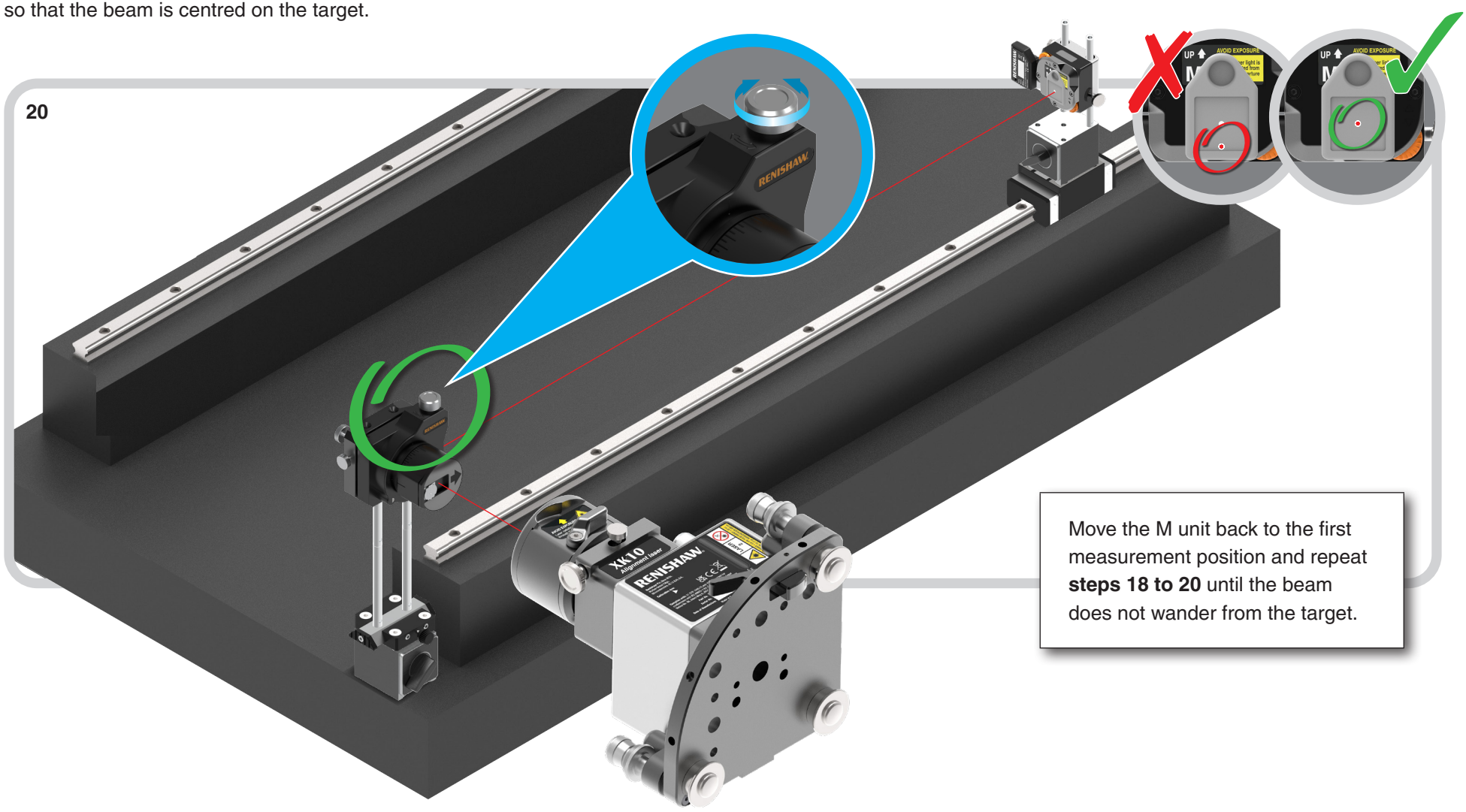
19

Adjust the **yaw of the launch unit** so that the beam is in line with the centre of the target.

NOTE: It is likely that the yaw of the launch unit will need to be adjusted so much that the beam no longer enters the input aperture. Slide the mirror back over the input aperture and **translate the pentaprism** until the beam is back on the centre, and then continue with the launch unit alignment.

Visual alignment of the launch unit to the reference rail

Adjust the **pitch of the pentaprism** (relative to the M unit), so that the beam is centred on the target.



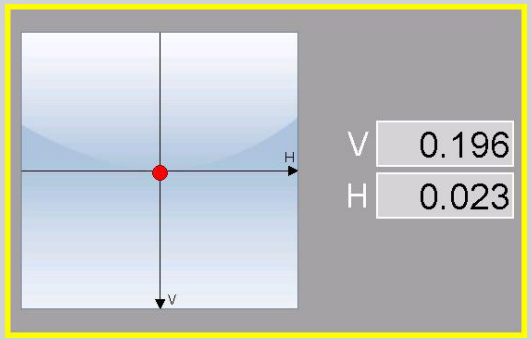
Move the M unit back to the first measurement position and repeat **steps 18 to 20** until the beam does not wander from the target.

Fine alignment of the launch unit to the reference rail

21

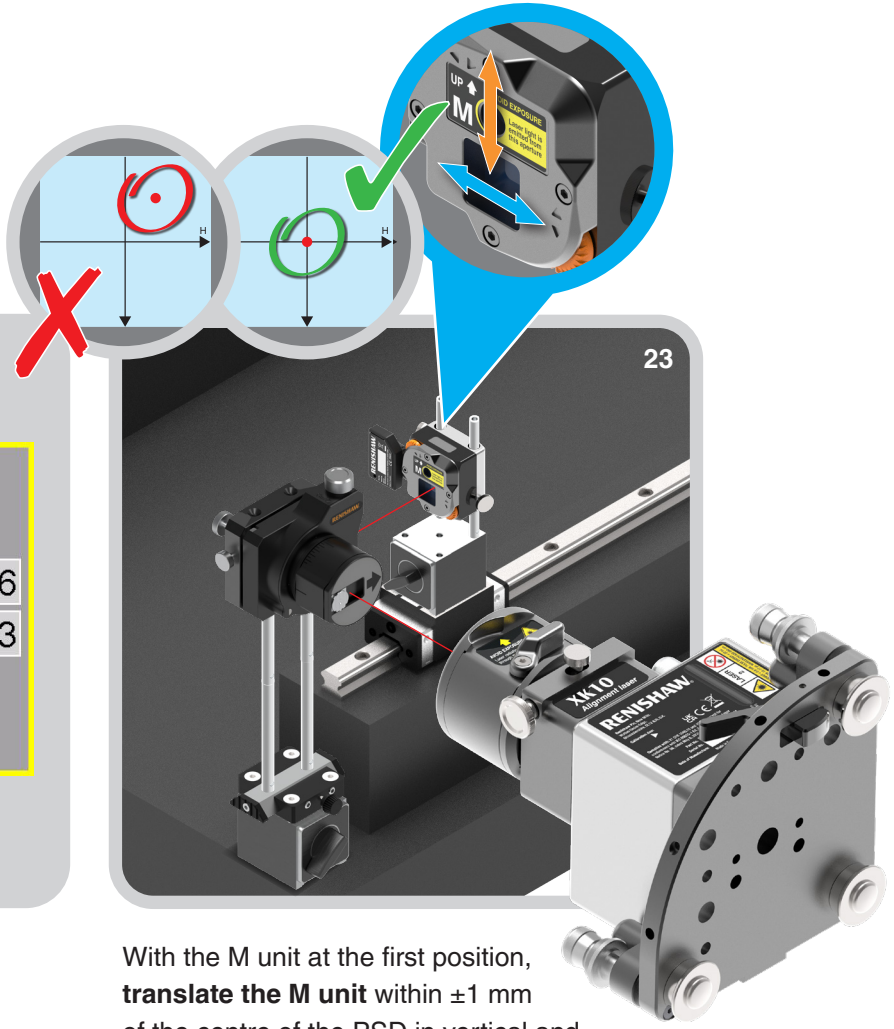
With the M unit at the first measurement position, and the beam centred on the target, remove the target.

22



Select the 'Show target' view.

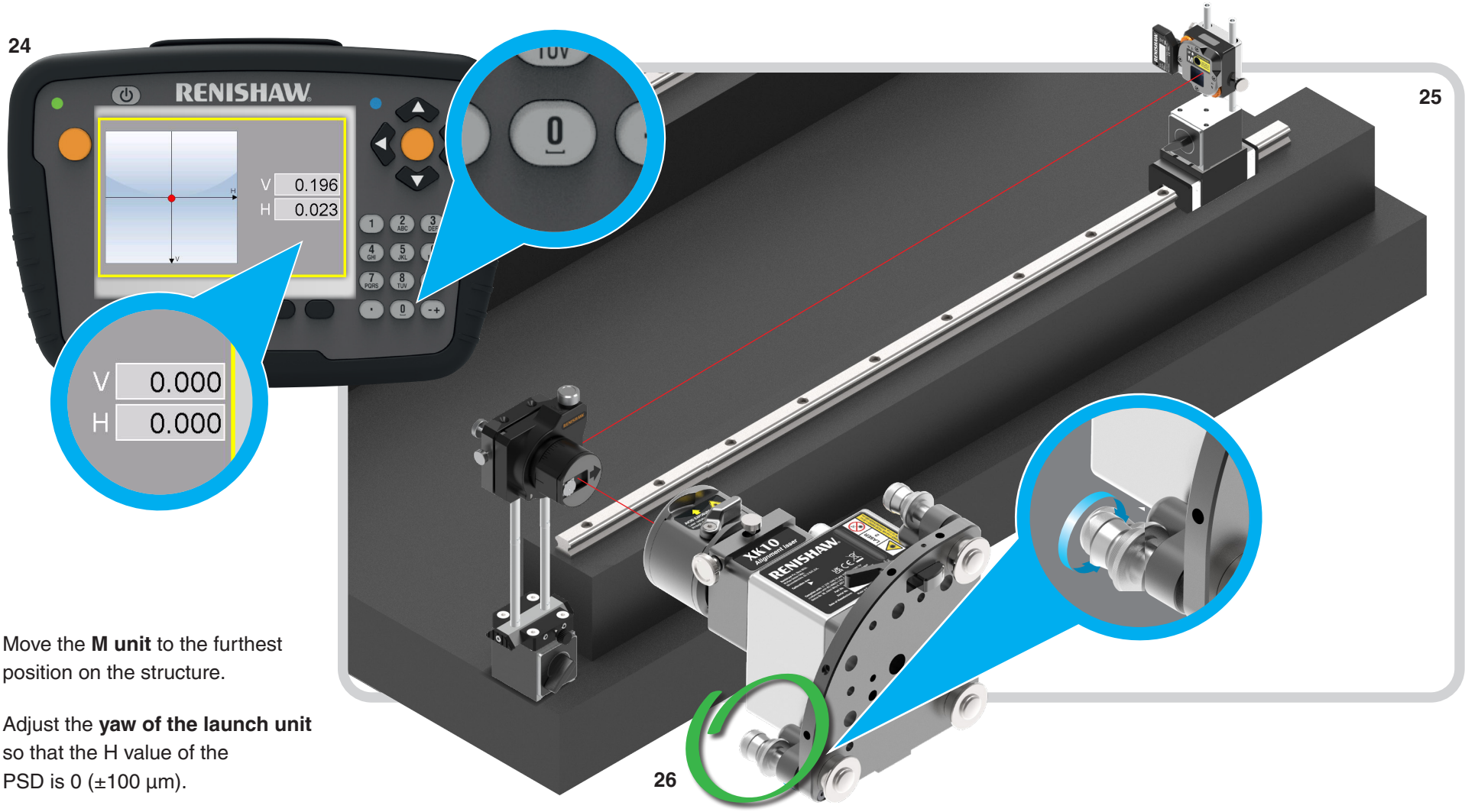
23



With the M unit at the first position, **translate the M unit** within ±1 mm of the centre of the PSD in vertical and horizontal.

Fine alignment of the launch unit to the reference rail

Select '0' on the display unit to zero the laser reading.

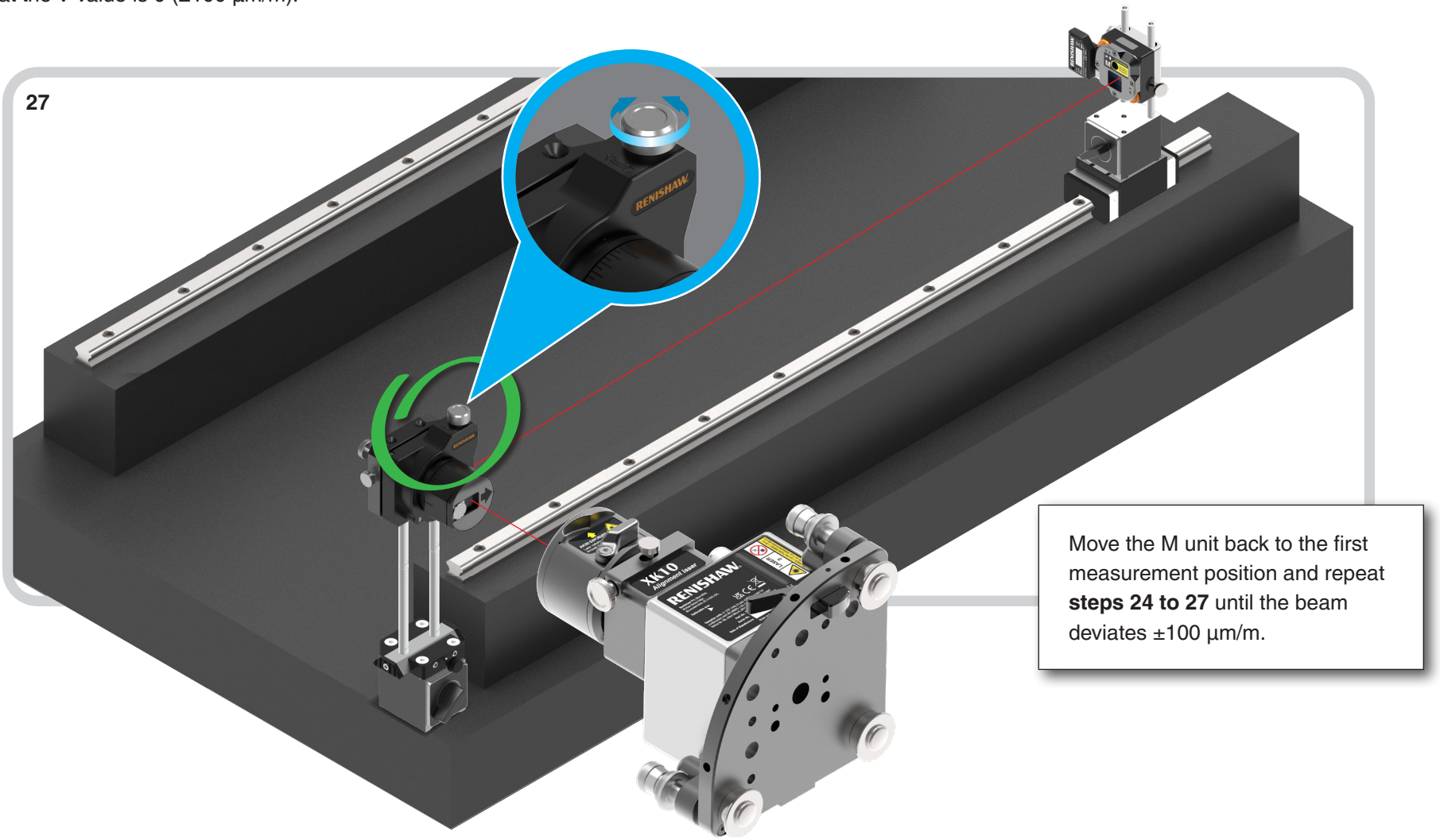


Move the **M unit** to the furthest position on the structure.

Adjust the **yaw of the launch unit** so that the H value of the PSD is 0 (±100 µm).

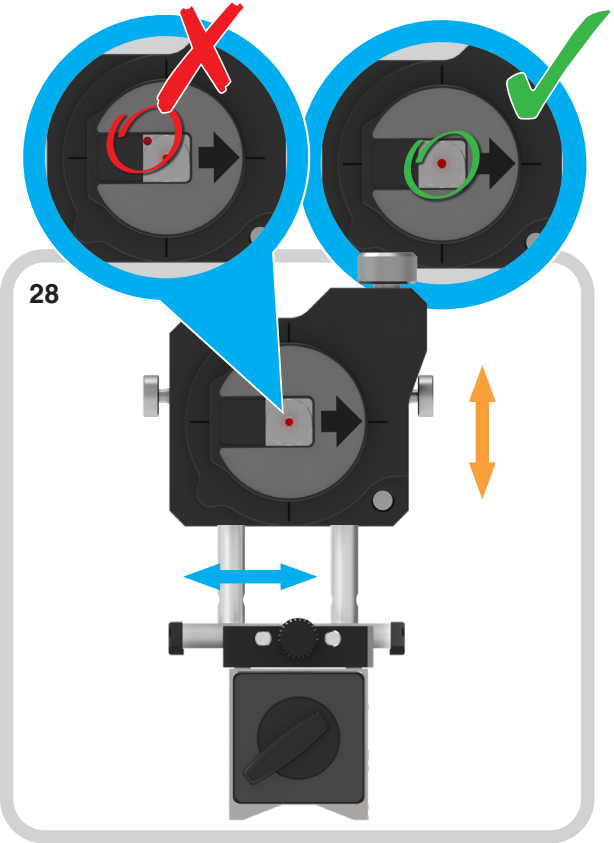
Fine alignment of the launch unit to the reference rail

Adjust the **pitch of the pentaprism** (relative to the M unit),
so that the V value is 0 (±100 µm/m).

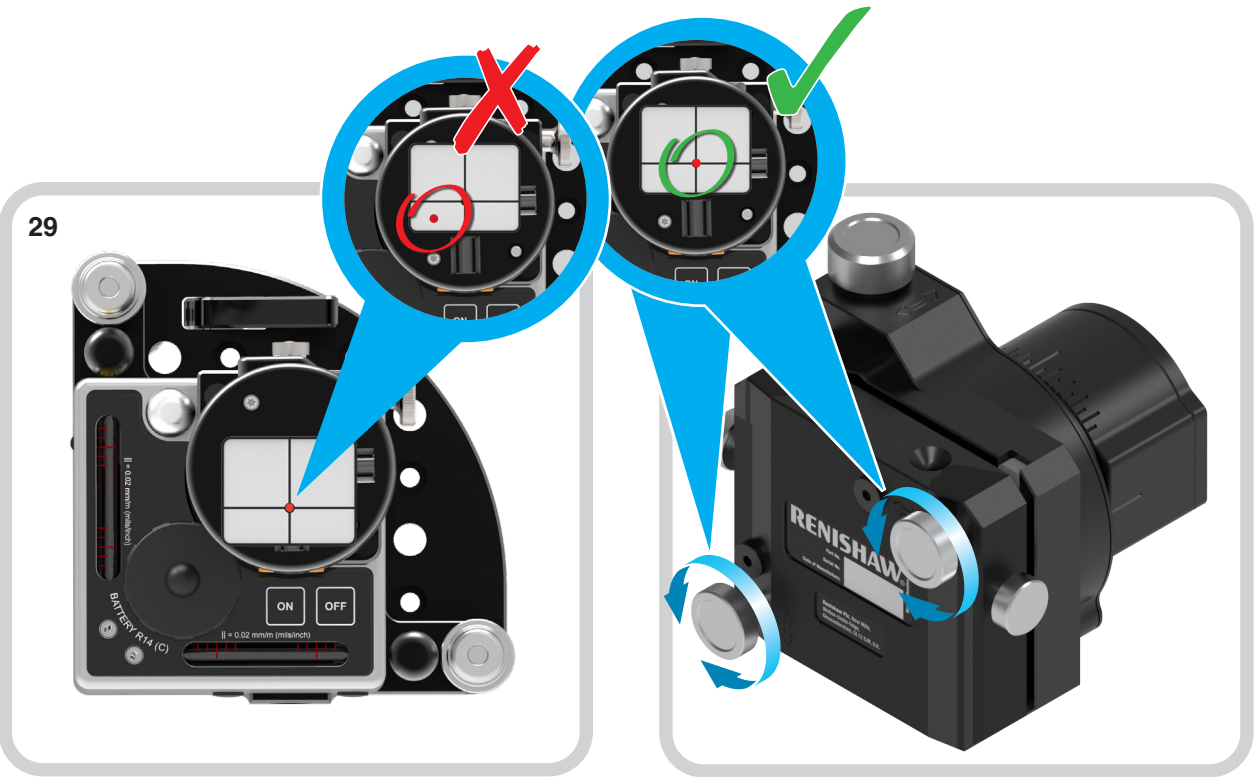


Fine alignment of the launch unit to the reference rail

NOTE: If making changes to the pentaprism pitch/yaw, be sure to recheck the alignment of the launch unit to the reference rail.



Slide the mirror/target over the input aperture of the pentaprism. Carefully place the target on the launch unit and recheck that the beam hits the centre of the mirror/target. If it does not, **translate the pentaprism**.



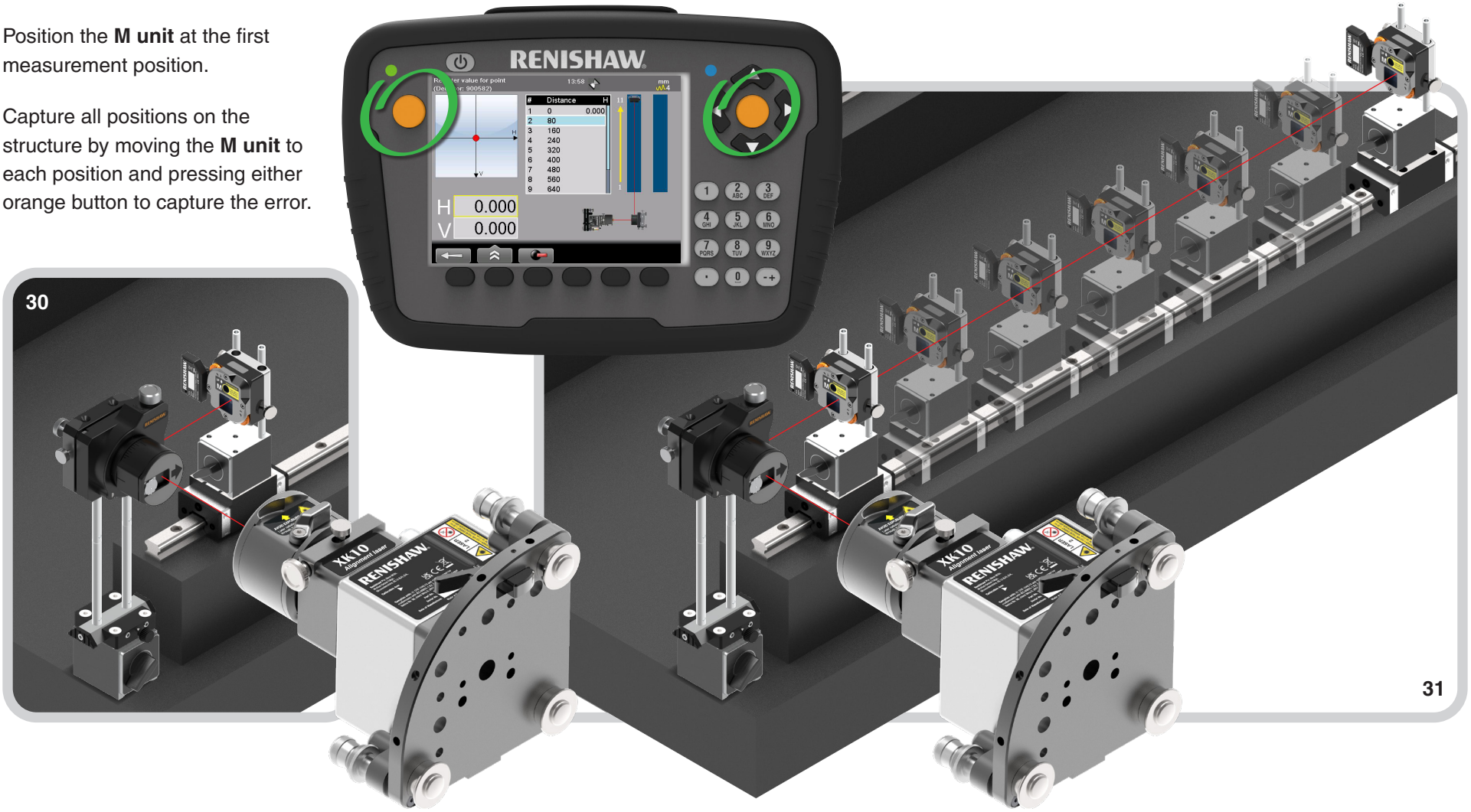
Recheck that the beam hits the centre of the launch unit target. If it does not, adjust the pitch/yaw of the **pentaprism**. When alignment is good, carefully remove the target from the launch unit and slide the target away from the input aperture of the pentaprism.

