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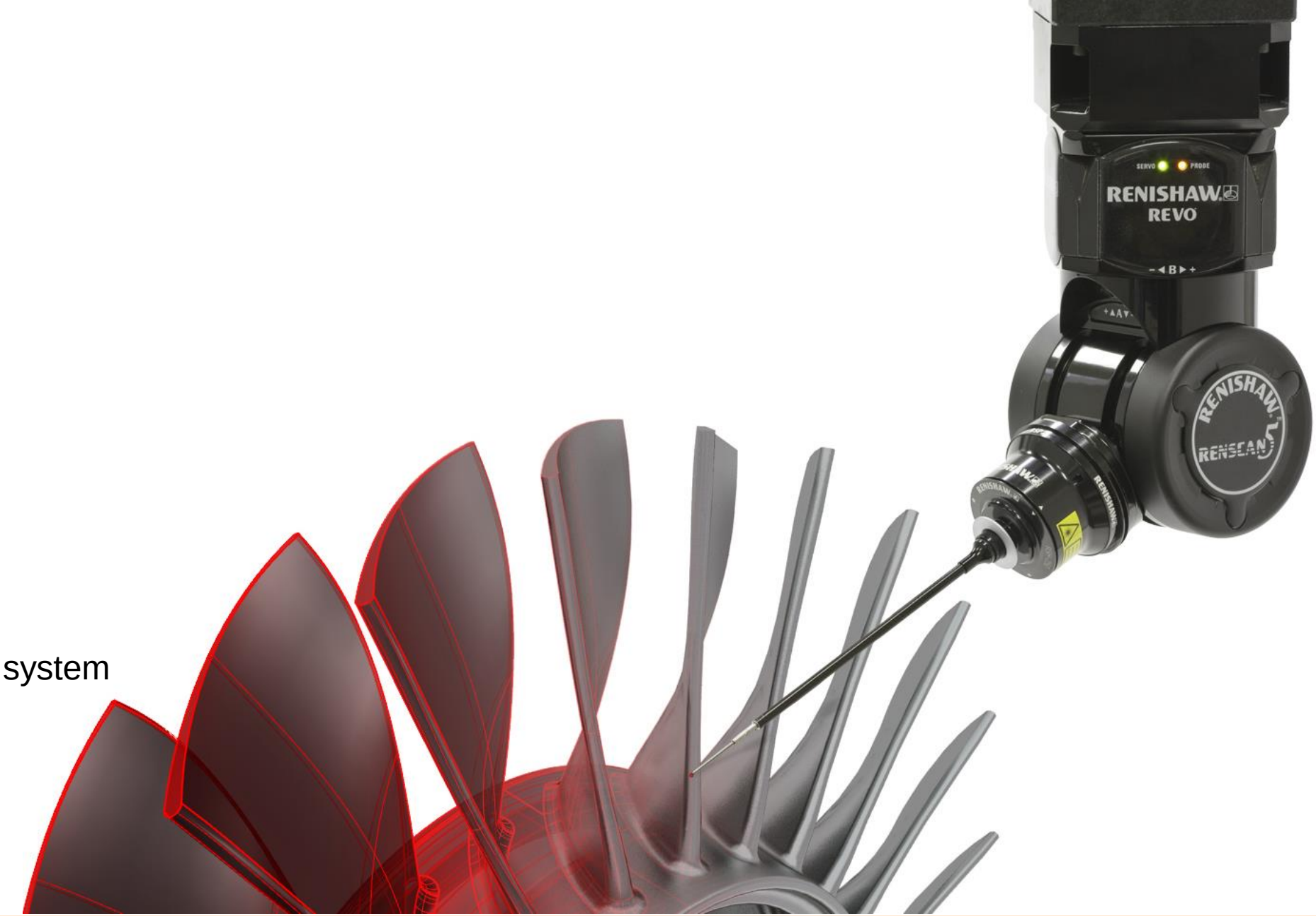
REVO 5-axis measurement system