Measure the reference rail

NOTE: The launch unit is now aligned to the reference rail. To maintain this reference, it is vital that the launch unit is not adjusted or moved in any way for the remainder of the test process.

Position the **M unit** at the first measurement position.

Capture all positions on the structure by moving the **M unit** to each position and pressing either orange button to capture the error.



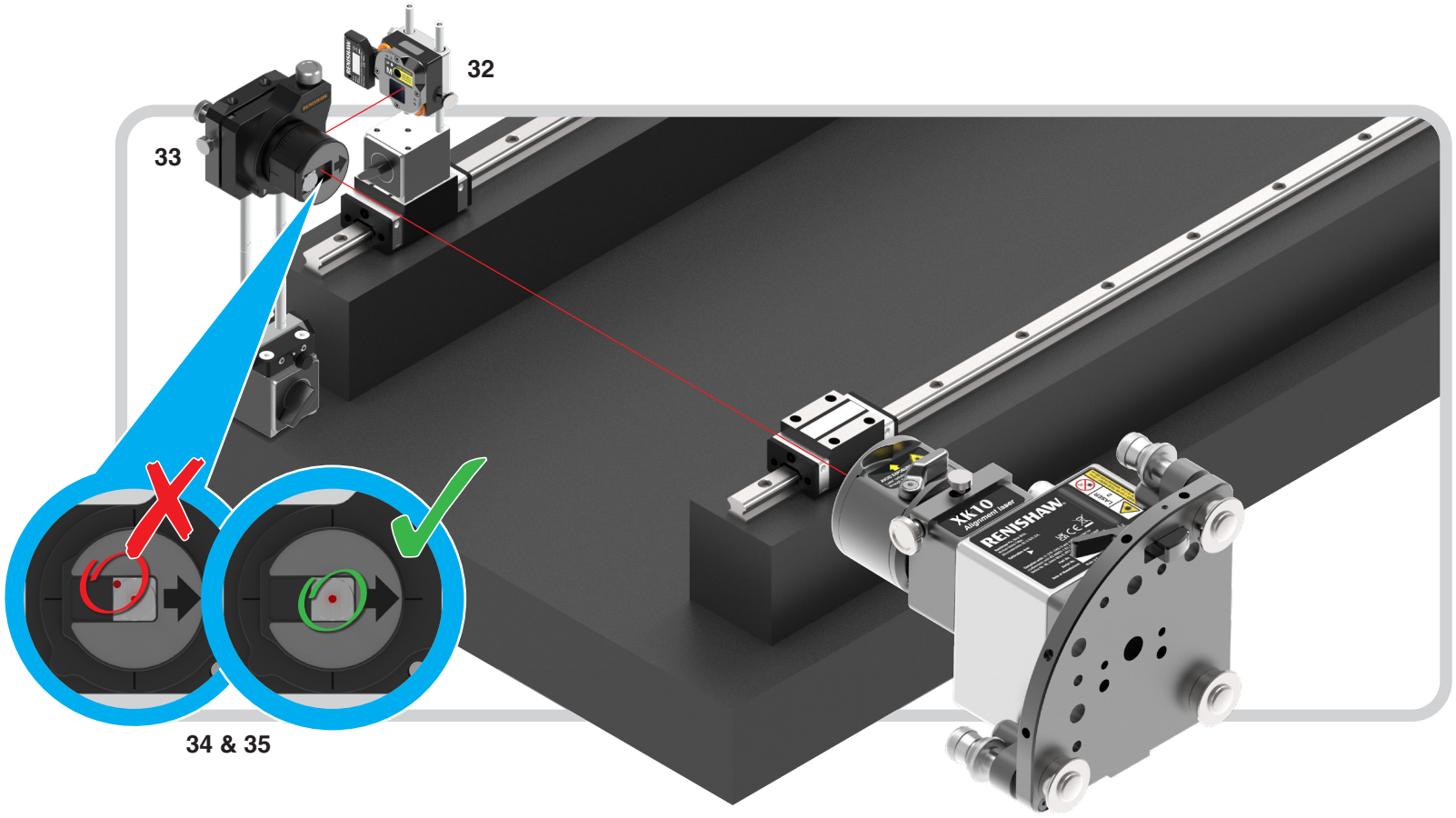
Pentaprism set-up for measurement rail

Move the **M unit** to the measurement rail, making sure the M unit top side is pointing in the same direction as for the measurement on the reference rail.

Move the **pentaprism** to a suitable place to ensure the output aperture of the pentaprism is in line with the M unit.

Slide the mirror/target over the input aperture of the pentaprism.

Position the **pentaprism** so that the beam from the launch unit hits the centre of the target/mirror.



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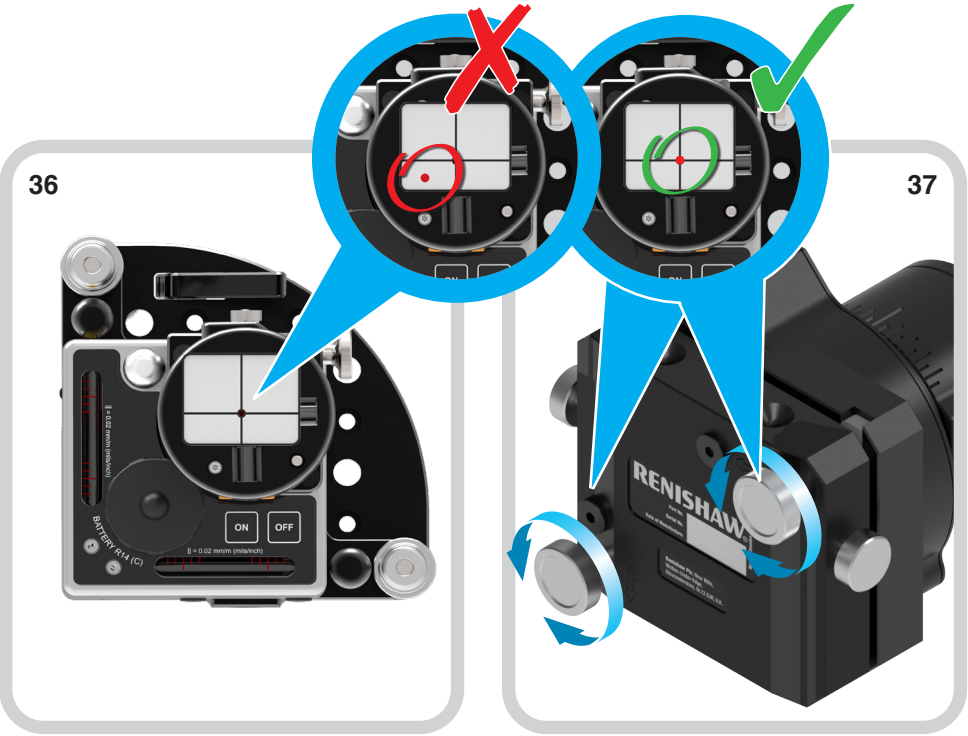
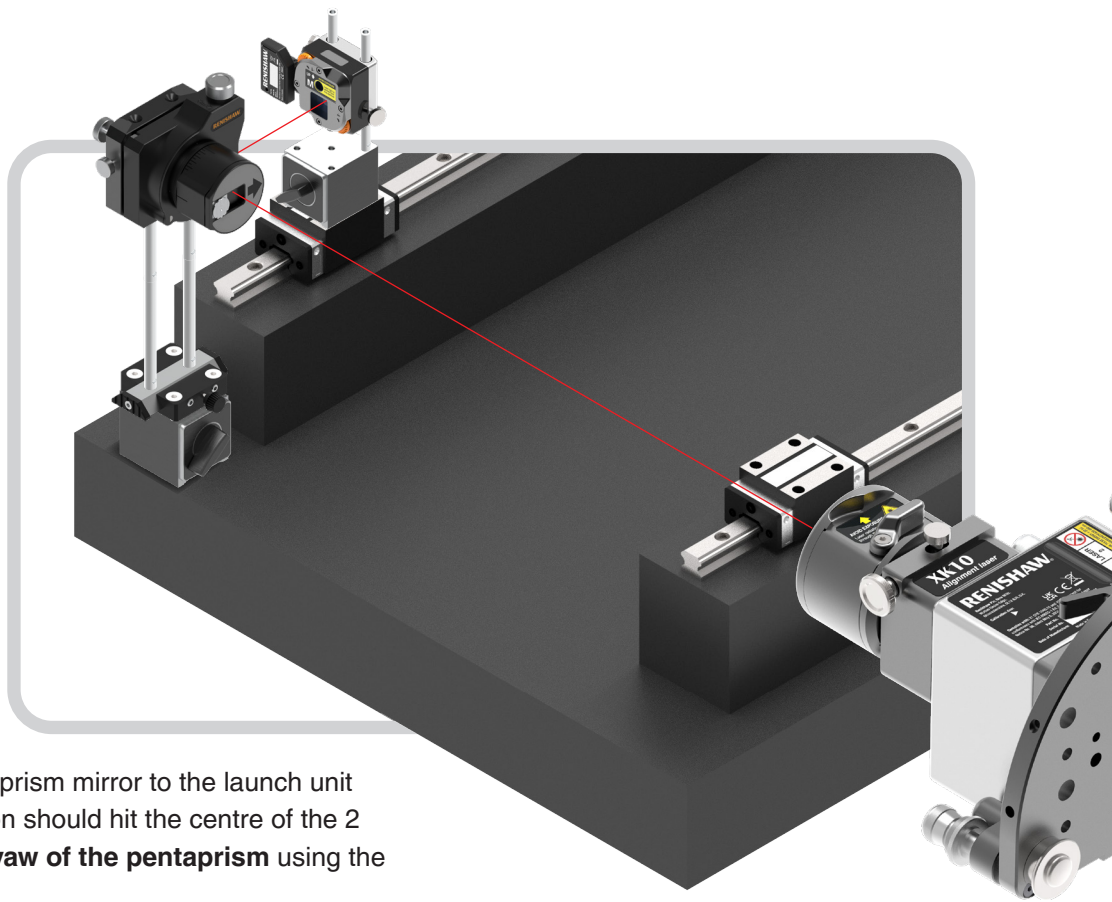
Align the pentaprism to the launch unit (measurement rail)



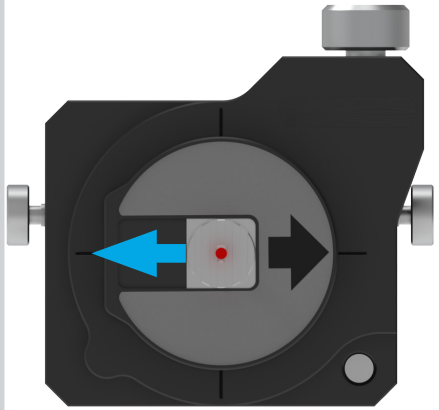


Carefully insert the beam reducer/ target into the output aperture of the launch unit.

Check the back-reflection from the pentaprism mirror to the launch unit output aperture target. The back-reflection should hit the centre of the 2 mm hole. If it does not, adjust the **pitch/yaw of the pentaprism** using the thumbscrew adjuster.

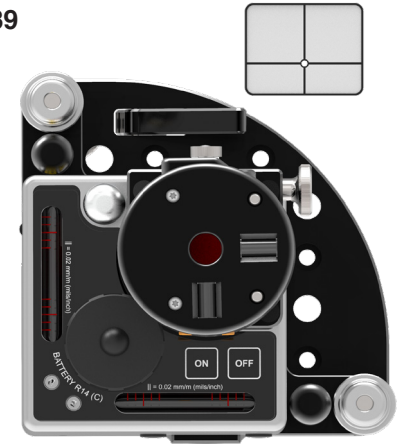
Align the pentaprism to the launch unit (measurement rail)

38



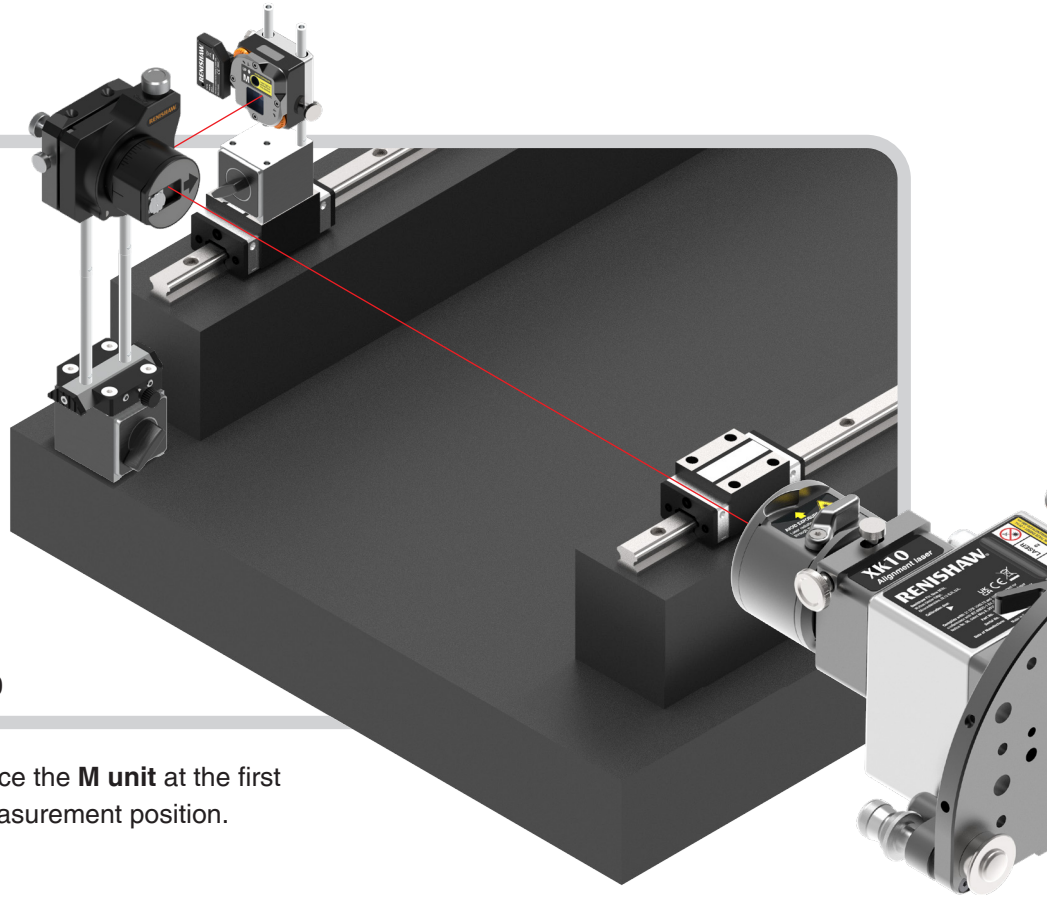
Slide the mirror/target away from the input aperture.

39



Carefully remove the target from the launch unit.

40

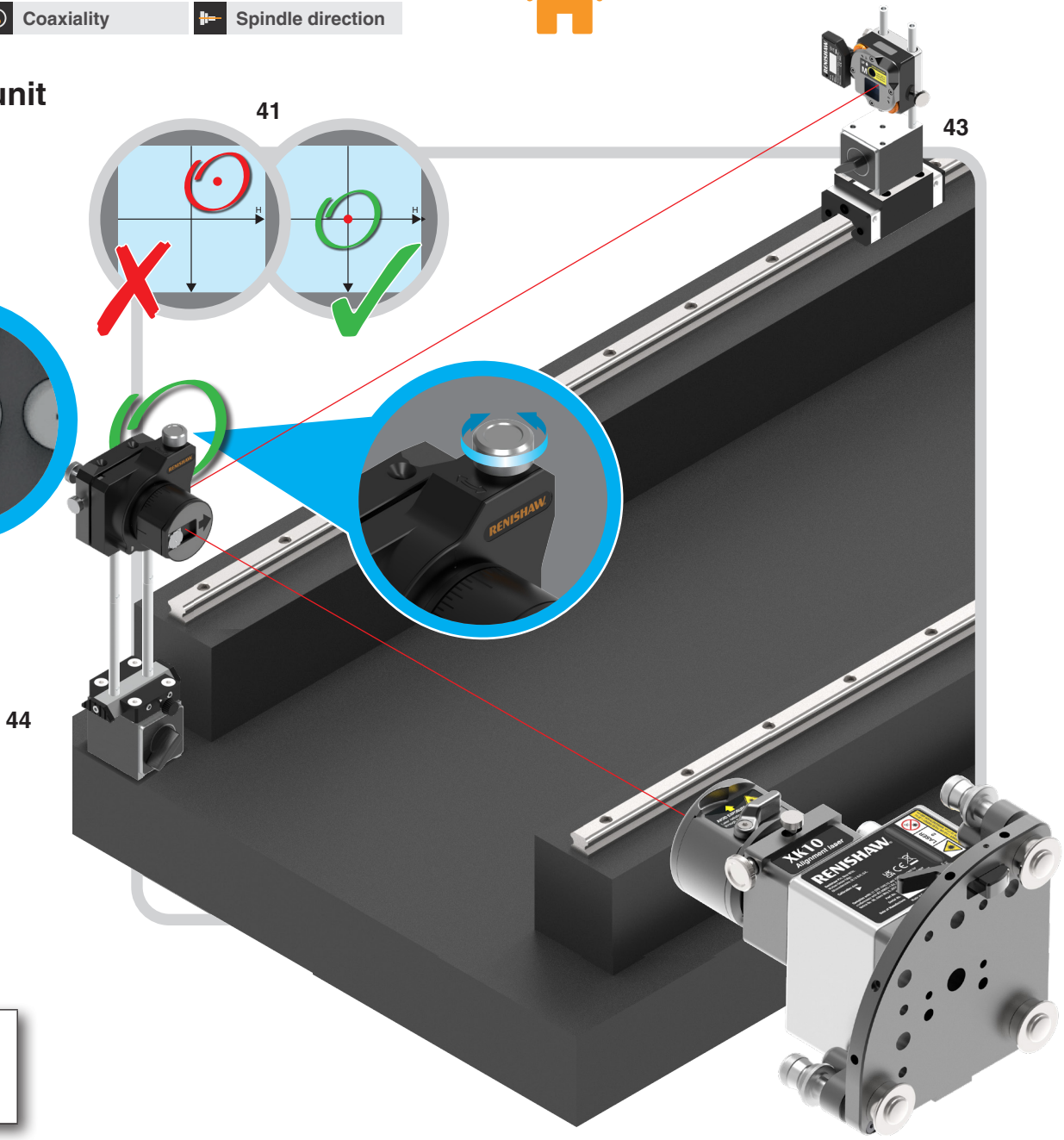


Place the **M unit** at the first measurement position.

Fine alignment of the pentaprism to the M unit

Select the 'Show target' function. **Translate the M unit** within ±1 mm of the centre.

Select '0' on the display unit to zero the laser reading.



Move the **M unit** to the furthest position on the structure.

Adjust the **pitch of the pentaprism** (relative to the M unit) so that the V value of the PSD is < 100 µm.

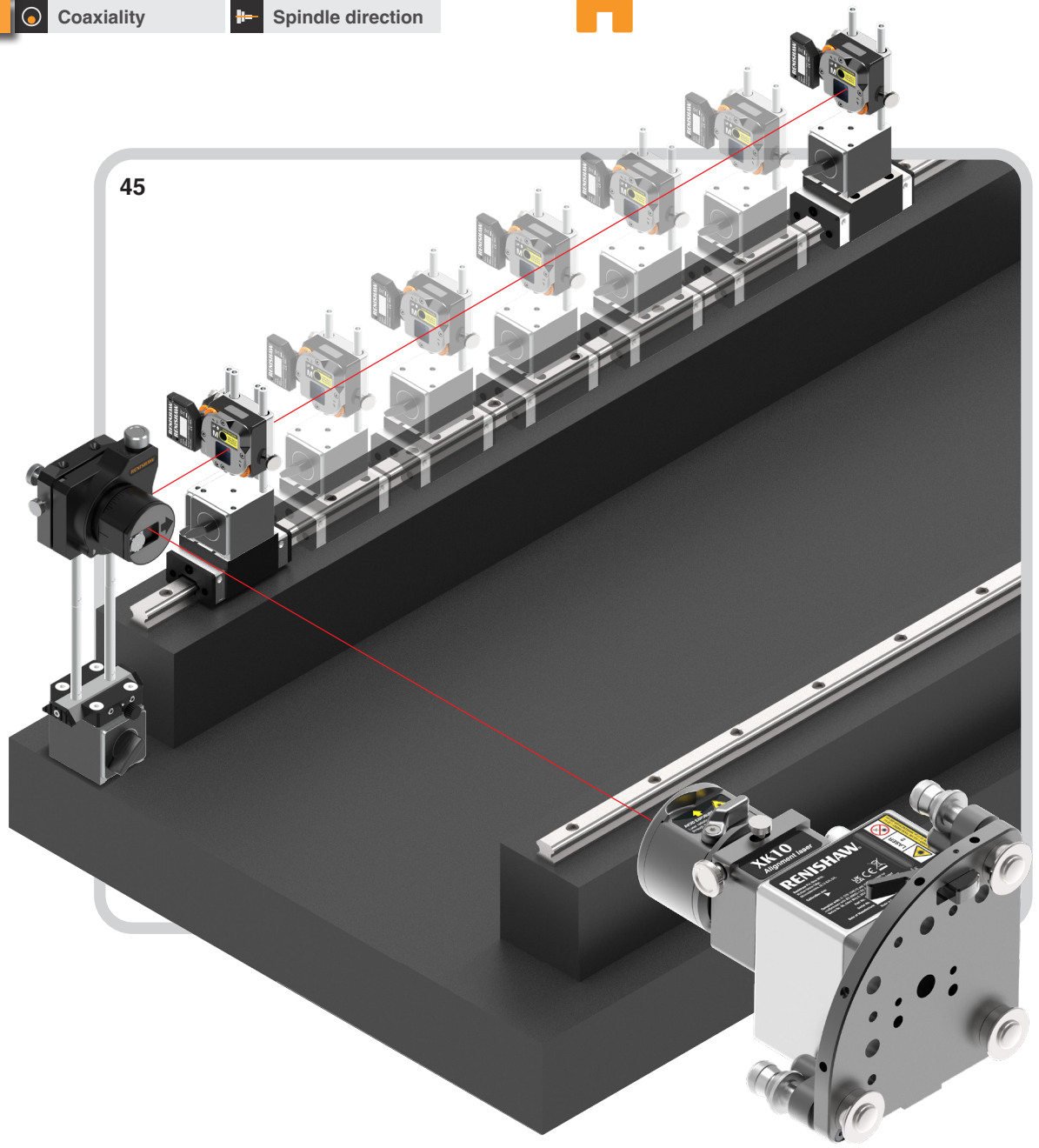
Move the M unit back to the first measurement position and repeat **steps 40 to 44** until the beam deviates < 100 µm.

Measure the measurement rail

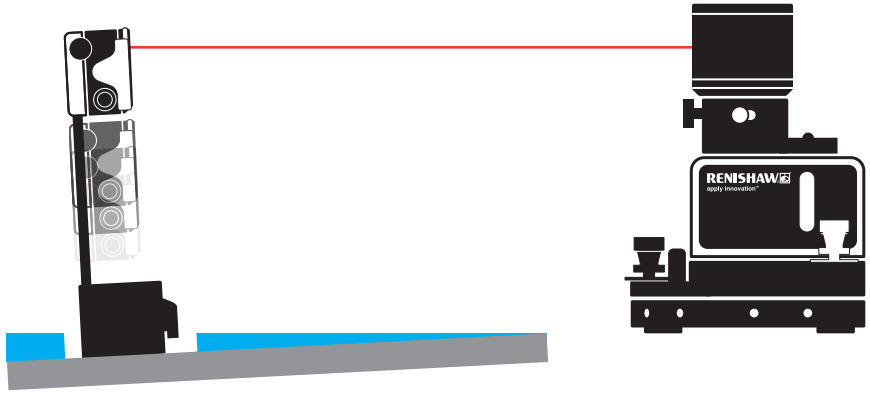
46

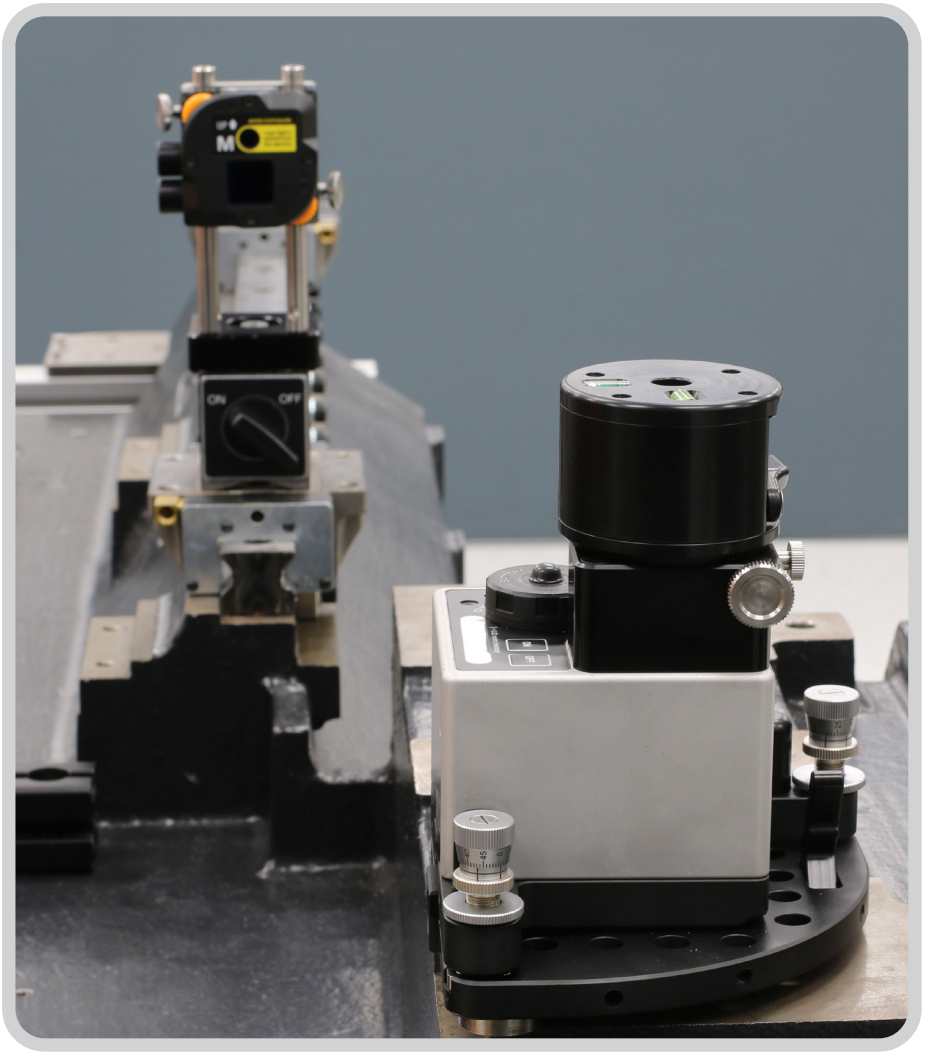
Capture all positions on the structure by moving the **M unit** to each position and pressing the orange button to capture the error.

After capturing the final position, data can then be saved and analysed.

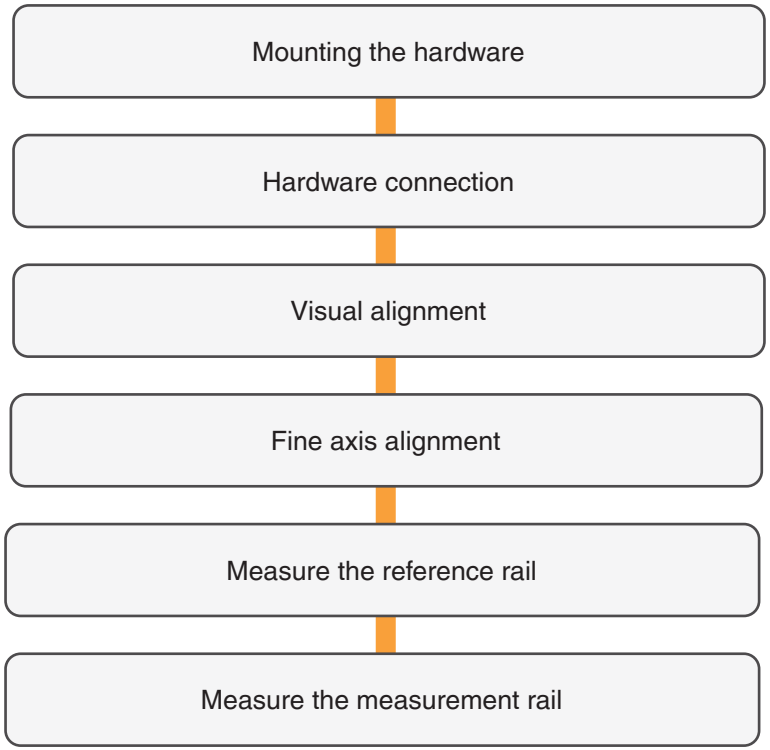


Parallelism (vertical)



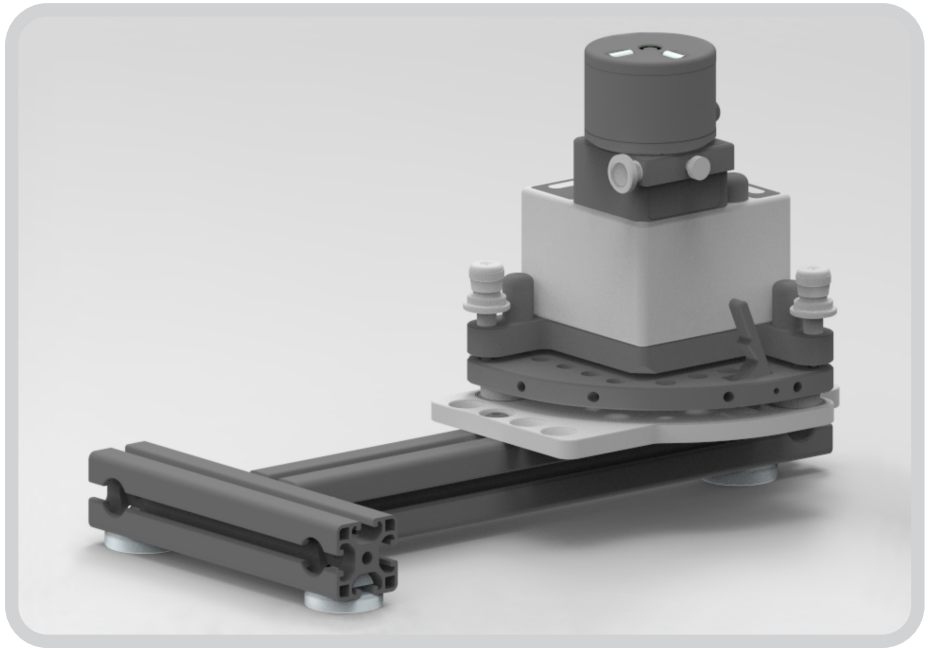


Overview


Mounting the hardware
Hardware connection
Visual alignment
Fine axis alignment
Measure the reference rail
Measure the measurement rail

Mounting the hardware

Fixture kit

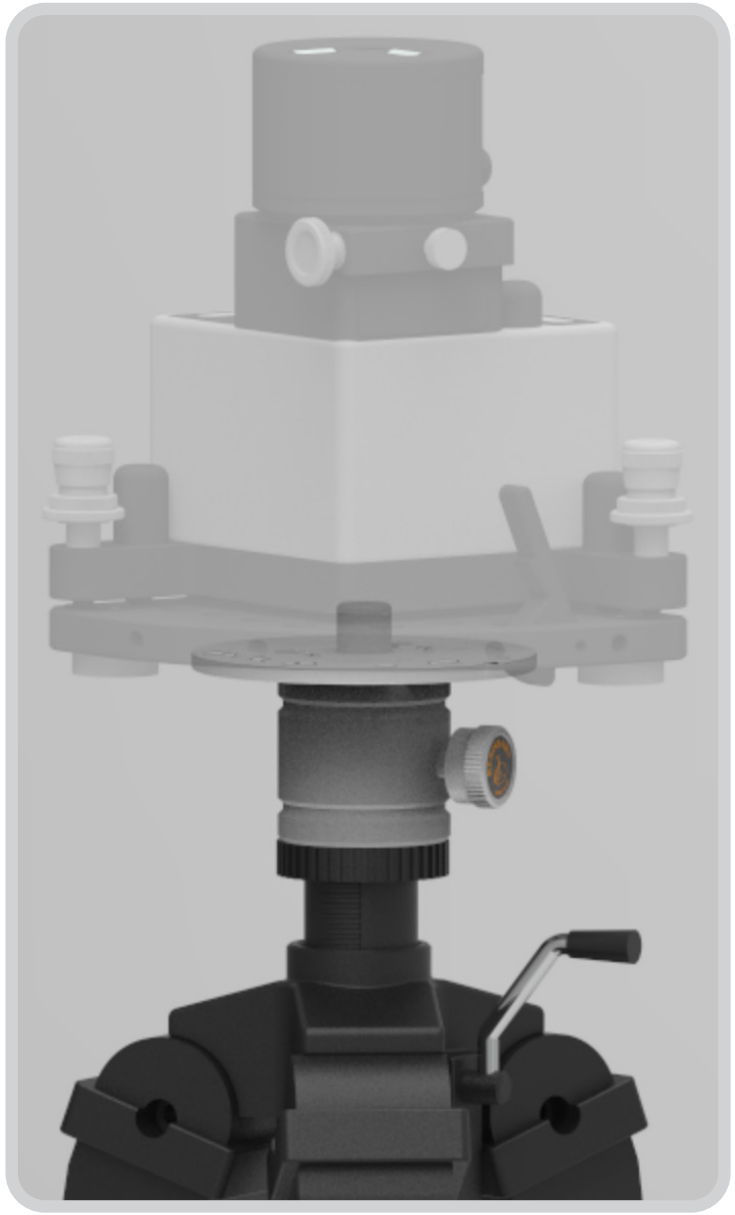


The launch unit can be mounted directly to the casting using the fixture kit ...

NOTE: The tripod should only be used where it is not possible to suitably fixture the launch unit to the machine structure. The launch unit is the reference, and as such, any instability in the tripod will impact the accuracy of any testing.

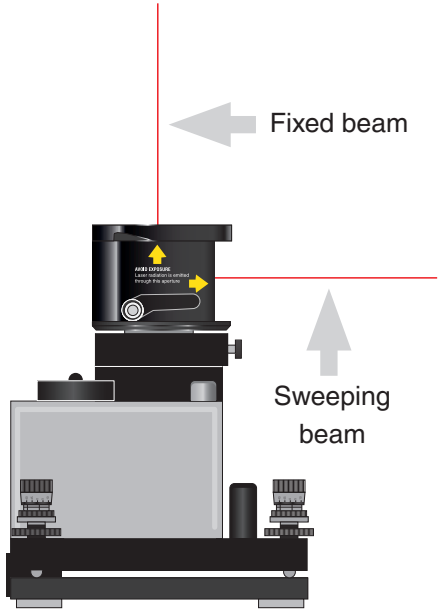
Tripod mount

…or by using the tripod mount on a suitable tripod.

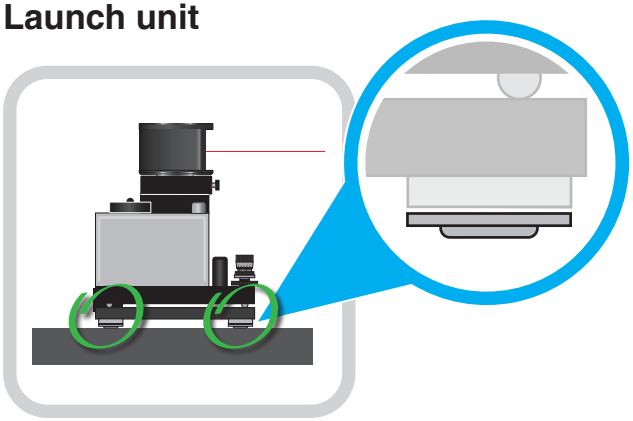


Mounting the hardware

- Vertical parallelism measurements are made with the launch unit and the M unit.
- The sweeping beam is used for vertical parallelism measurements.



Launch unit



Non-magnetic feet can be used on non-ferrous surfaces, for example, granite tables.

Mounted to the surface of measurement.

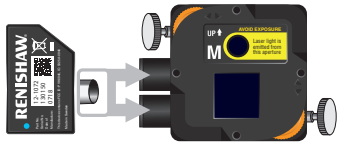
M unit

Mounted on a rotational magnetic base.

Mounted to a reference mount, on a rotational element.

Hardware connection

1



Insert the wireless module into the M unit.

2

Power on the display unit.

3

Select the 'Settings' icon.

4

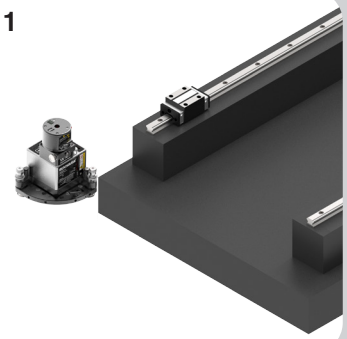
Select the 'Wireless' icon.

5

Enable the wireless device plugged into the M unit.

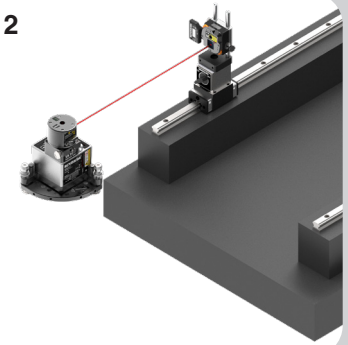
Alignment - Visual alignment

1



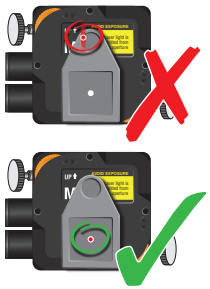
Position the launch unit to measure the reference rail, mounted either to the structure or the tripod.

2



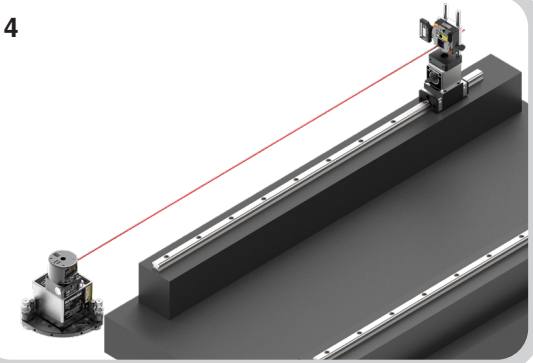
Move the M unit to the first measurement position on the reference rail.

3



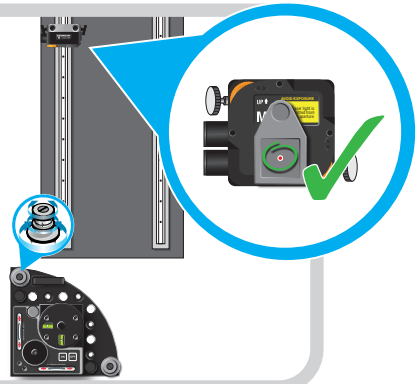
Adjust the height of the M unit on the pillars so that the beam aligns with the centre of the target.

4



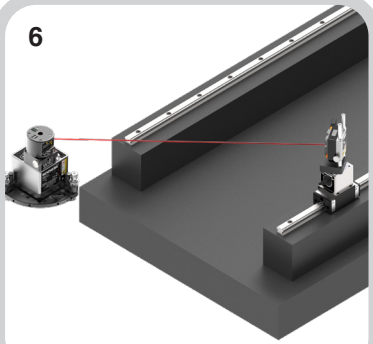
Move the M unit to the furthest measurement position on the reference rail.

5



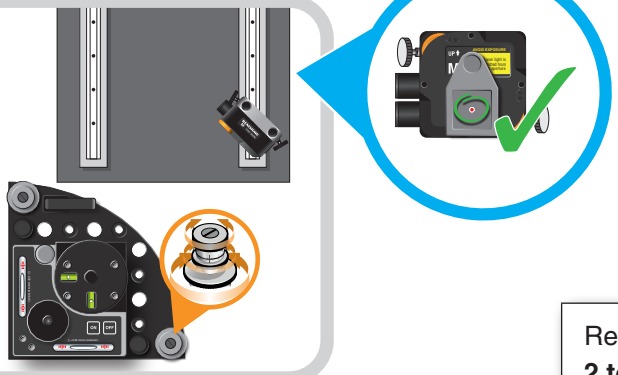
Align the beam onto the centre of the target by rotating the sweeping beam for horizontal alignment and use the pitch/yaw adjusters for vertical alignment.

6



Move the M unit to the first measurement position on the measurement rail.

7



Align the beam onto the centre of the target by rotating the sweeping beam for horizontal alignment and use the pitch/yaw adjusters for vertical alignment.

Repeat **steps 2 to 7** until the beam remains on the centre of the target in all three positions.

Alignment

Fine axis alignment

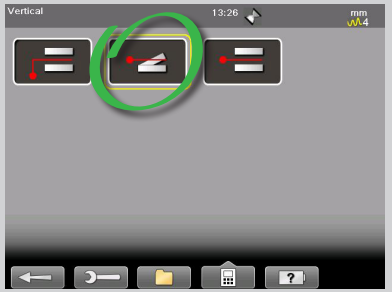
8

With the M unit at the first position on the reference rail, remove the target.

9

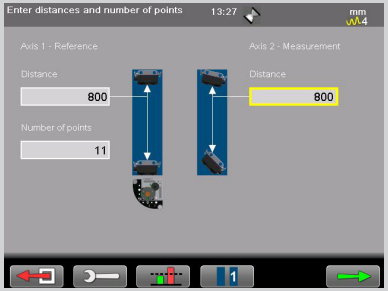
Select 'Parallelism'.

10



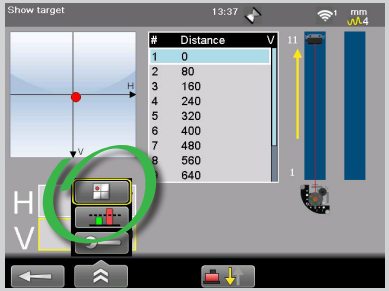
Select 'Vertical parallelism'.

11



Input parameters for the test.

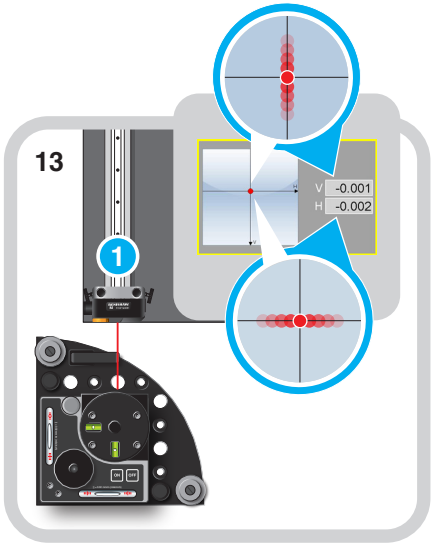
12



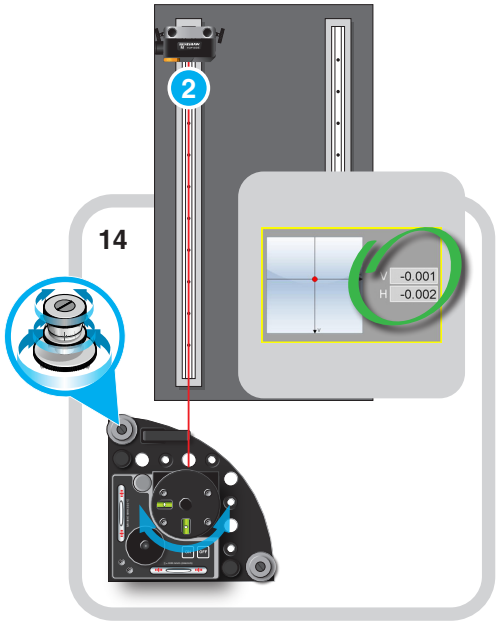
Select the 'Show target' function.

Alignment

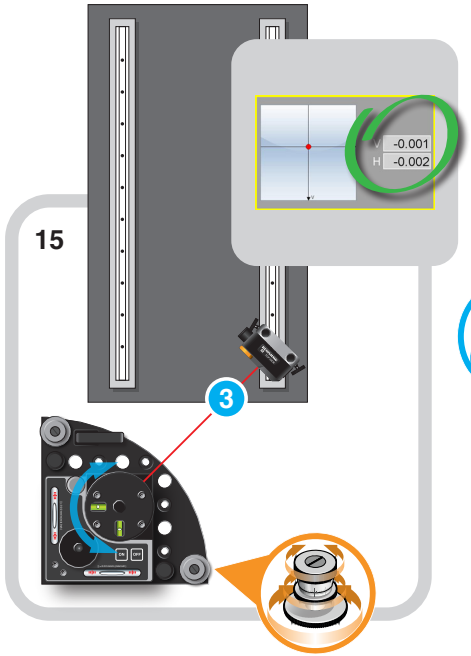
Fine axis alignment



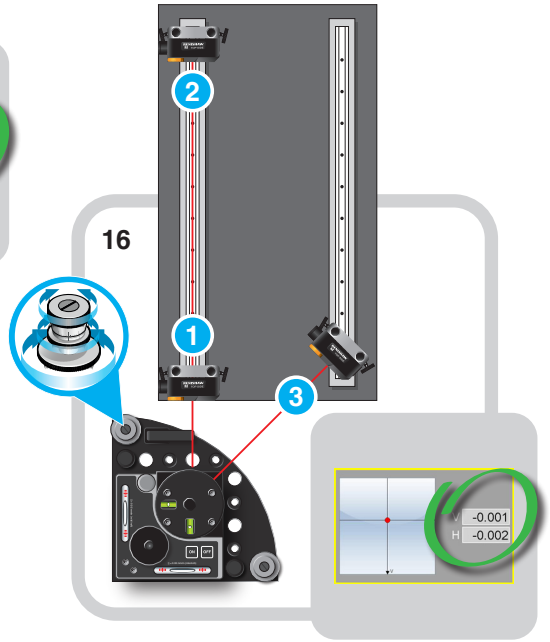
'Zero' the laser reading.