Touch trigger probing

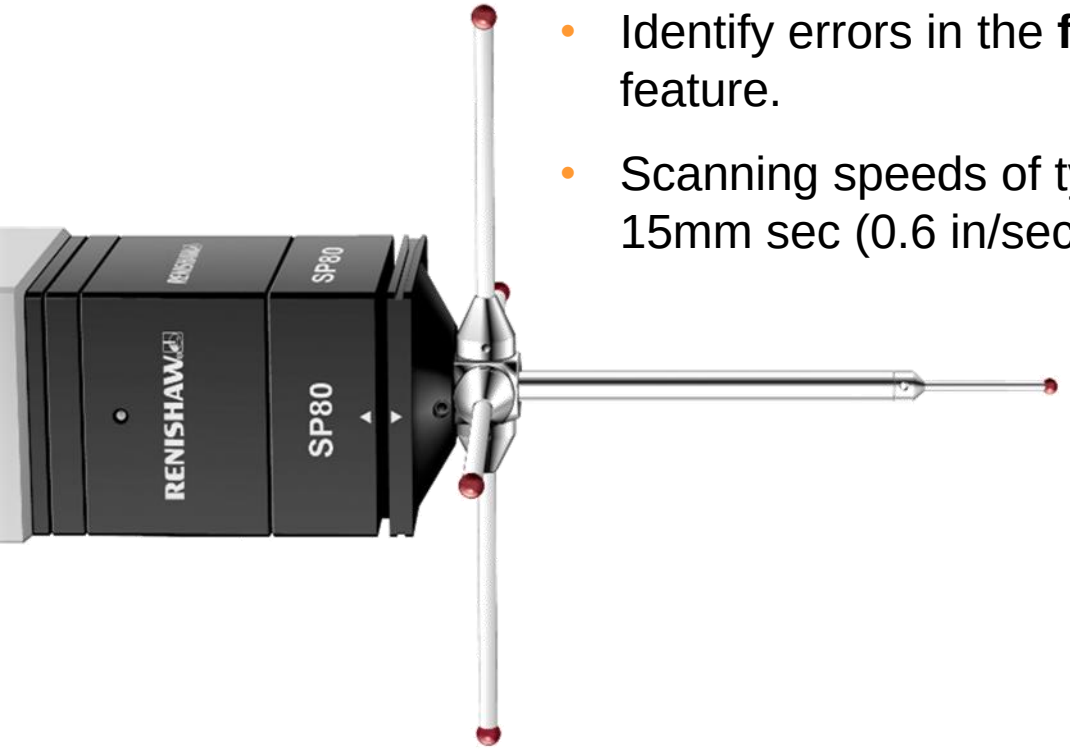
Touch-trigger probes are ideal for:

- Controlling the **position** or **size** of features.
- Discrete point measurement with data capture rates of 1 or 2 points per second.

3-axis scanning

3-axis scanning is ideal for:

- Determining the feature **position.**
- Accurately measure the feature **size.**
- Identify errors in the **form** or shape of the feature.
- Scanning speeds of typically less then 15mm sec (0.6 in/sec).



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Dynamic effects on scanning performance

The scanning paradox…

- Modern CMMs can move quickly, yet conventional scanning is typically performed at low speeds.
- Typically less than 15mm sec (0.6 in/sec).

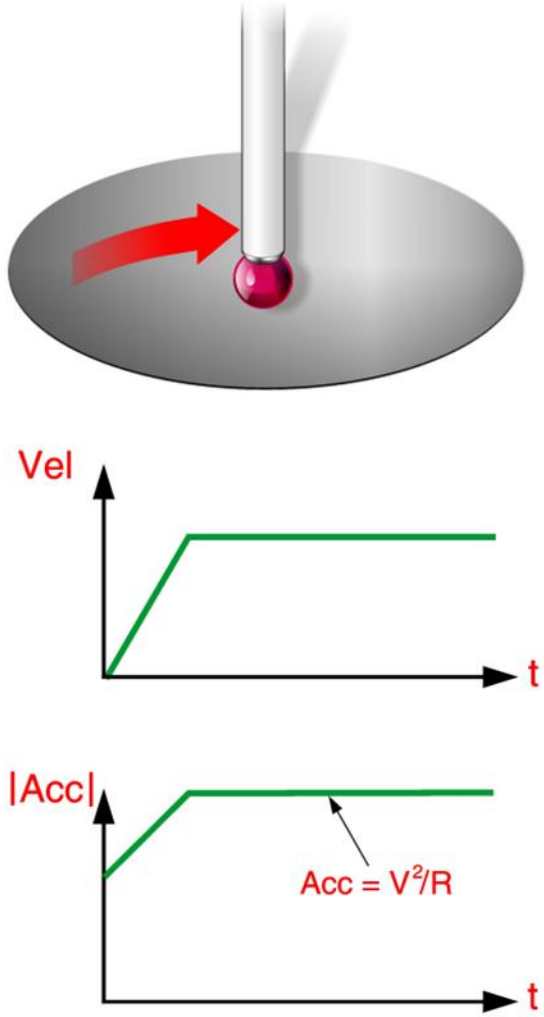
Why?