Move the **M unit** to the last position on the reference rail. Rotate the sweeping beam so that the H value is ±1 mm. **Adjust the V value within the alignment tolerance*.**



Move the **M unit** to the first position on the measurement rail. Rotate the sweeping beam so that the H value is ±1 mm. **Adjust the V value within the alignment tolerance*.**



Repeat the alignment process until the vertical alignment at all three points is **within the alignment tolerance*.**

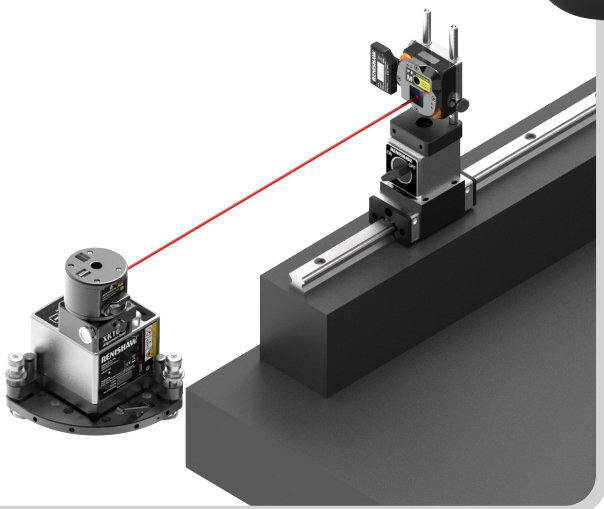
NOTE: *value of ±100 µm

Measure the reference rail

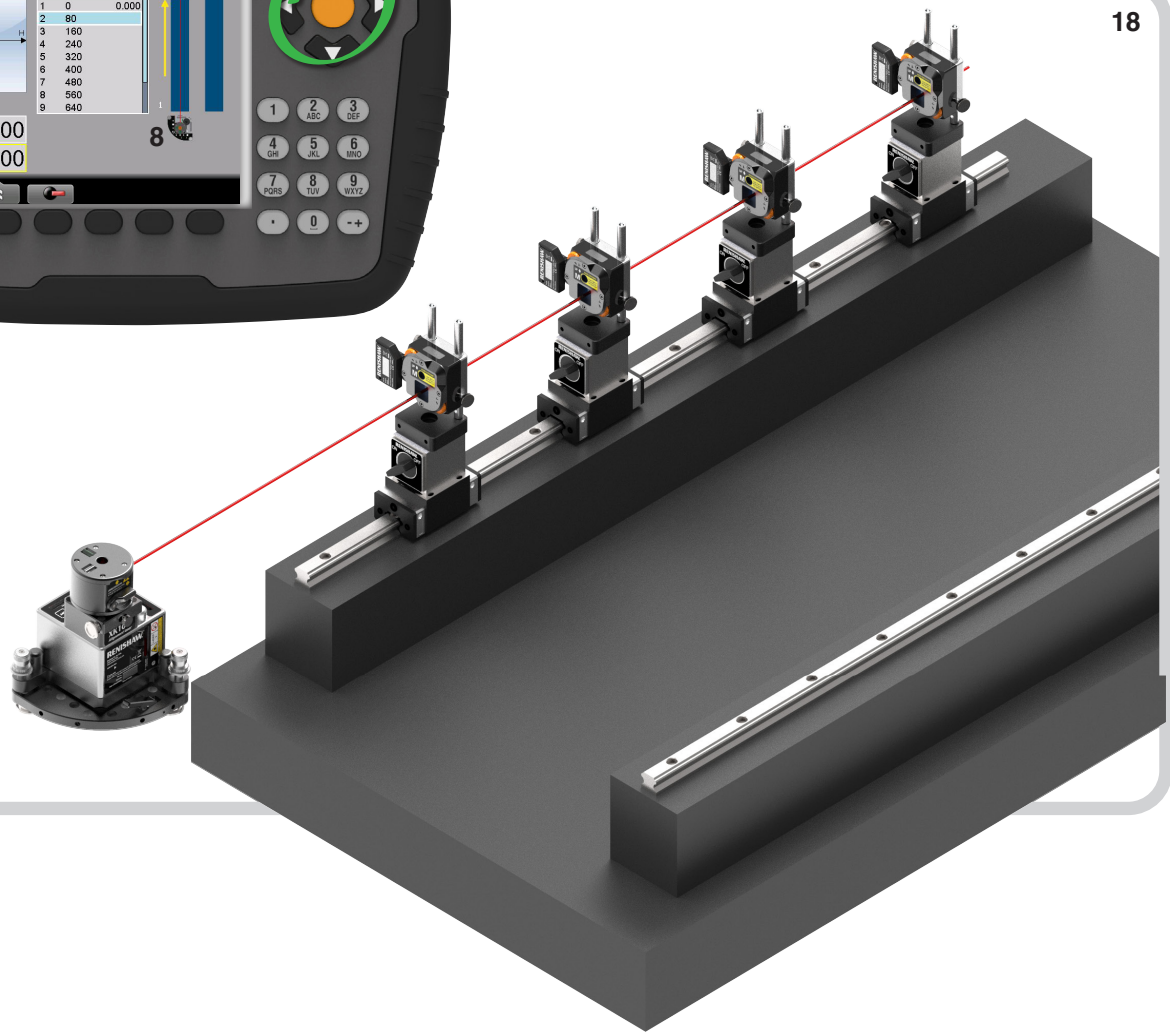
Position the **M unit** at the first measurement position.

Capture all positions on the structure by moving the **M unit** to each position and pressing either orange button to capture the error.

17

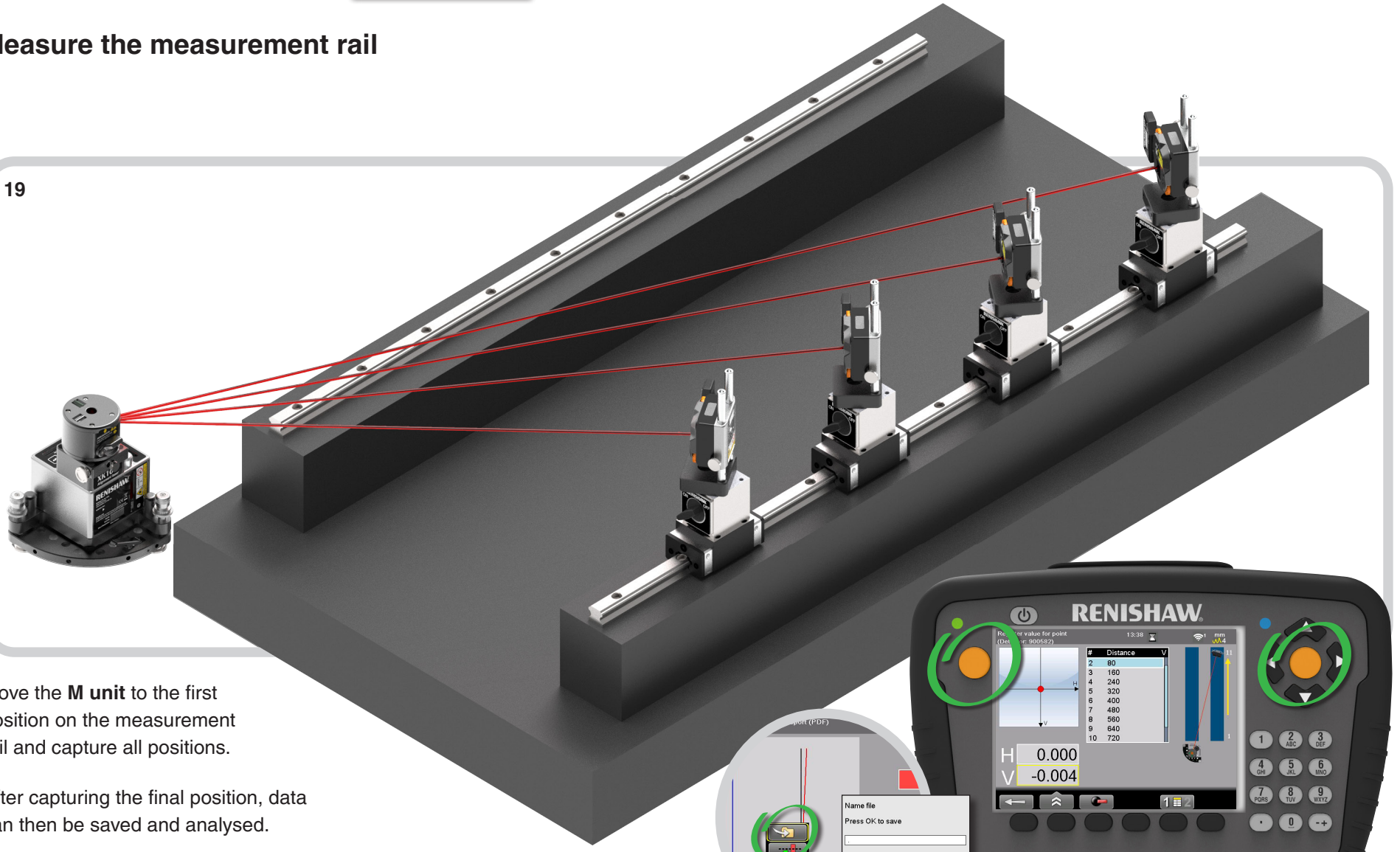


18



Measure the measurement rail

19



Move the **M unit** to the first position on the measurement rail and capture all positions.

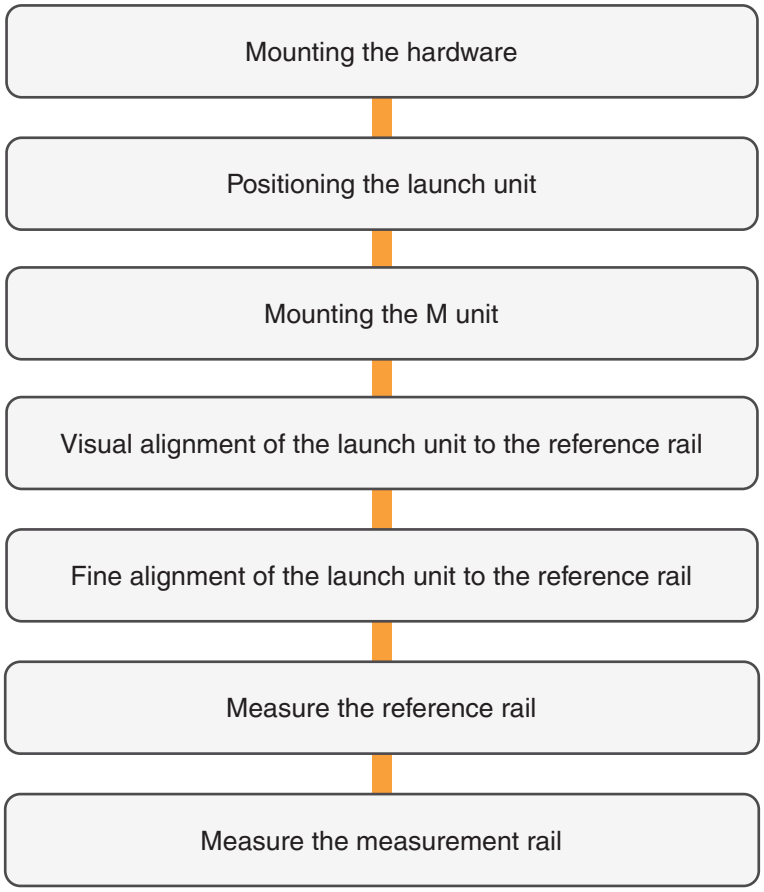
After capturing the final position, data can then be saved and analysed.

20

Parallelism (combined horizontal and vertical)

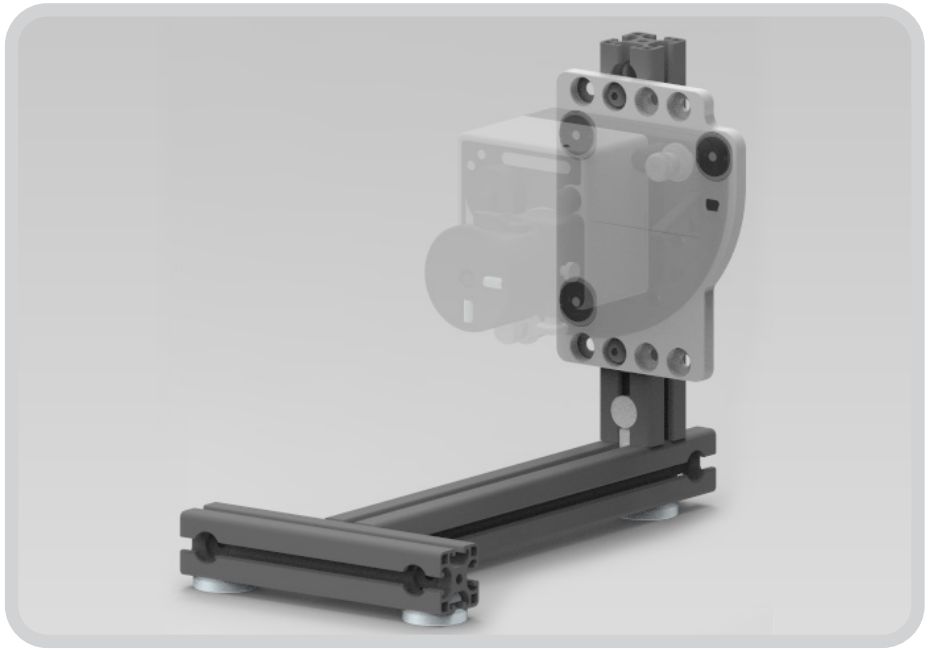
NOTE: For further information, see **Appendix D**.

Overview


Mounting the hardware
Positioning the launch unit
Mounting the M unit
Visual alignment of the launch unit to the reference rail
Fine alignment of the launch unit to the reference rail
Measure the reference rail
Measure the measurement rail

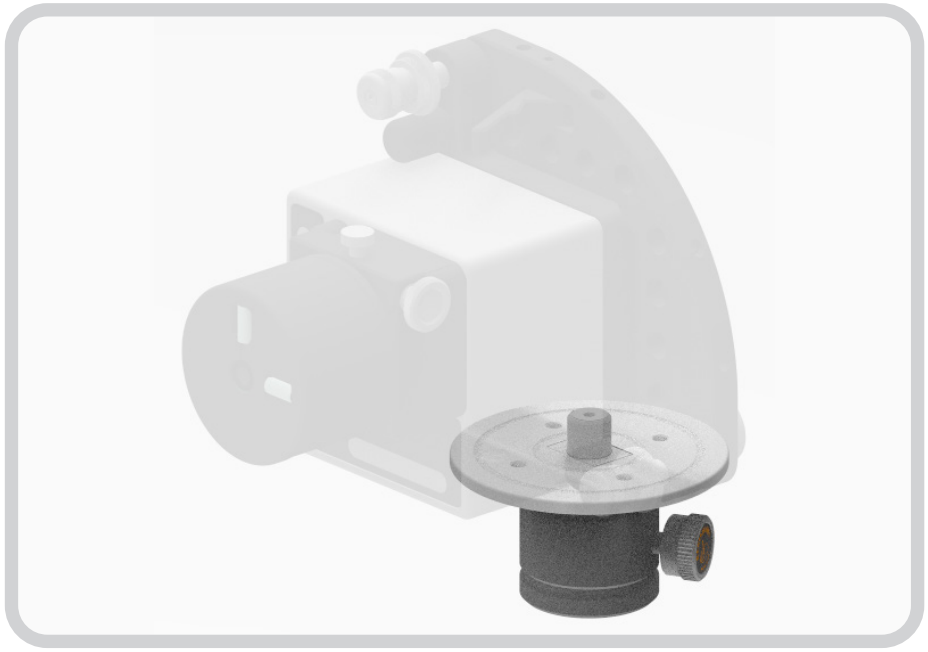
Mounting the hardware

Fixture kit



The launch unit can be mounted directly to the casting using the fixture kit ...

Tripod mount



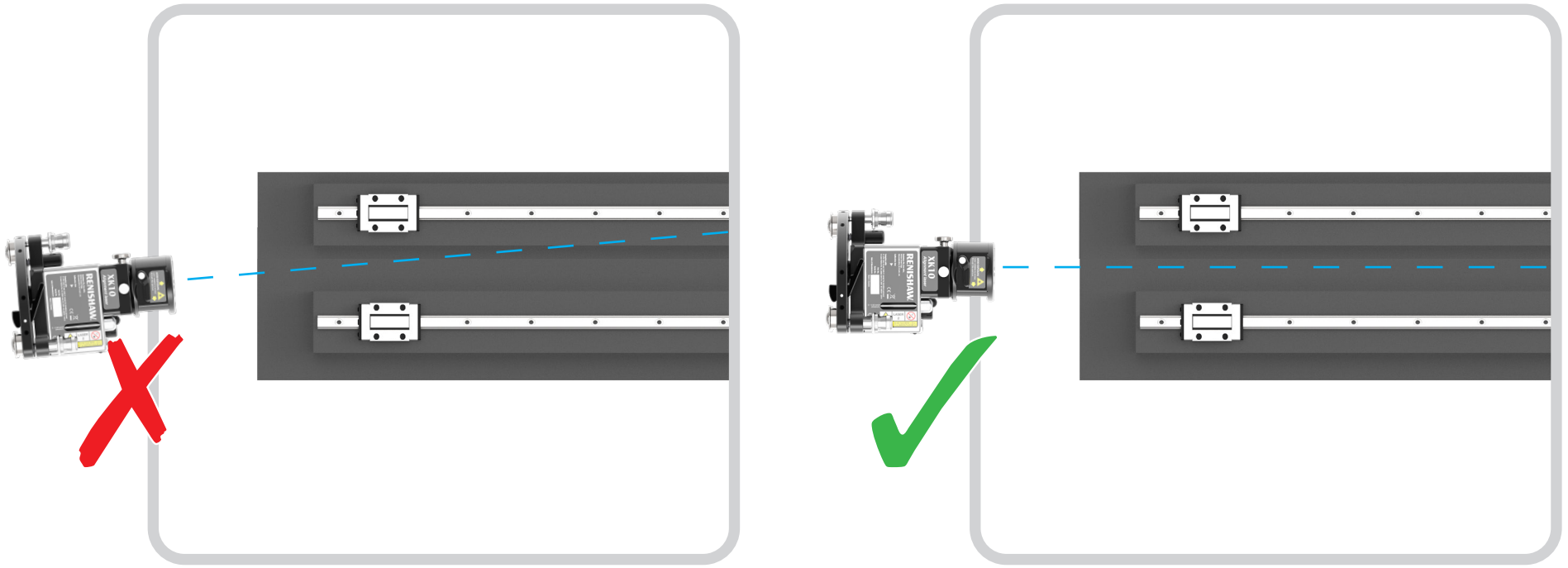
... or using the tripod mount on a suitable tripod.

NOTE: The tripod should only be used where it is not possible to suitably fixture the launch unit to the machine structure. The launch unit is the reference, and as such, any instability in the tripod will impact the accuracy of any testing.

Positioning the launch unit

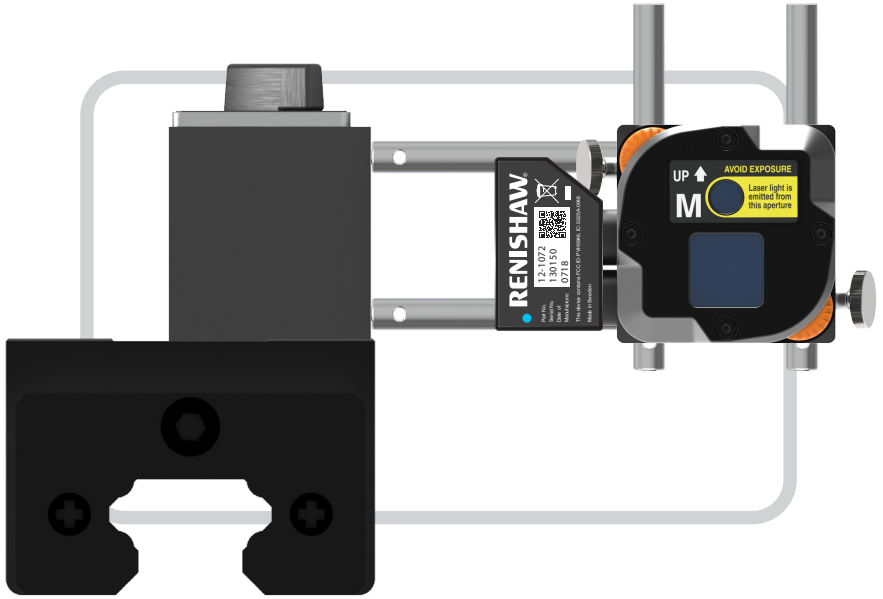
Visually position the launch unit parallel to the measurement rails.

(It is good practice to approximately level the launch according to the spirit levels).



Mounting the M unit

Using the 90 degree bracket, mount the M unit to the carriage using the standard magnetic base.



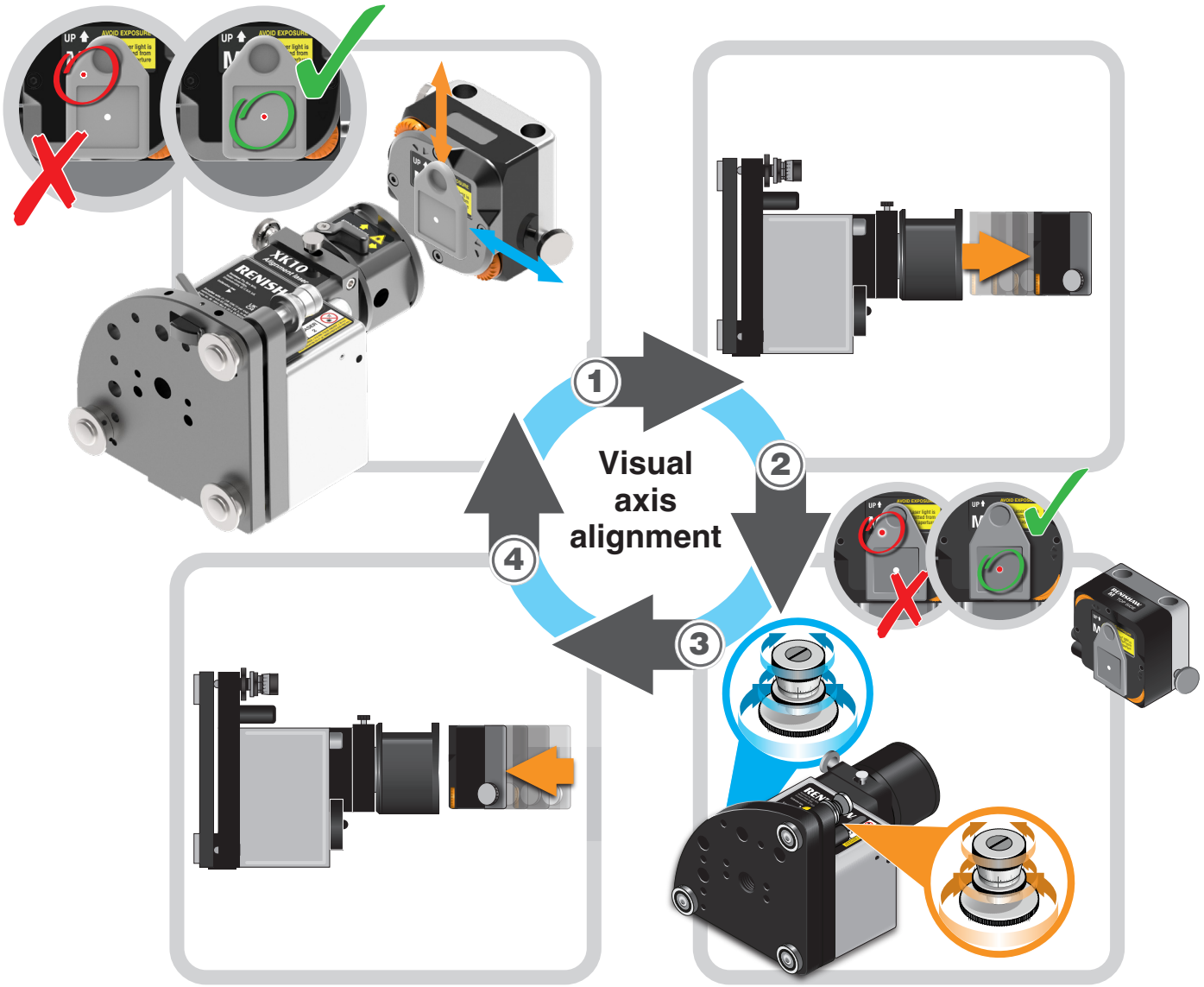
NOTE: It is recommend to only use one set of pillars. If more pillars are needed, it suggests the span of the rail is too large, increasing the risk of roll errors impacting the straightness reading.