How do machine dynamic errors arise?

Scanning requires continuously changing velocity vectors as the stylus moves across a curved surface.

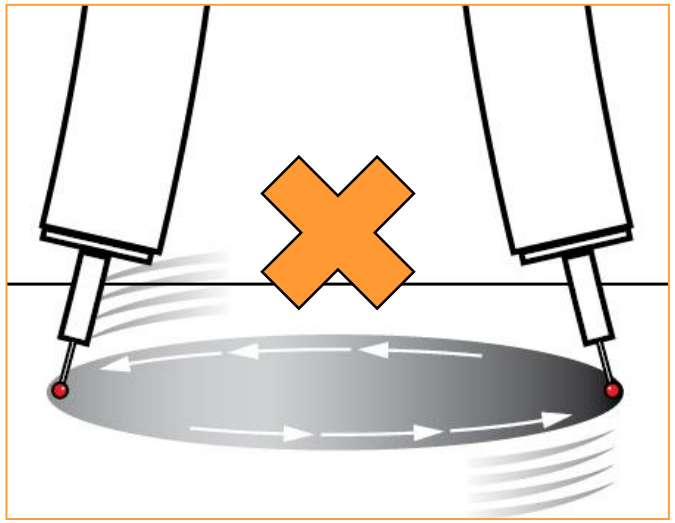
Varying inertial forces are induced, which cause the machine to deflect.

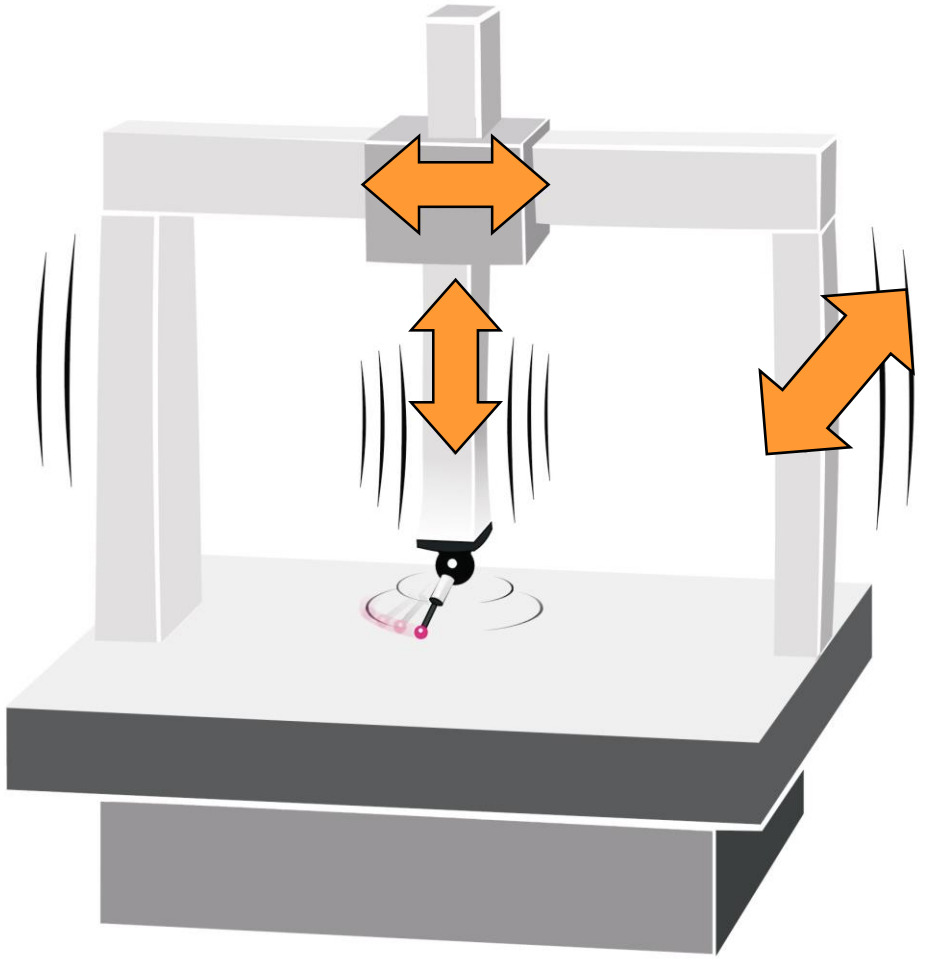
Vibration is also a factor when scanning.