Alignment

Visual alignment

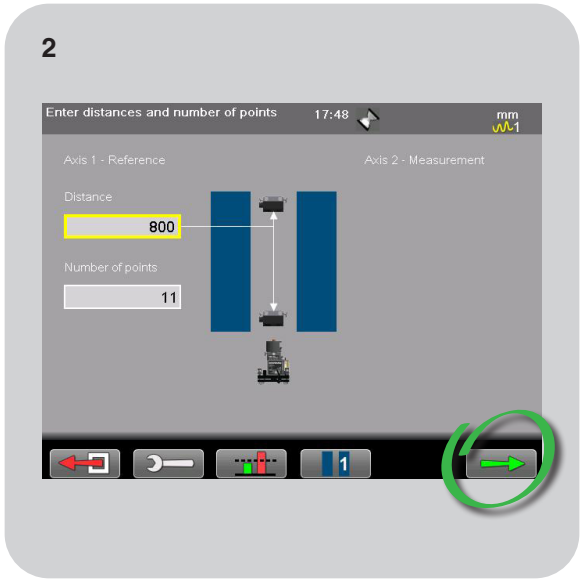
Start by positioning the M unit so it's visually centered between the rails.

Continue the illustrated process until the beam stays on the target along the full axis.

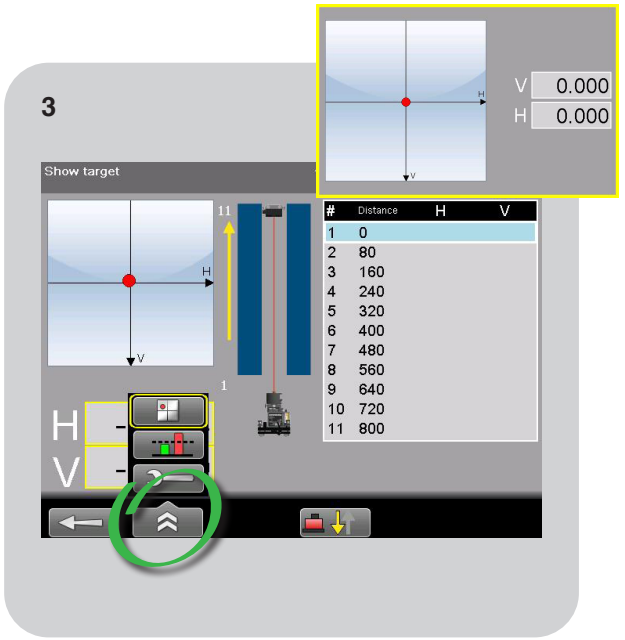


Test definition and visual setup

Load the 'Parallelism' option – select the 'Horizontal and vertical' mode.



Input the parameters for the test set-up. Select the green arrow.



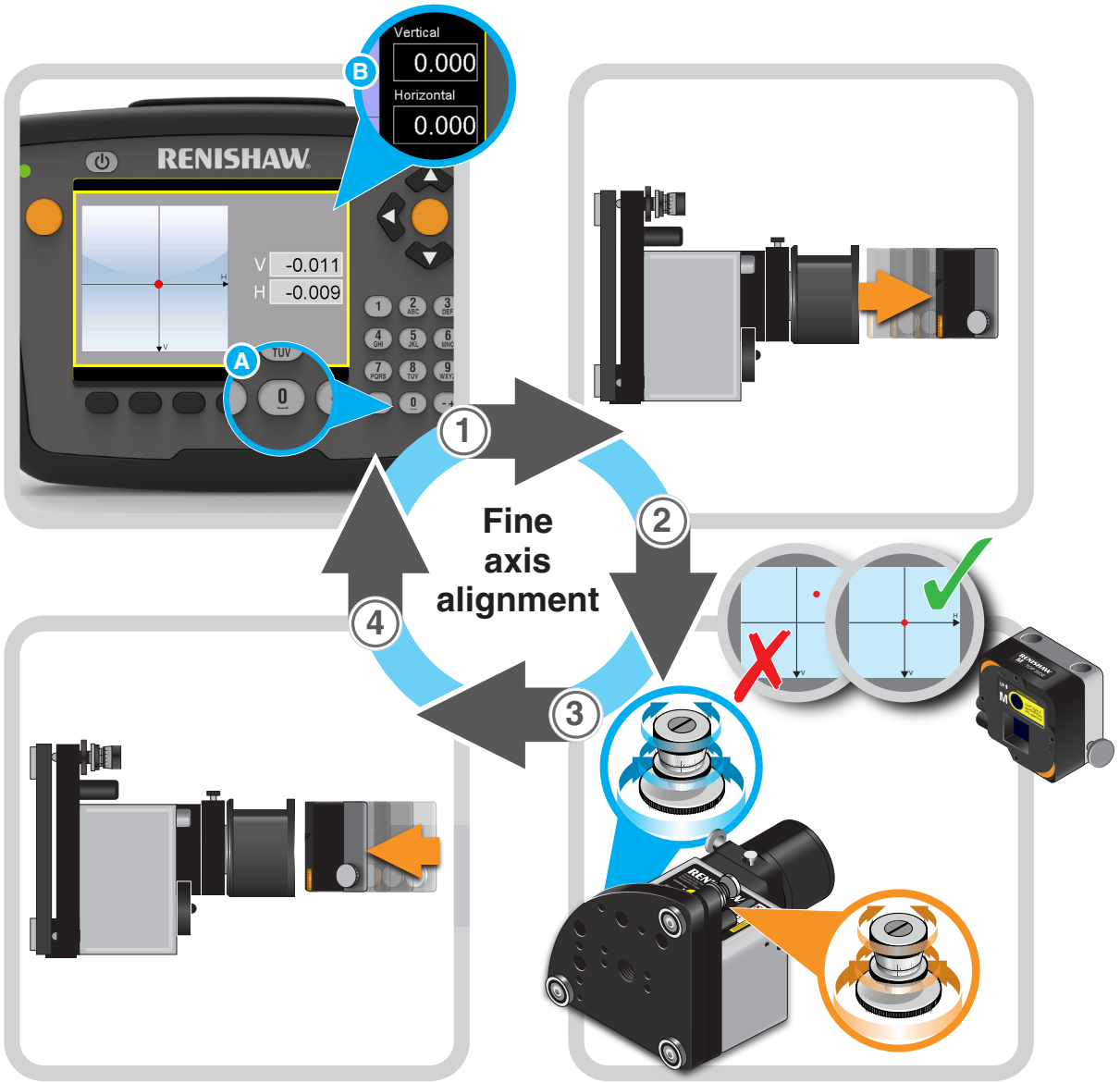
Select the 'Show target' view, remove the target from the M unit and zero the laser reading.

NOTE: Select the 'Launch orientation' icon to change the reference rail/location of the launch unit.

Alignment

Fine axis alignment

Continue the process shown until the beam stays **within the alignment tolerance (value of ±100 µm)** over the measurement range.

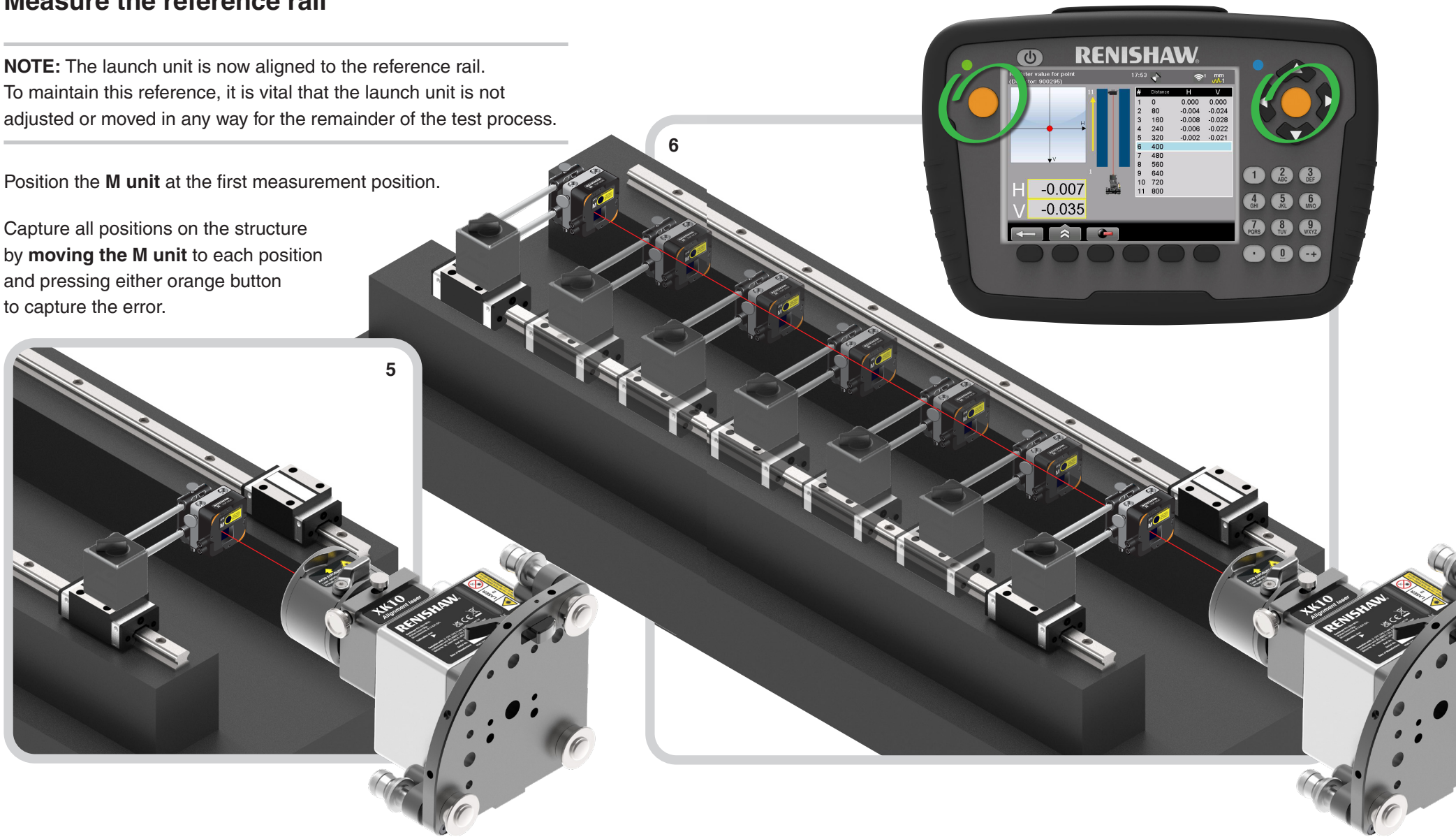


Measure the reference rail

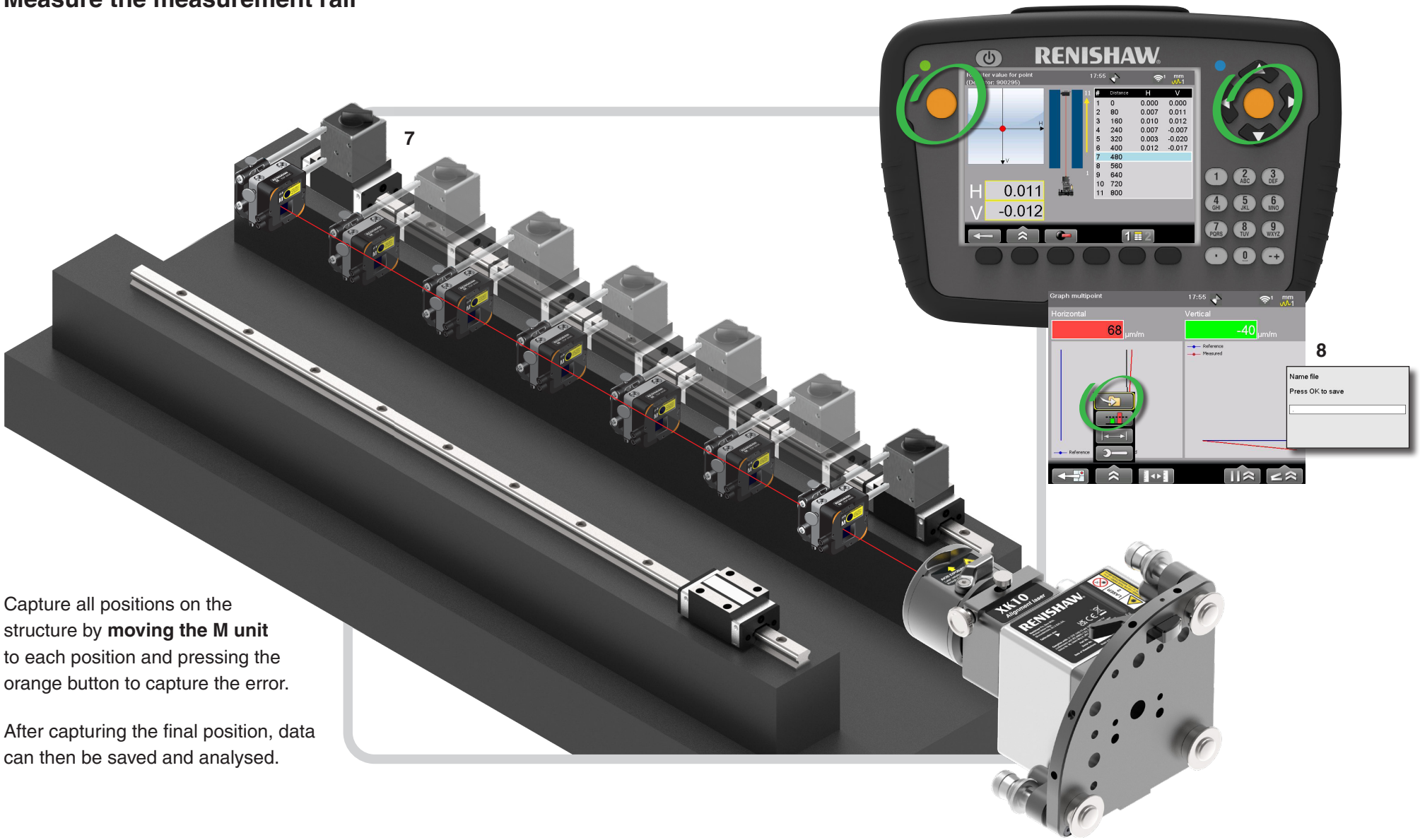
NOTE: The launch unit is now aligned to the reference rail. To maintain this reference, it is vital that the launch unit is not adjusted or moved in any way for the remainder of the test process.

Position the **M unit** at the first measurement position.

Capture all positions on the structure by **moving the M unit** to each position and pressing either orange button to capture the error.



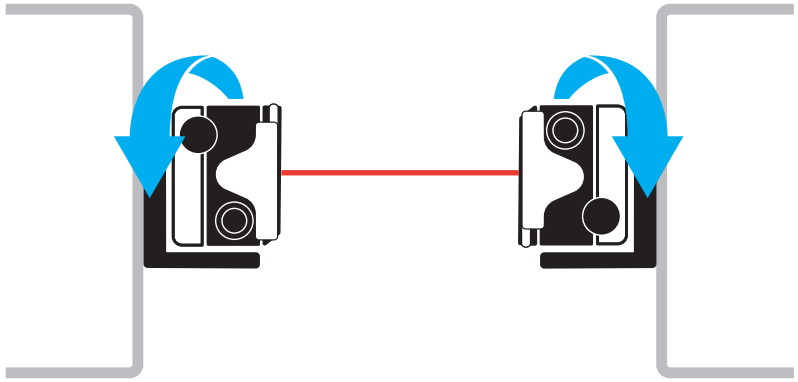
Measure the measurement rail

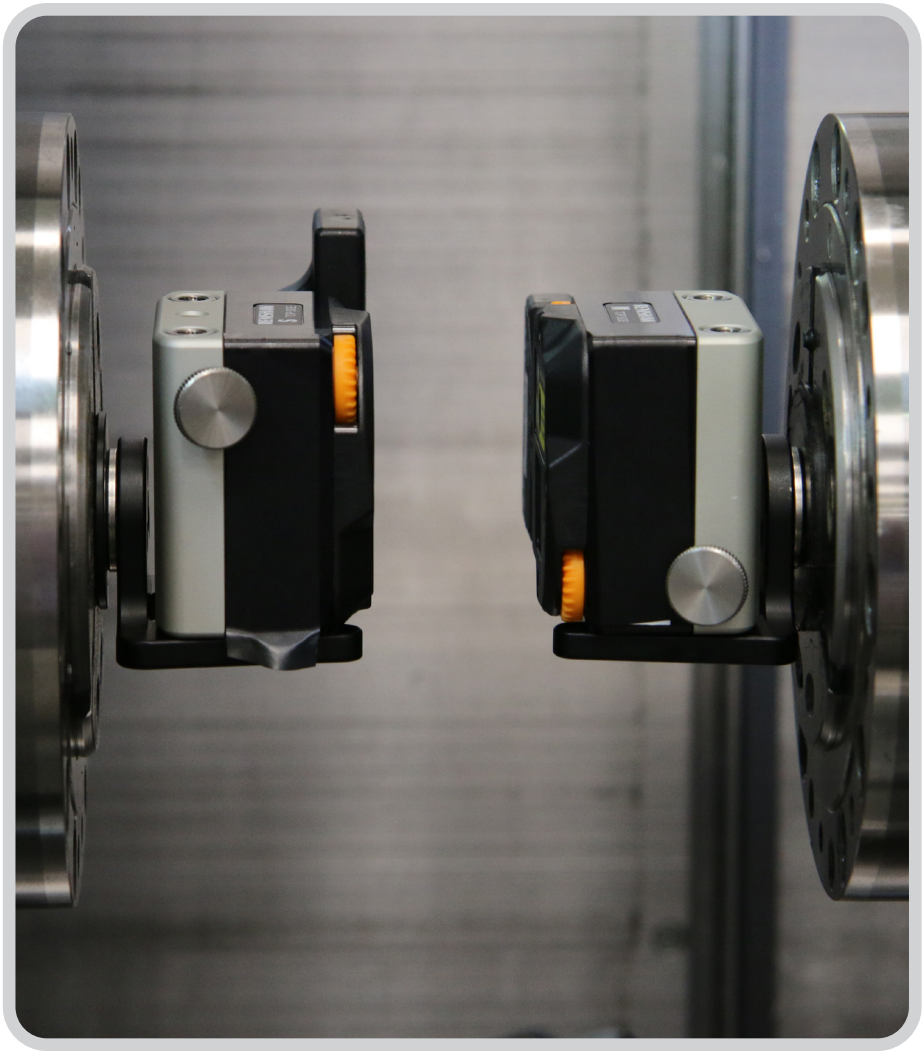


Capture all positions on the structure by **moving the M unit** to each position and pressing the orange button to capture the error.

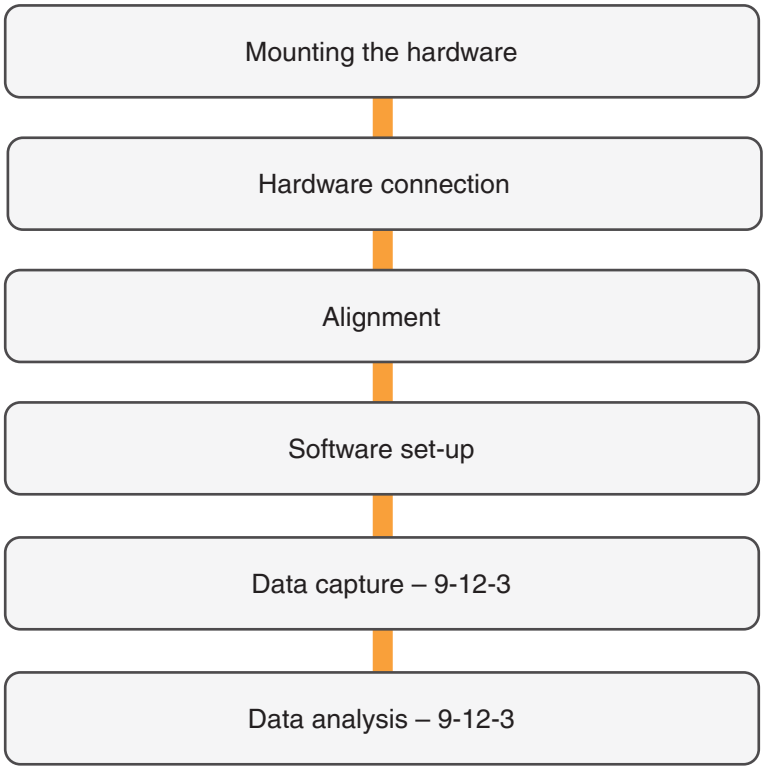
After capturing the final position, data can then be saved and analysed.