Dynamic effects on scanning performance

All 3-axis scanning systems suffer from poor accuracy unless speeds are kept low.





Why 5-axis scanning technology?

The Proposal:

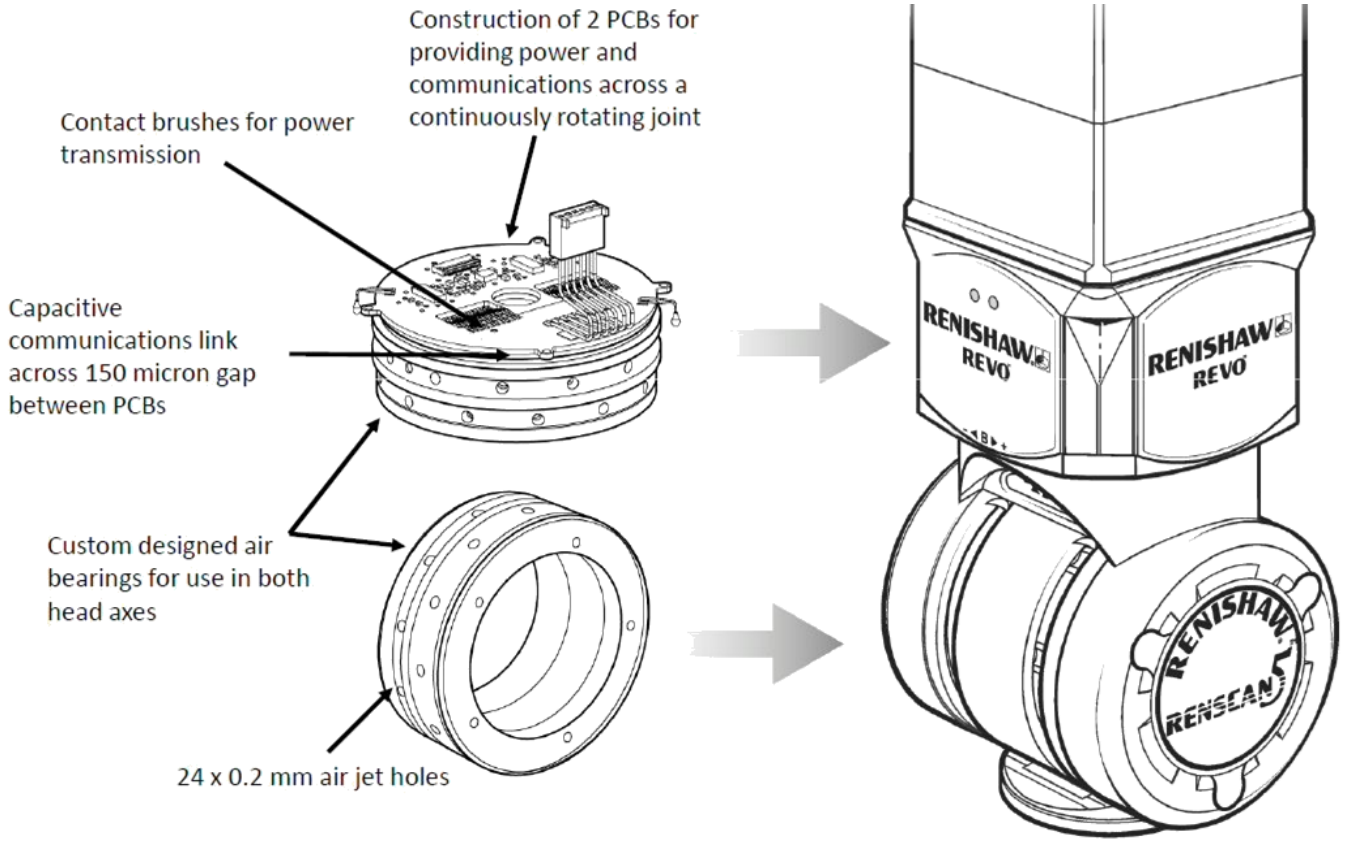
Greatly reduce dynamic errors by minimizing machine movement.

The Solution:

Renishaw's REVO 5-axis scanning technology.

REVO head technology

- Ultra stiff spherical air bearing technology.
- State of the art brushless motors.
- Purpose-designed Renishaw high-resolution encoders.
- Fast, high accuracy positioning.



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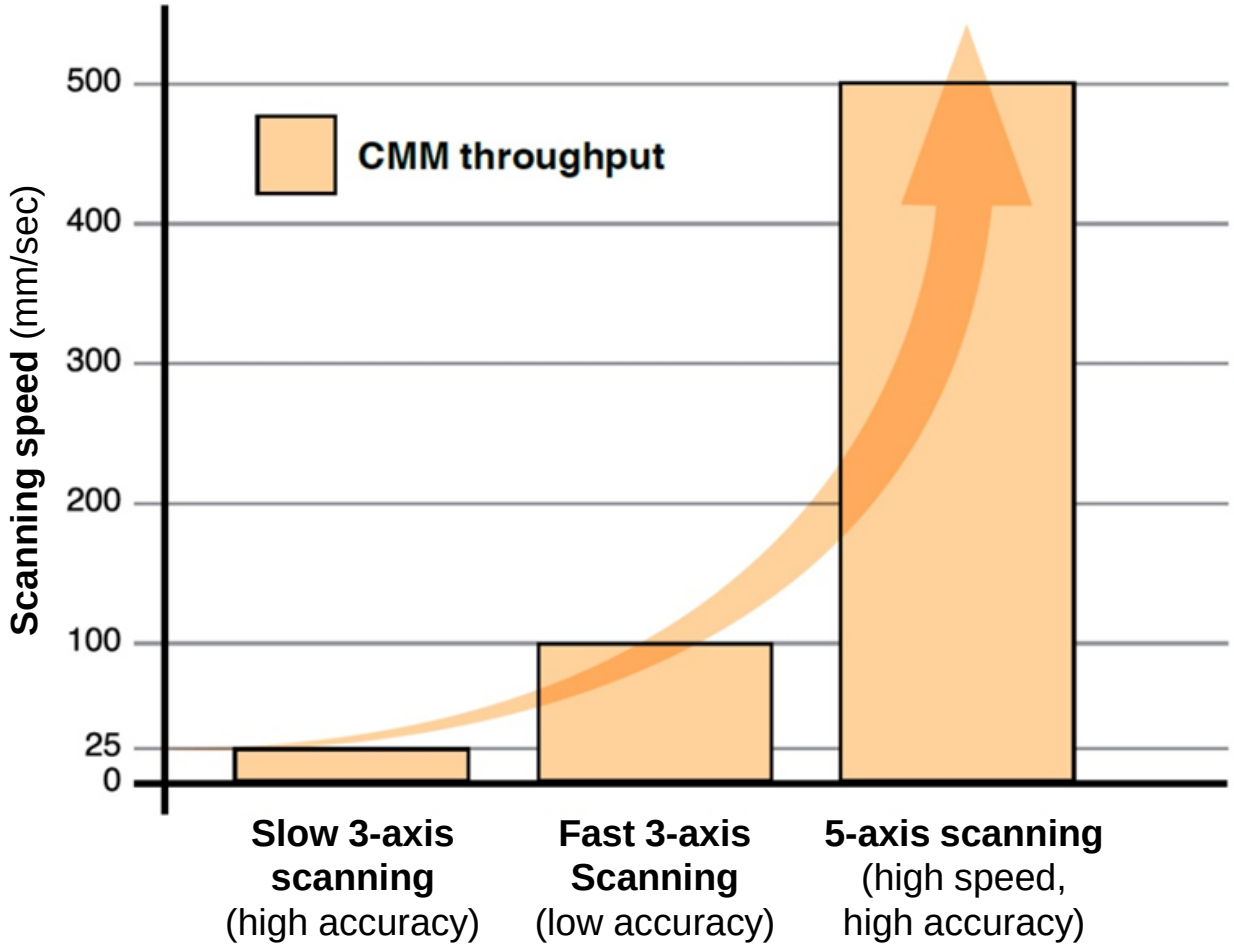
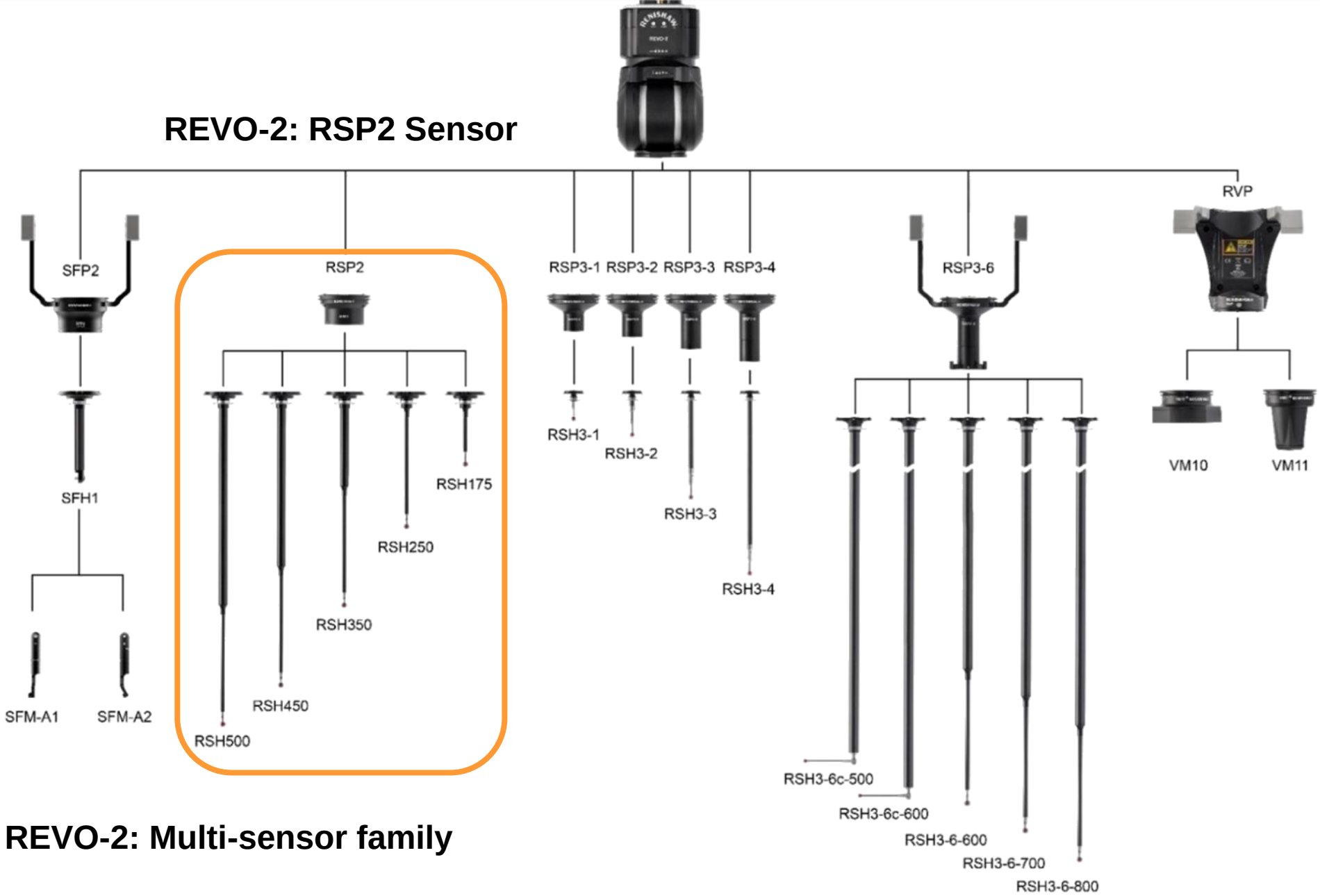
Why 5-axis scanning technology?