Coaxiality



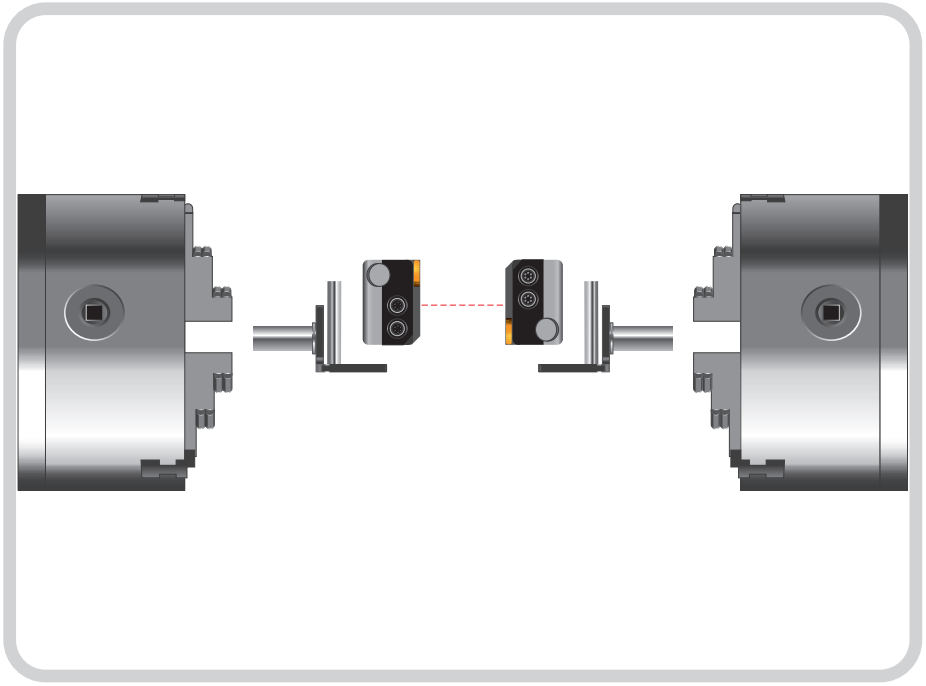


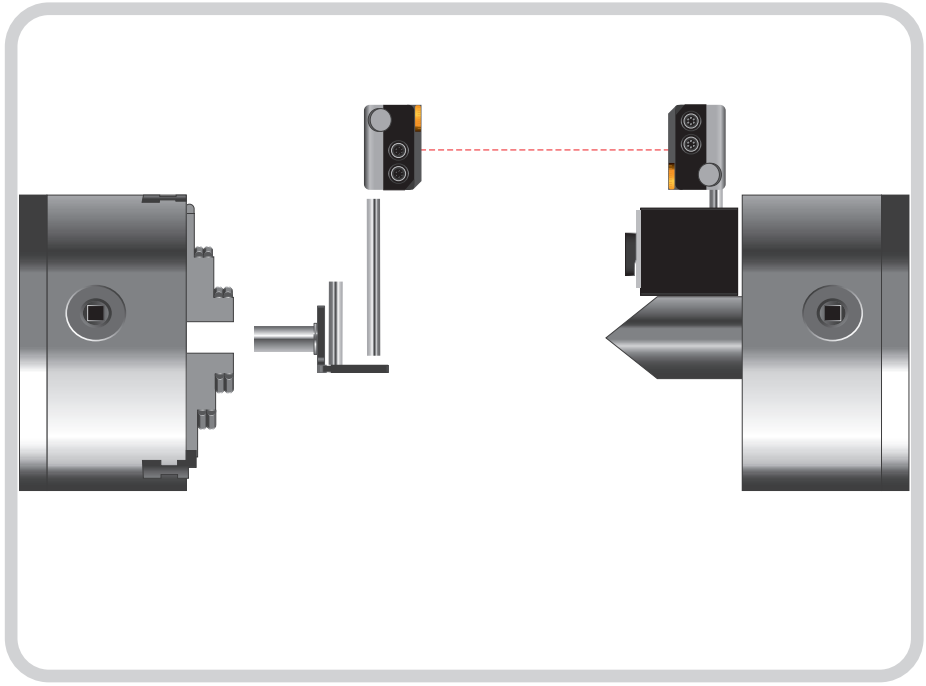
Overview


Mounting the hardware
Hardware connection
Alignment
Software set-up
Data capture – 9-12-3
Data analysis – 9-12-3

Mounting the hardware

Coaxiality measurements are made with the S unit and the M unit.





The S unit mounted on the main spindle and the M unit in the sub-spindle/tailstock.

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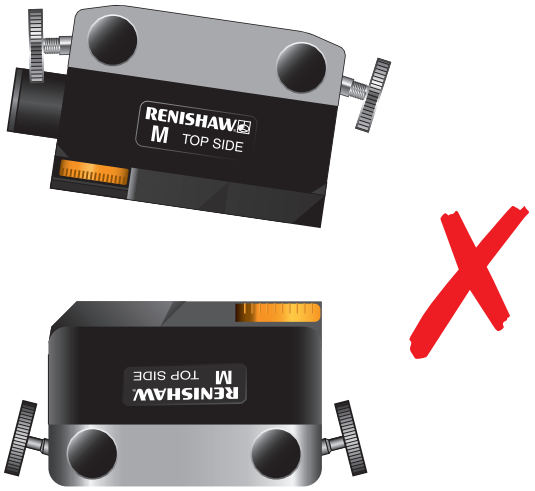
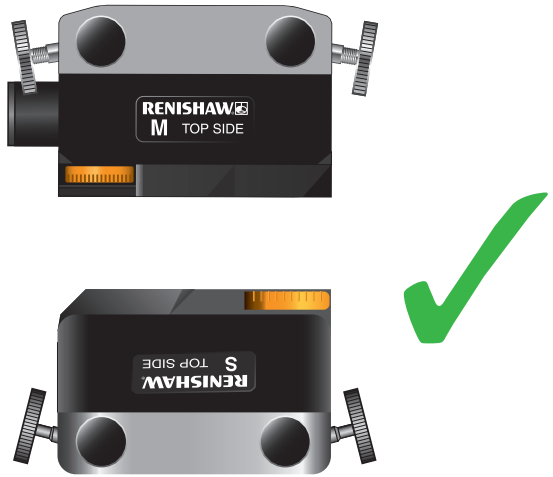
Mounting the hardware – best practice



Check that the S unit and M unit are square to each other.



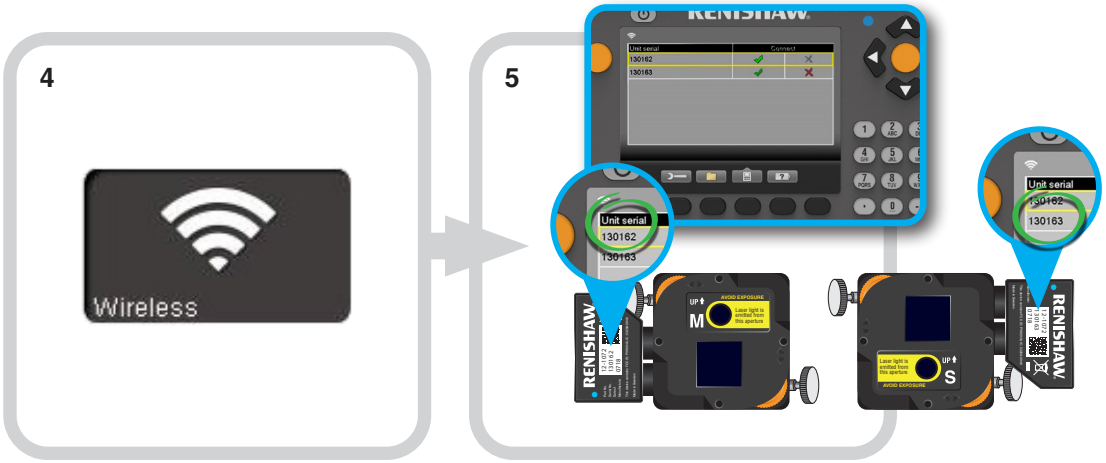
Adjust the M unit until it is square with the S unit.

Hardware connection

Insert the wireless module into the S unit and M unit.

Power on the display unit.

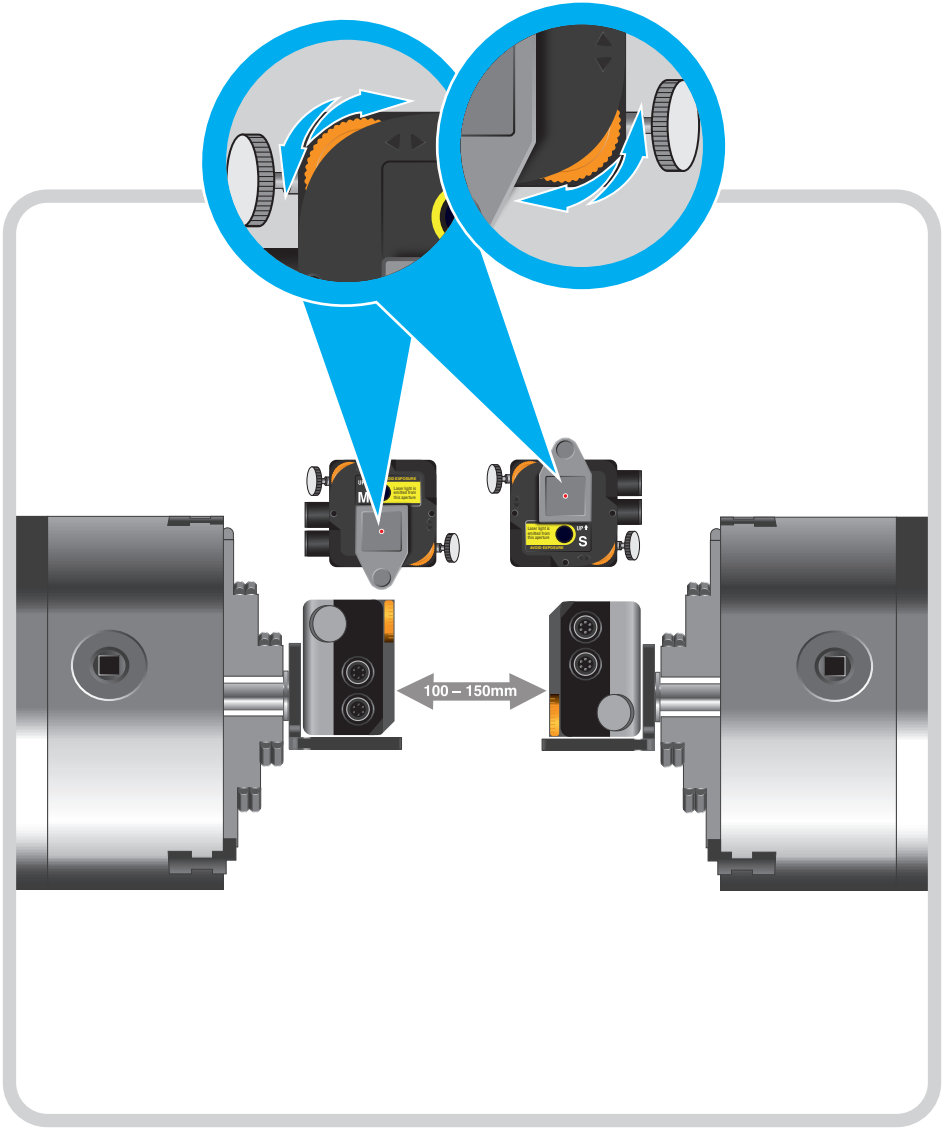
Select the 'Settings' icon.



Select the 'Wireless' icon.

Enable the wireless device plugged into the S unit and M unit.

Alignment



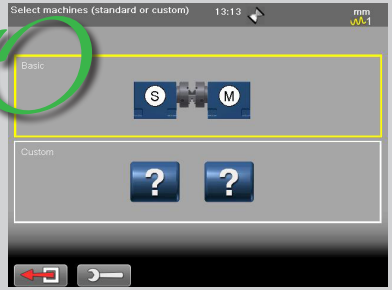
Ensure both beams are on the centre of the targets.
Use the orange beam steerers to align the beams onto the centre.

Software set-up

1

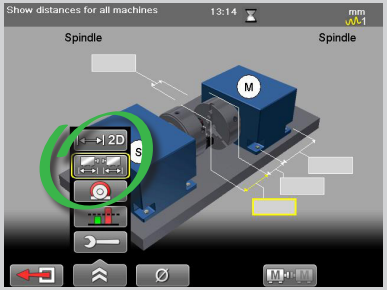
Select 'Coaxiality' on the display unit.

2



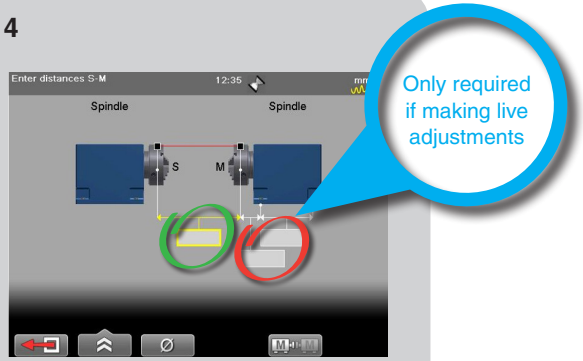
Select the 'Basic' configuration.

3



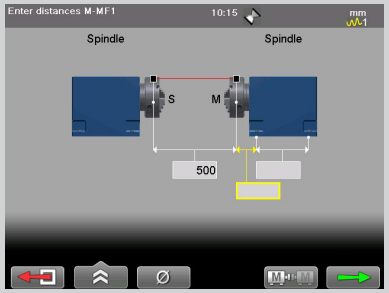
View the configuration in 2D or 3D.

4



Input the S-M distance.

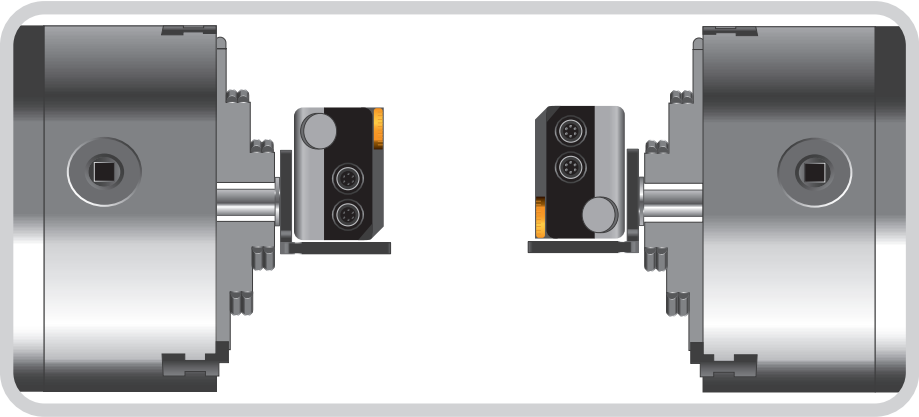
5



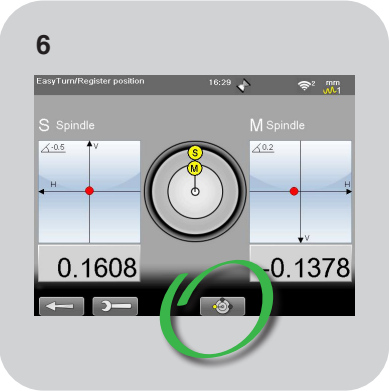
NOTE: If not making live adjustment, input S-M distance and press orange button on display unit.

Data capture – 9-12-3

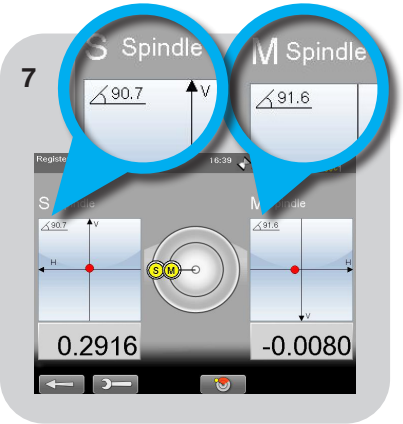
Rotate the shafts so that the S unit and M unit are orientated upwards.



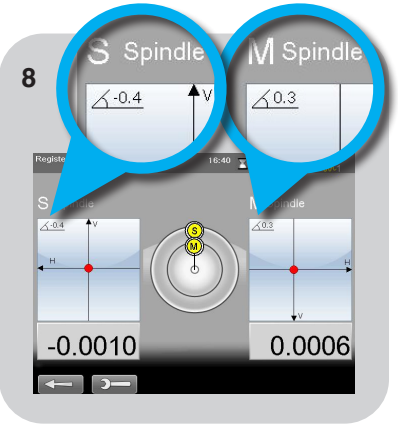
NOTE: If rotating by hand, aim for < 2 degrees angular difference between the S unit and the M unit. If rotating under machine control, match the position of both spindles on the controller.



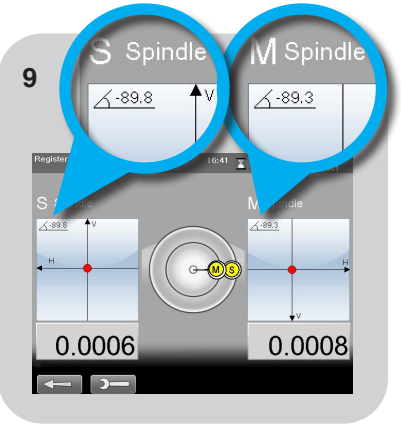
Select the '9-12-3' method.



Rotate both the S unit and the M unit until they align with the 9 o'clock position. Capture the first point.



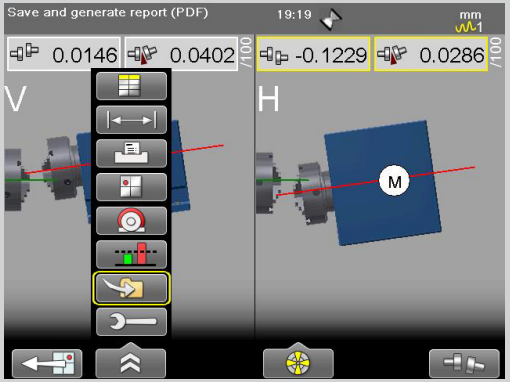
Repeat to capture the 12 o'clock position. Capture the second point.



Repeat to capture the 3 o'clock position. Capture the final point.

Data analysis – 9-12-3

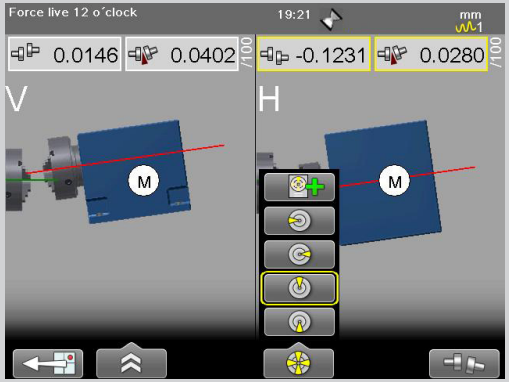
10



View live coaxiality results for vertical and horizontal.

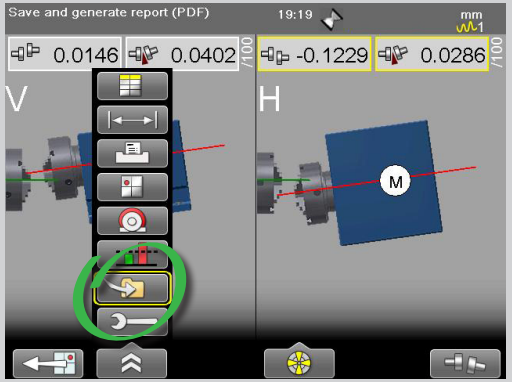
NOTE: Live view will only be enabled when inputting foot spacings on set-up page.

11



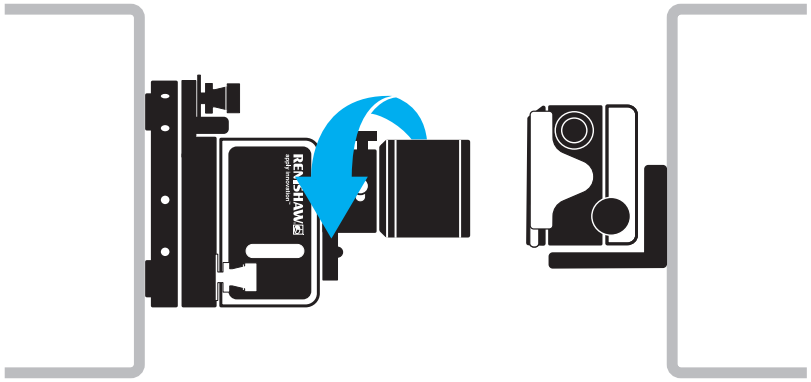
To access the live view, rotate the S unit and the M unit to the desired position and select the corresponding view.

12

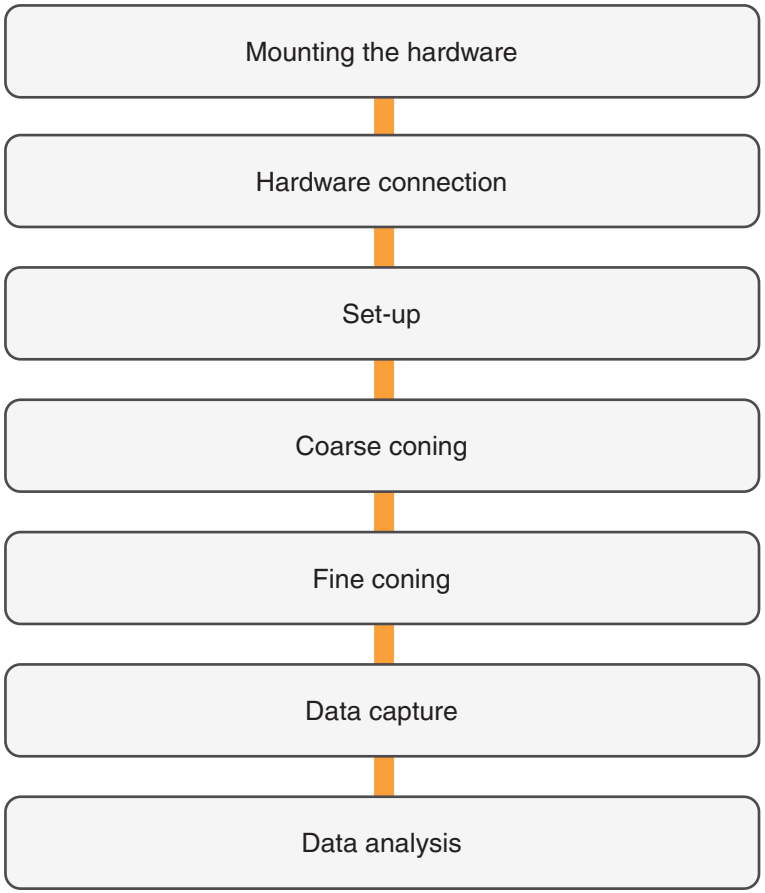


'Save' your data.

Spindle direction



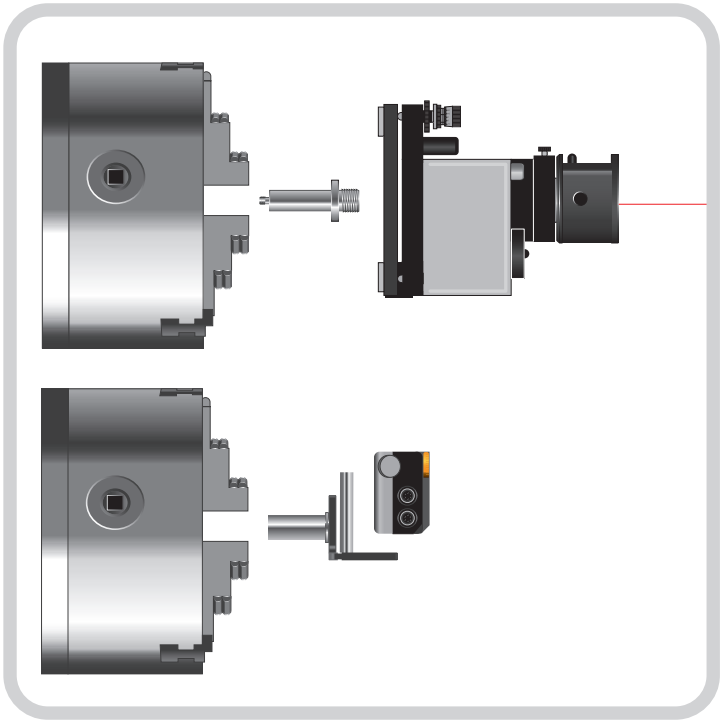
Overview


Mounting the hardware
Hardware connection
Set-up
Coarse coning
Fine coning
Data capture
Data analysis

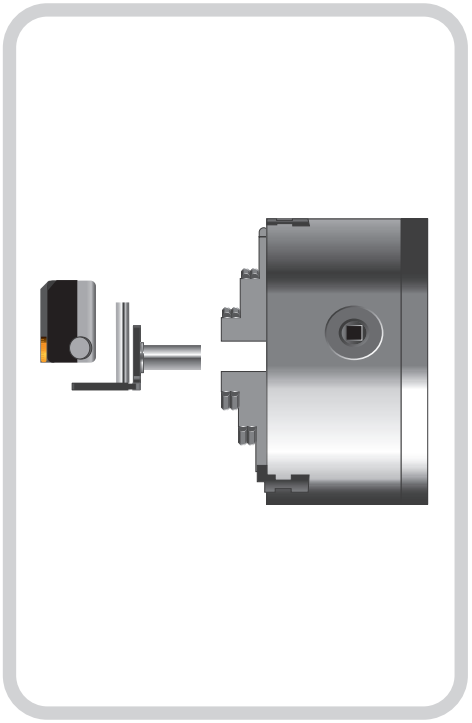
Mounting the hardware

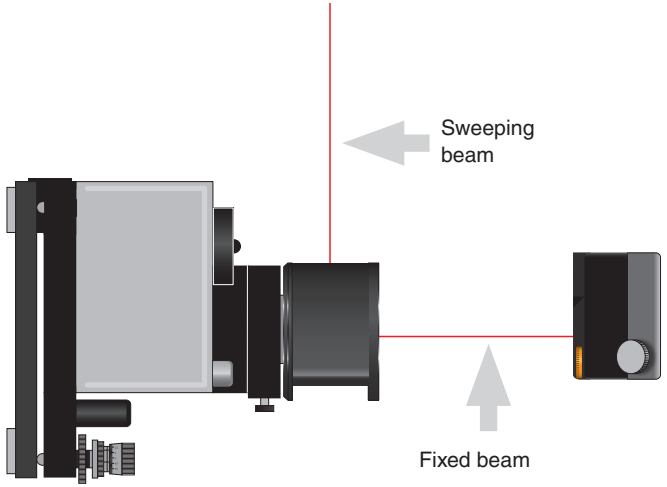
- Spindle direction measurements are performed with the launch unit and the M unit.
- The fixed beam is used for this measurement.

Launch unit



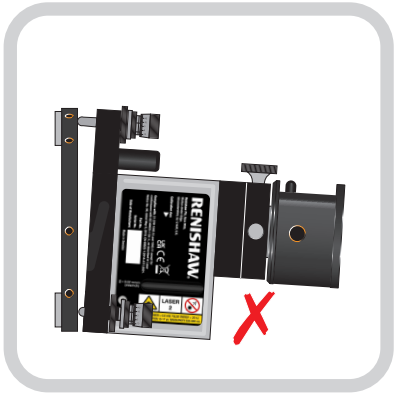
M unit



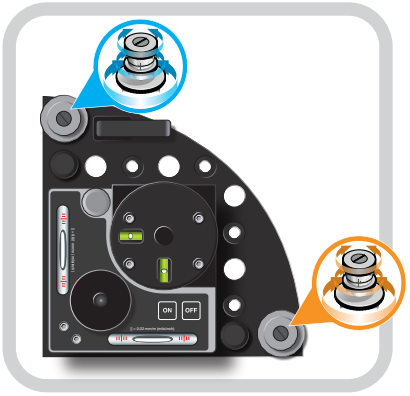


NOTE: The S unit can be used in space-compromised situations, however it is advised that the launch unit is used for ease of coning.

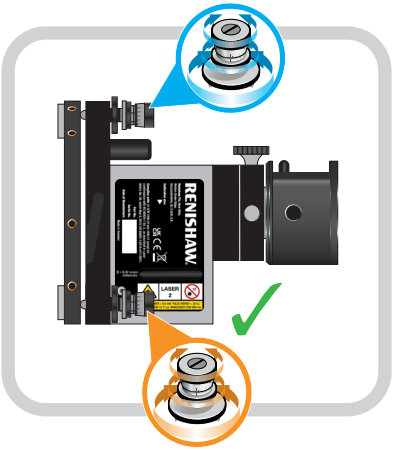
Mounting the hardware – best practice



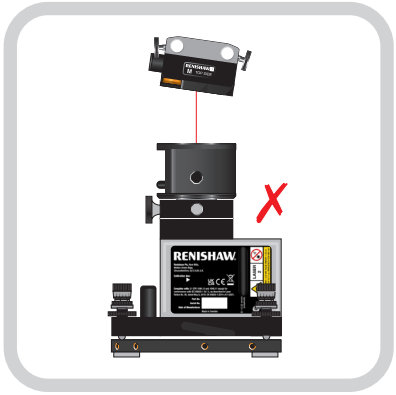
Check that the tilting plate is in the central position.



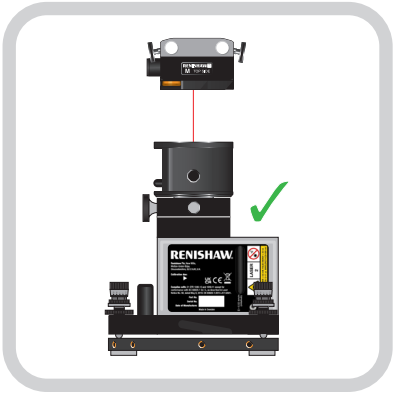
Adjustments can be made to the tilting plate using the pitch/ yaw adjusters.



Adjust until the tilting plate is in the nominal position.

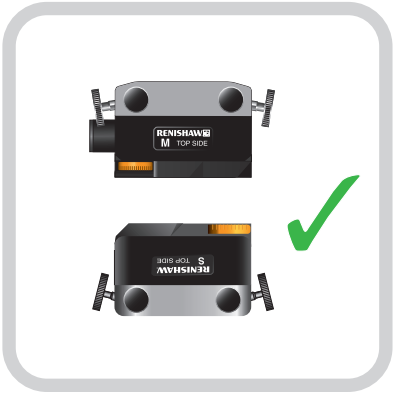


Check that the launch unit and receiver are square to each other.



Adjust the M unit until it is square with the launch unit.

Check that the S unit and M unit are square to each other.



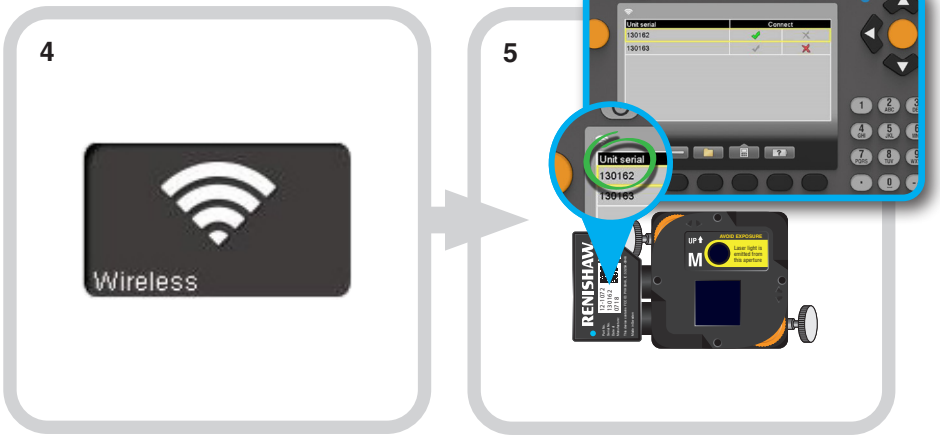
Adjust the M unit until it is square with the S unit.

Hardware connection

Insert the wireless module into the M unit.

Power on the display unit.

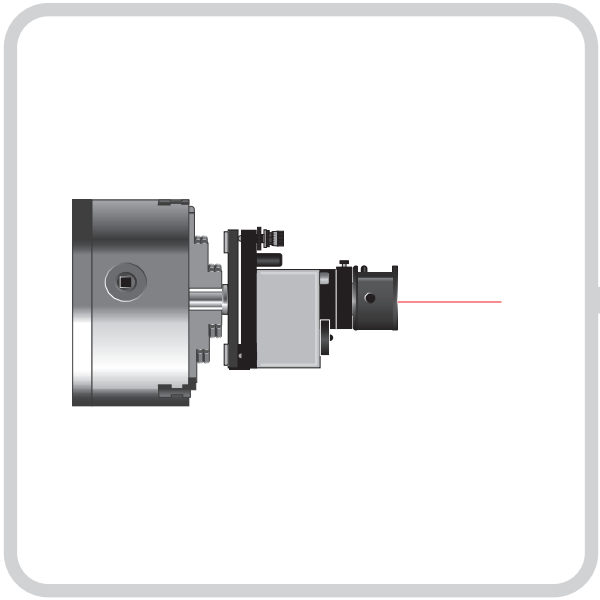
Select the 'Settings' icon.



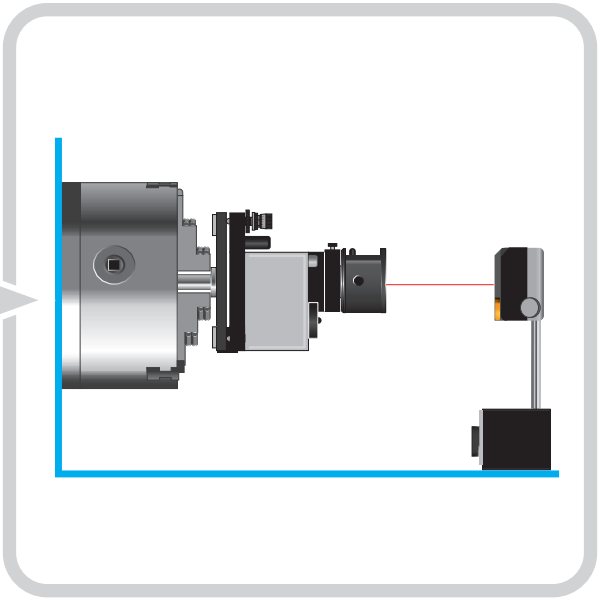
Select the 'Wireless' icon.

Enable the wireless device plugged into the M unit.

Set-up



Mount the launch unit in the spindle or rotary axis.



Mount the M unit along the axis, roughly in line with the launch unit and approximately 500 mm away from it.

NOTE: It is not necessary to measure the full stroke of the machine to get an accurate spindle direction measurement.

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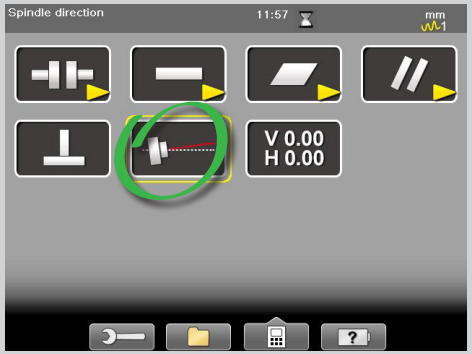
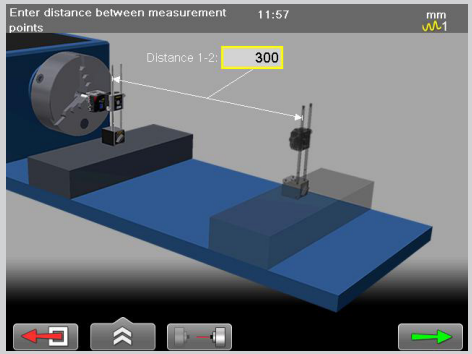
Software set-up

1



Open the 'Spindle direction' application.

2



Measure the distance between the start and end positions of the M unit and input this value into the software.

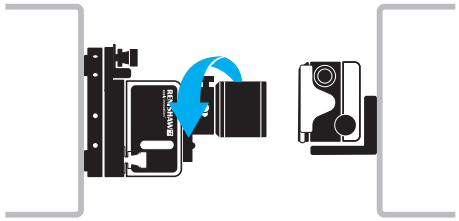
NOTE: The end position for the M unit should not be further than the position at which the laser is coned (approx 500 mm).

Coning

Coarse coning

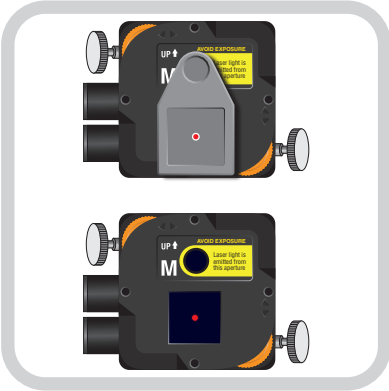
Repeat the process shown until the beam stays on the target when rotating 180 degrees.

NOTE: Coning is performed with the M unit at the end position.



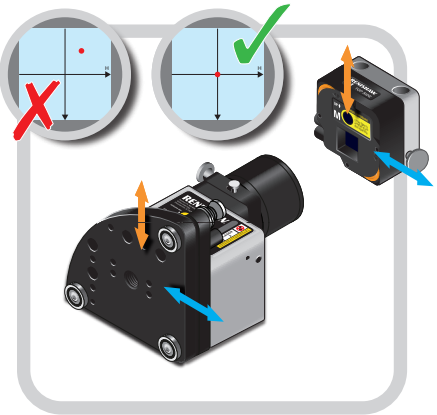
Coning

Fine coning



Remove the target.

Open the 'Show target' view.

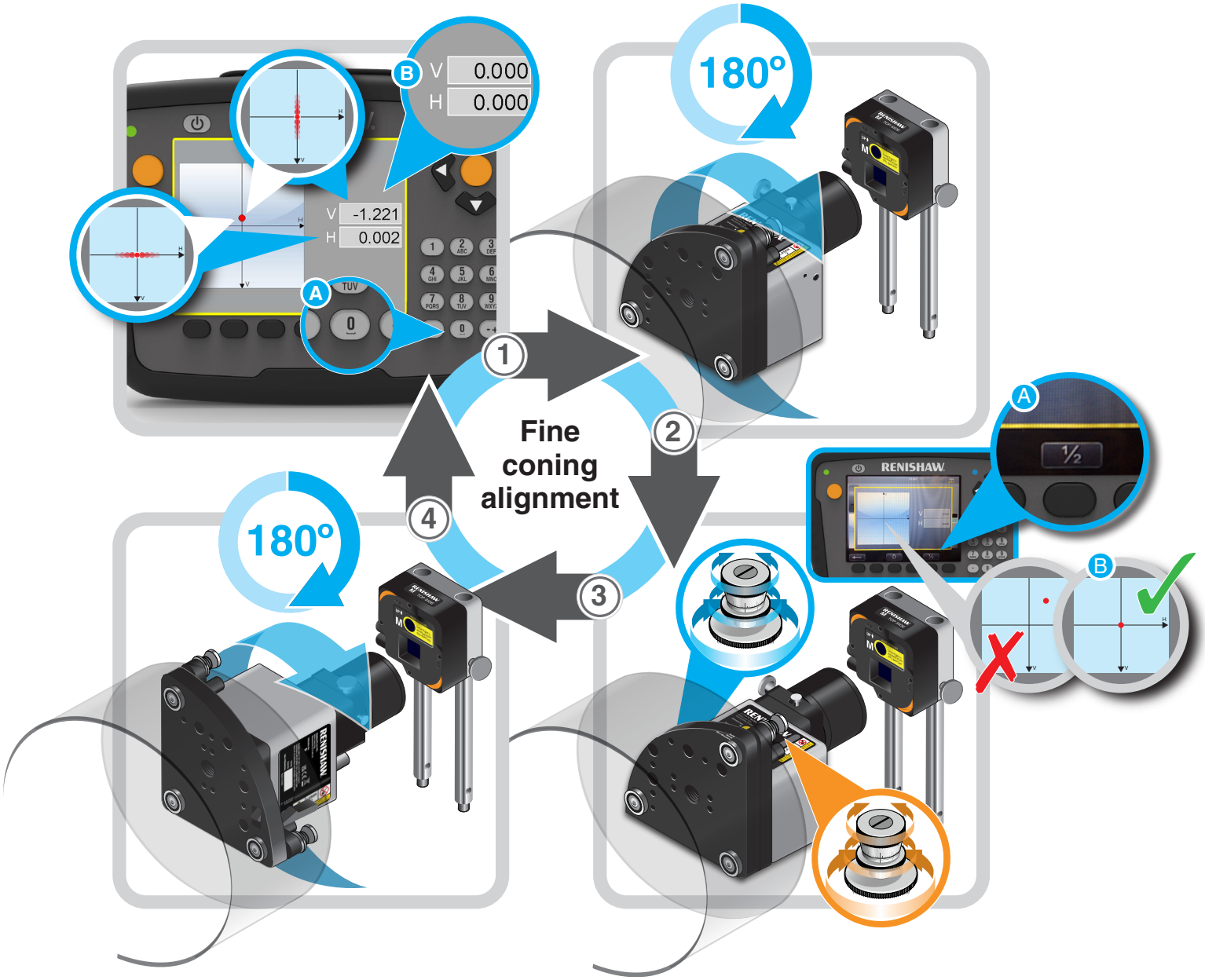


Translate the M unit to centre the beam on the PSD.

Coning

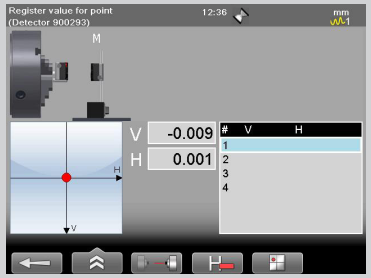
Fine coning

Continue the process shown until the beam stays **within the coning tolerance (value of ±100 µm)** through a 180 degree rotation of the launch unit.



Data capture

1

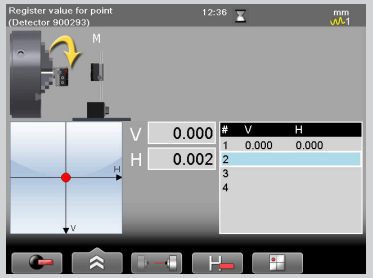


Move the M unit to the nearest position.

2

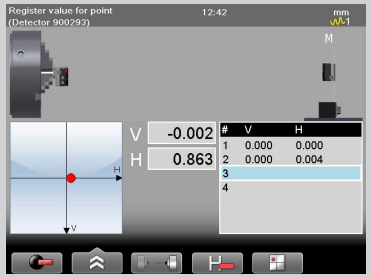
Capture data.

3



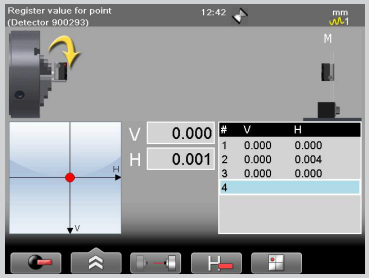
Rotate the launch unit 180 degrees and capture the second point.

4



Move the M unit to the furthest measurement position and capture the third point.

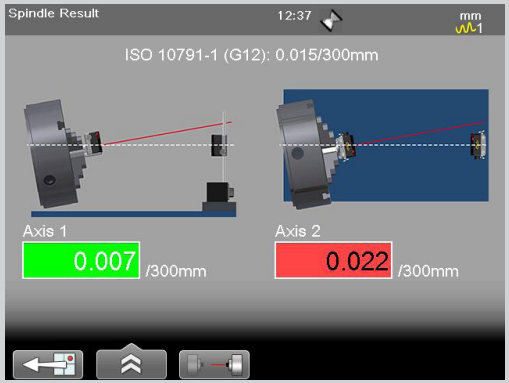
5



Rotate the launch unit 180 degrees and capture the fourth point.

Data analysis

6



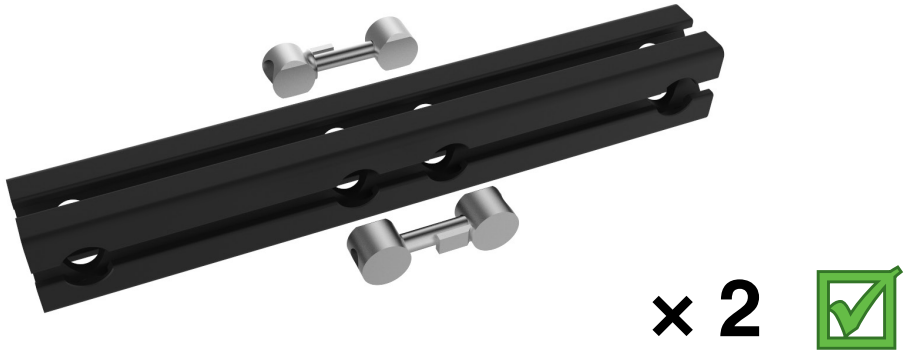
After completing the measurements, the results will be automatically displayed.

7

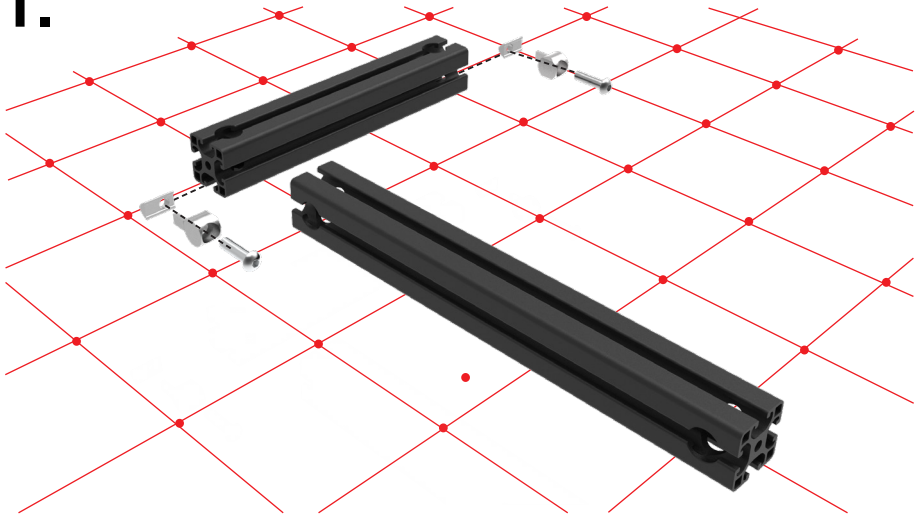
The data can now be saved.

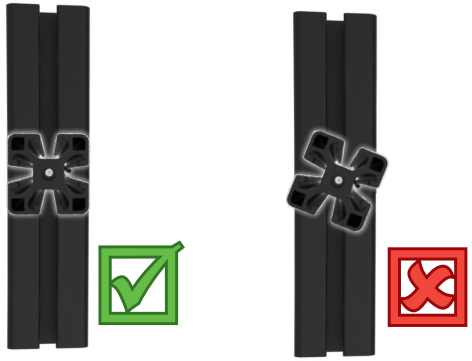
Appendix A

Fixturing kit good practice guide

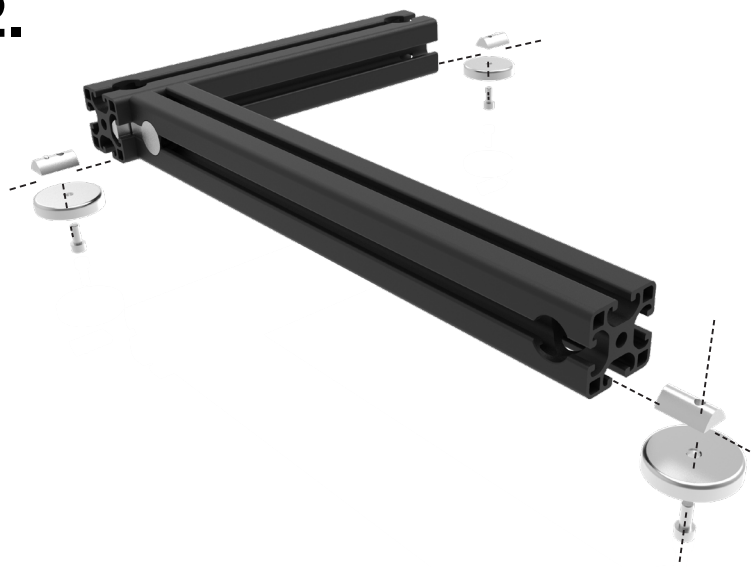


1.

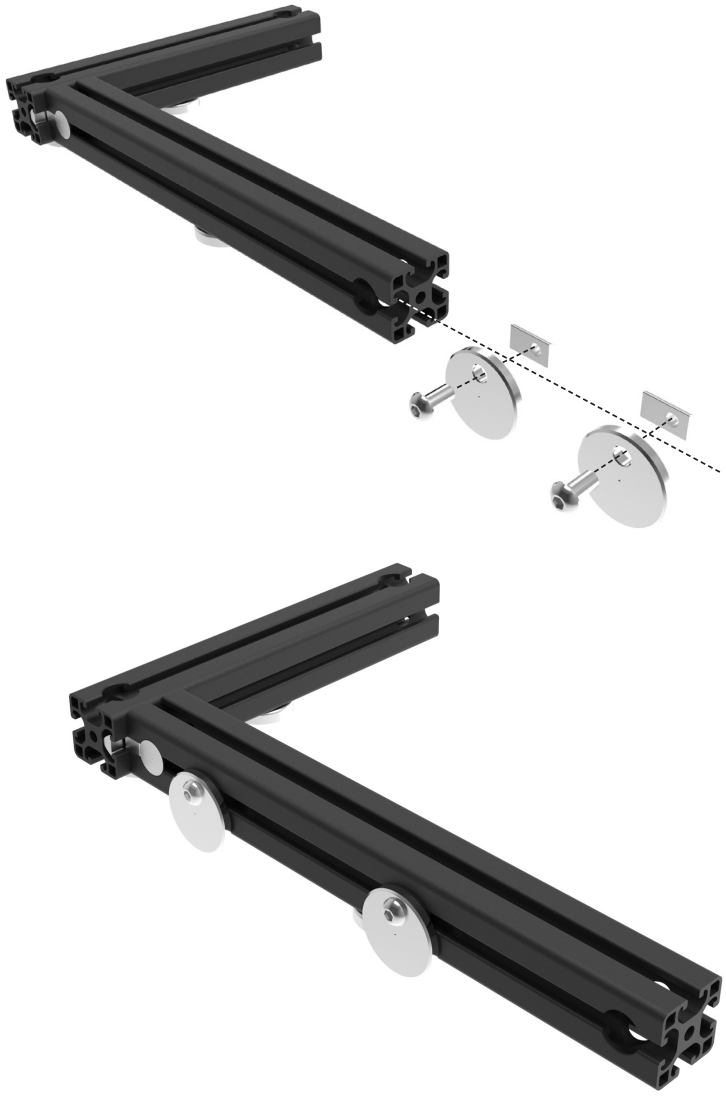




2.

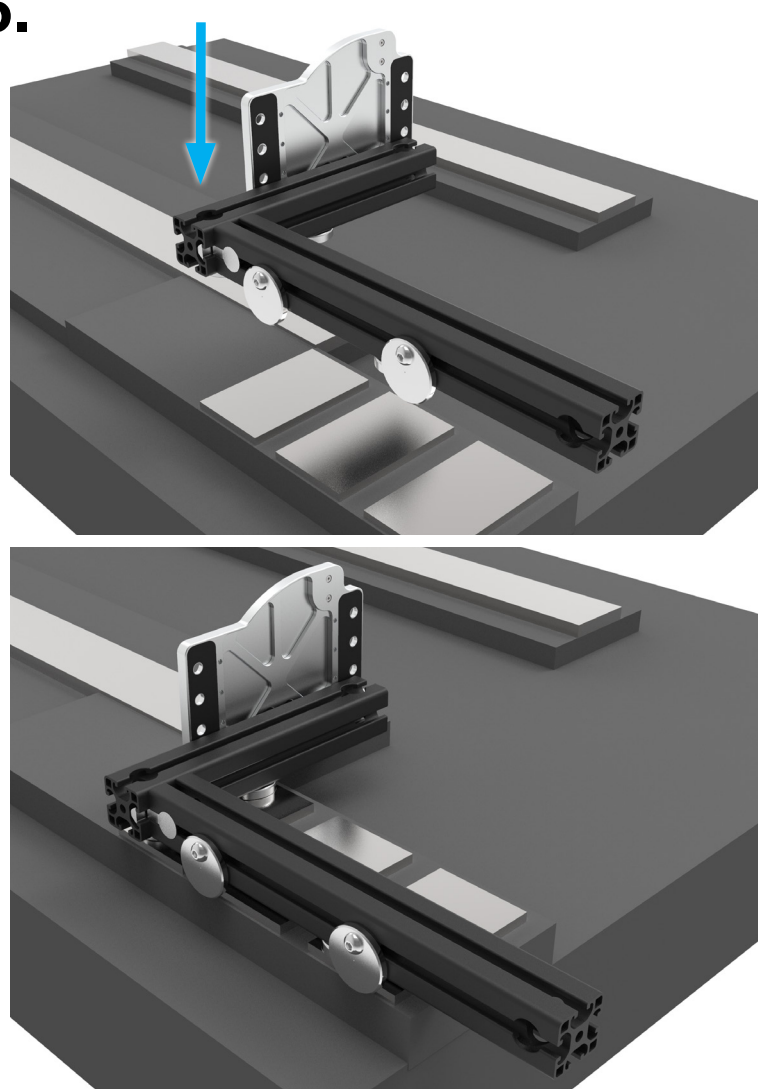


3.

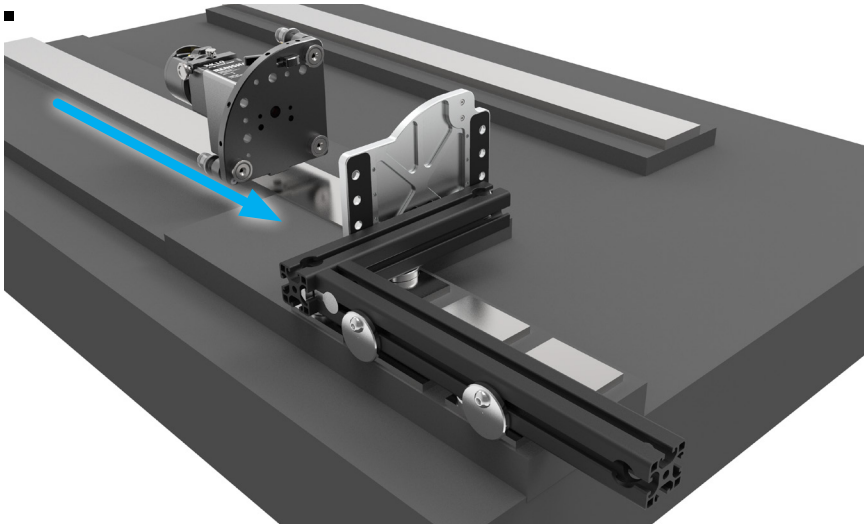


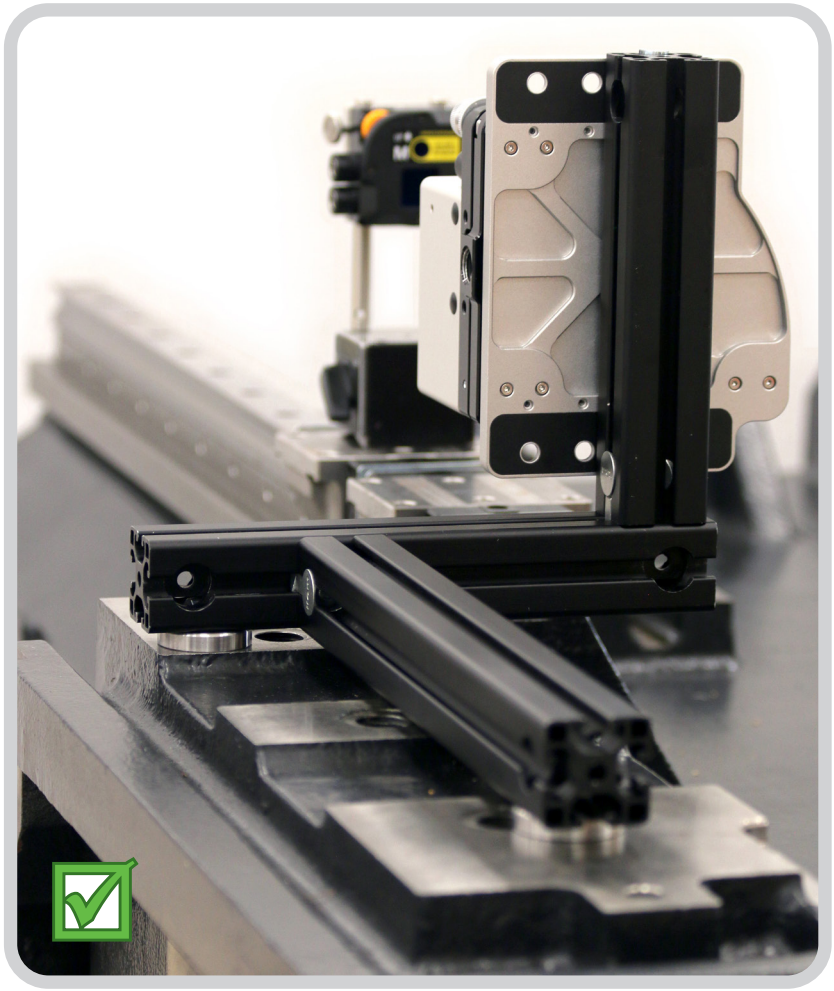
4.

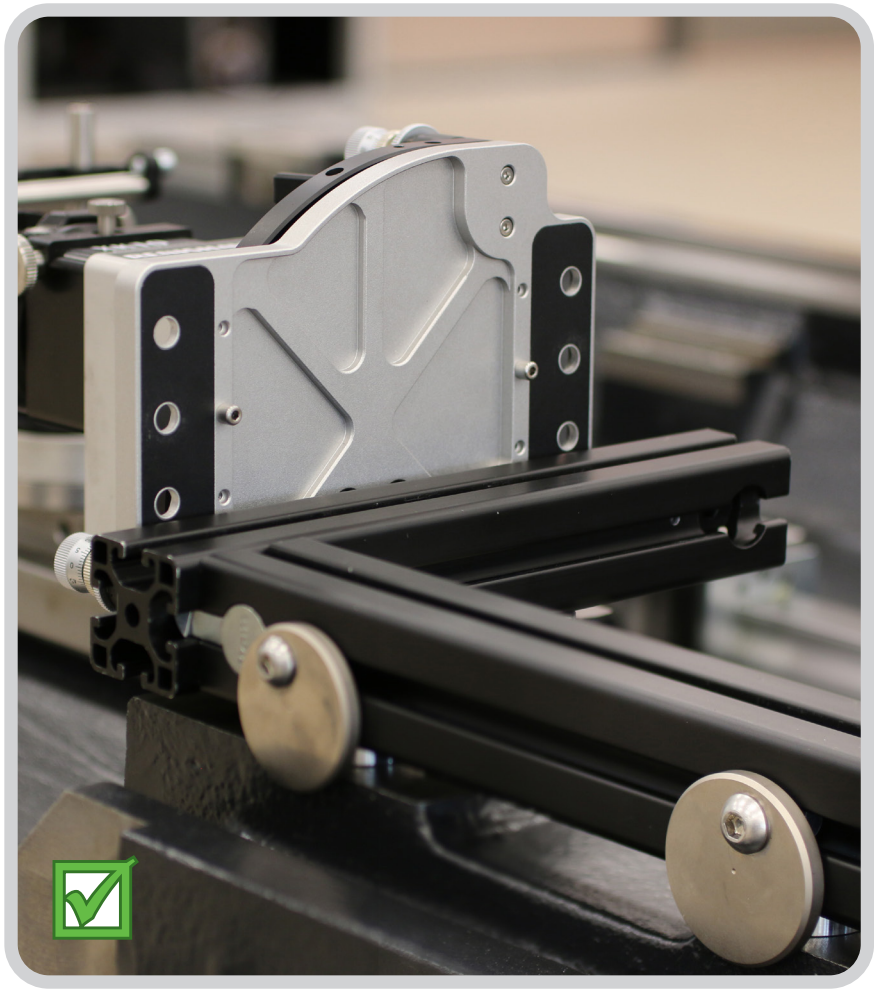
5.



6.







Appendix B: Filtering

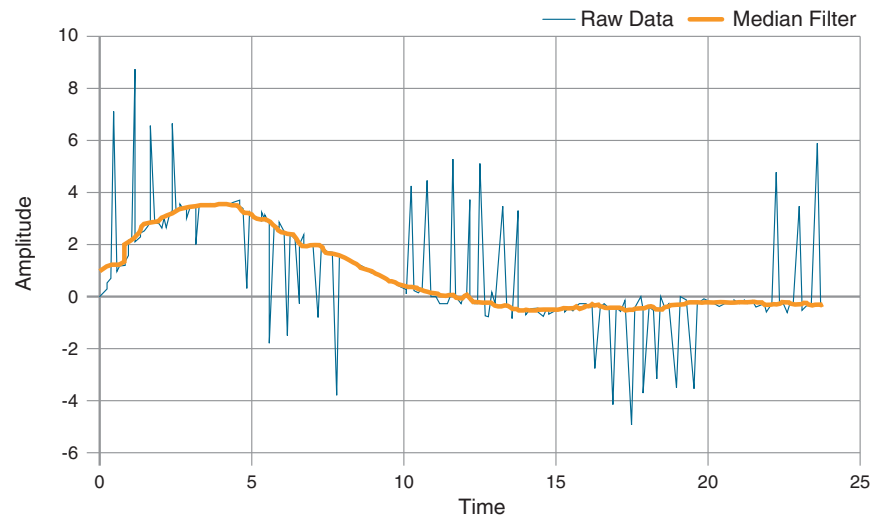
Filtering vs averaging

XK10 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.

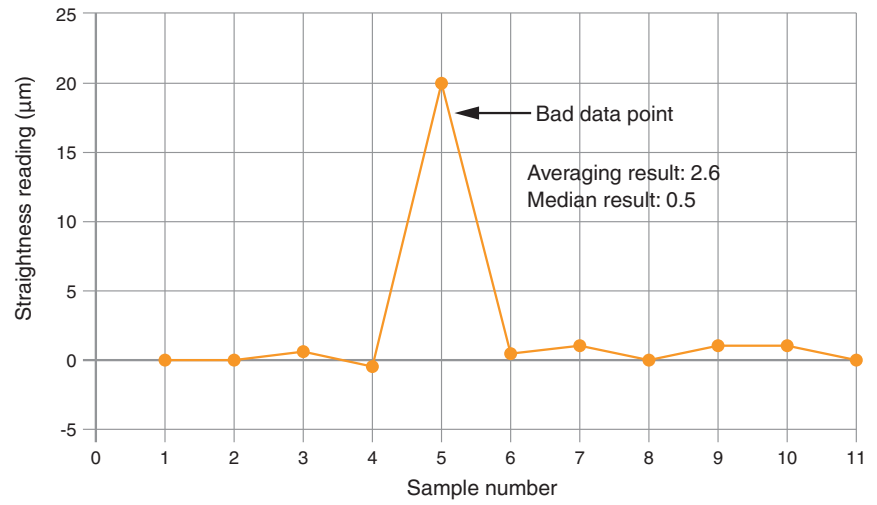
With averaging, when data is captured (for example, 4 second averaging) the average of all data points over a 4 second period is returned; this means that noisy data is also included in the result. However, with a median filter, noisy data points are replaced with the median data point within the sample.

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

Median Averaging



Straightness data capture



Appendix B: Filtering

XK10 uses median filters in two ways:

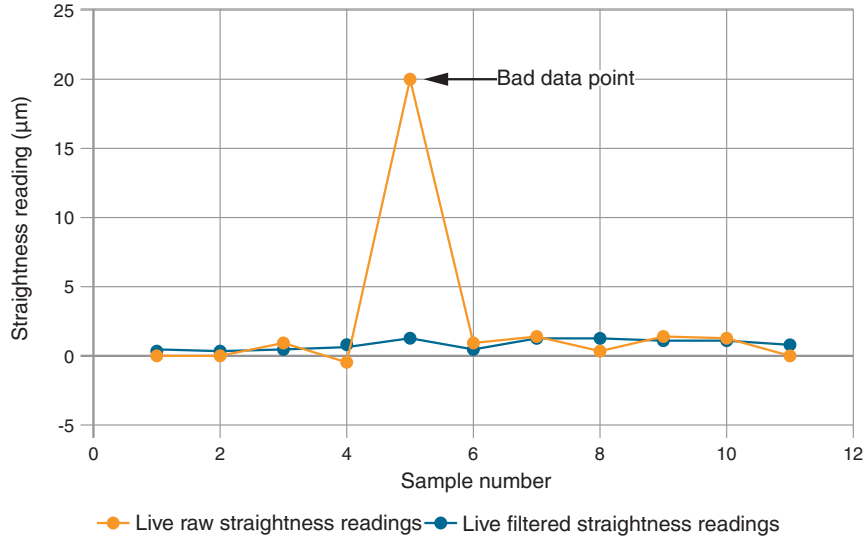
1. **Live median filter**

   The live filter smooths the raw readings from the M unit and S unit and replaces each data point with the median of the corresponding set of data points. The size of this set of data points is dependent on the filtering level.

2. **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

Appendix C: XK10 straightness analysis explained

Statistics are calculated once measurements have been completed and displayed as shown here.

Statistics	V	H
Max:	0.000	-0.001
Min:	-0.005	-0.071
Peak-peak:	0.006	0.071
Standard deviation:	0.002	0.021
Straightness RMS:	0.003	0.039
Average level:	-0.003	-0.033
Max waviness (1):	0.003	0.002

Magnitude of deviations

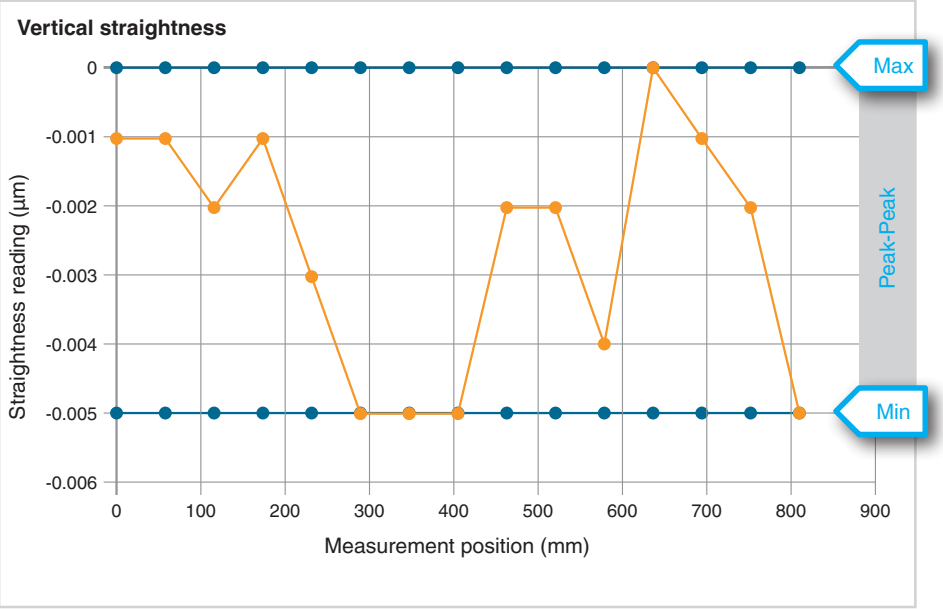
Max and Min

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.

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



Appendix C: XK10 straightness analysis explained

Deviations from the average

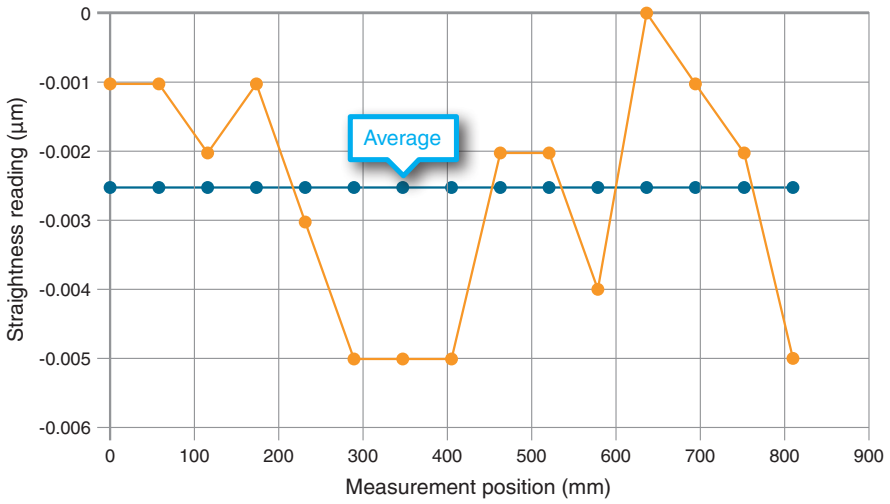
Average level

This is the average deviation along an axis.

Standard deviation (STD) and straightness RMS (root mean squared)
Standard deviation (STD) and straightness RMS both represent the amount of deviation/spread from the average. Although they are calculated differently, they both represent the uniformity of straightness, i.e. the smaller the RMS or STD, the better the straightness. Therefore, an axis with a very small STD or RMS would be considered very 'straight'.

RMS is a common statistic used for surface roughness, while STD is a standard statistic for general deviation.

Vertical straightness



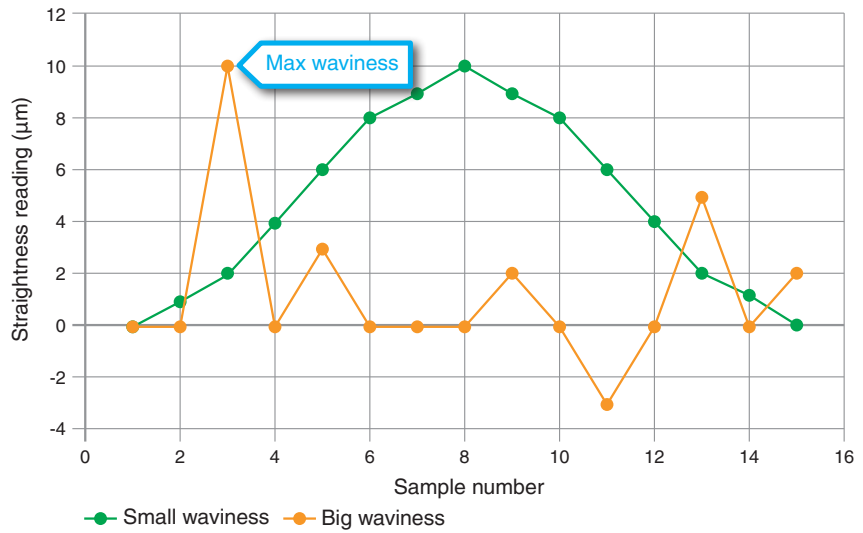
Deviations between points

Waviness

Waviness is used to show if there are any sudden changes or sharp spikes between points. It is a measure of change between points.

This is useful for machines where smooth transitions are very important. Unlike STD and RMS, waviness ignores the general straightness deviation along the axis, and is only concerned with deviations between points.

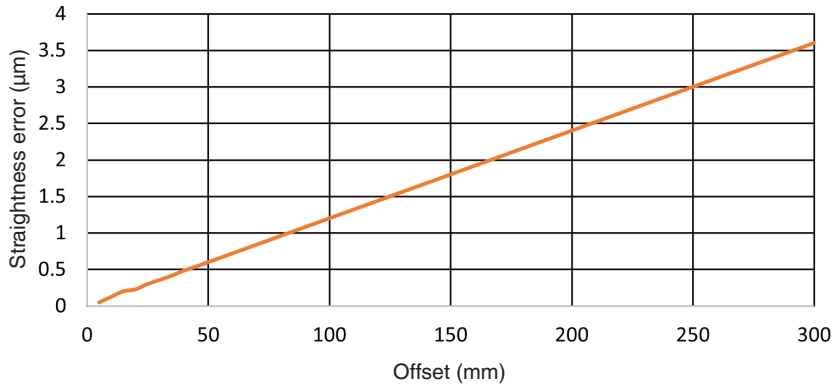
Straightness results with varying waviness



Appendix D: 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.

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