REVO 5-axis scanning achieves extremely high speeds without compromising accuracy.



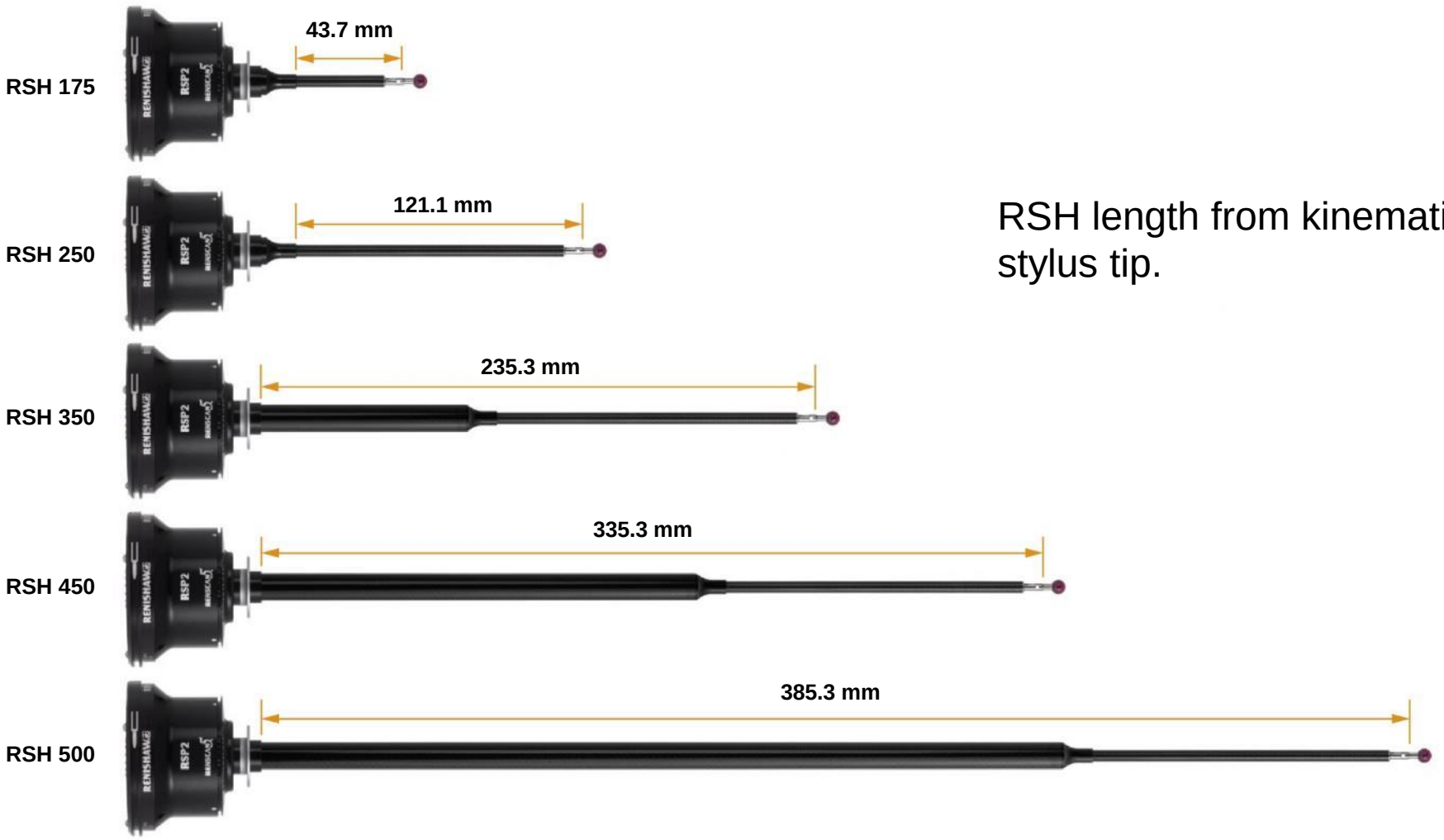
REVO-2: RSP2 Sensor



REVO-2: Multi-sensor family

REVO RSP2 tip sensing technology

REVO RSH maximum reach



RSH length from kinematic plane to thread for stylus tip.

REVO RSP2 measurement techniques

Gasket scan

Surface sweep scan

Edge sweep scan

Head touches

Circle scan

Helical scan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REVO 50 mm/s ring scan at head angles A=0, B=0

Date Time :	19-Apr-2007	
Ring Gauge Ø	100.0008	mm
Stylus ball Ø	6.0004	mm
Theorical Radius	47.0002	mm

Deflection 0.10 mm
Speed 50.0 mm/s
RSH250

Best Fitted Cylinder

x	139.6430	mm
y	200.8311	mm
z	42.9513	mm
Radius	47.0006	mm
nx	0.000 036	
ny	0.000 070	
nz	1.000 000	

Radius Error

0.34 µm

Form errors (µm)

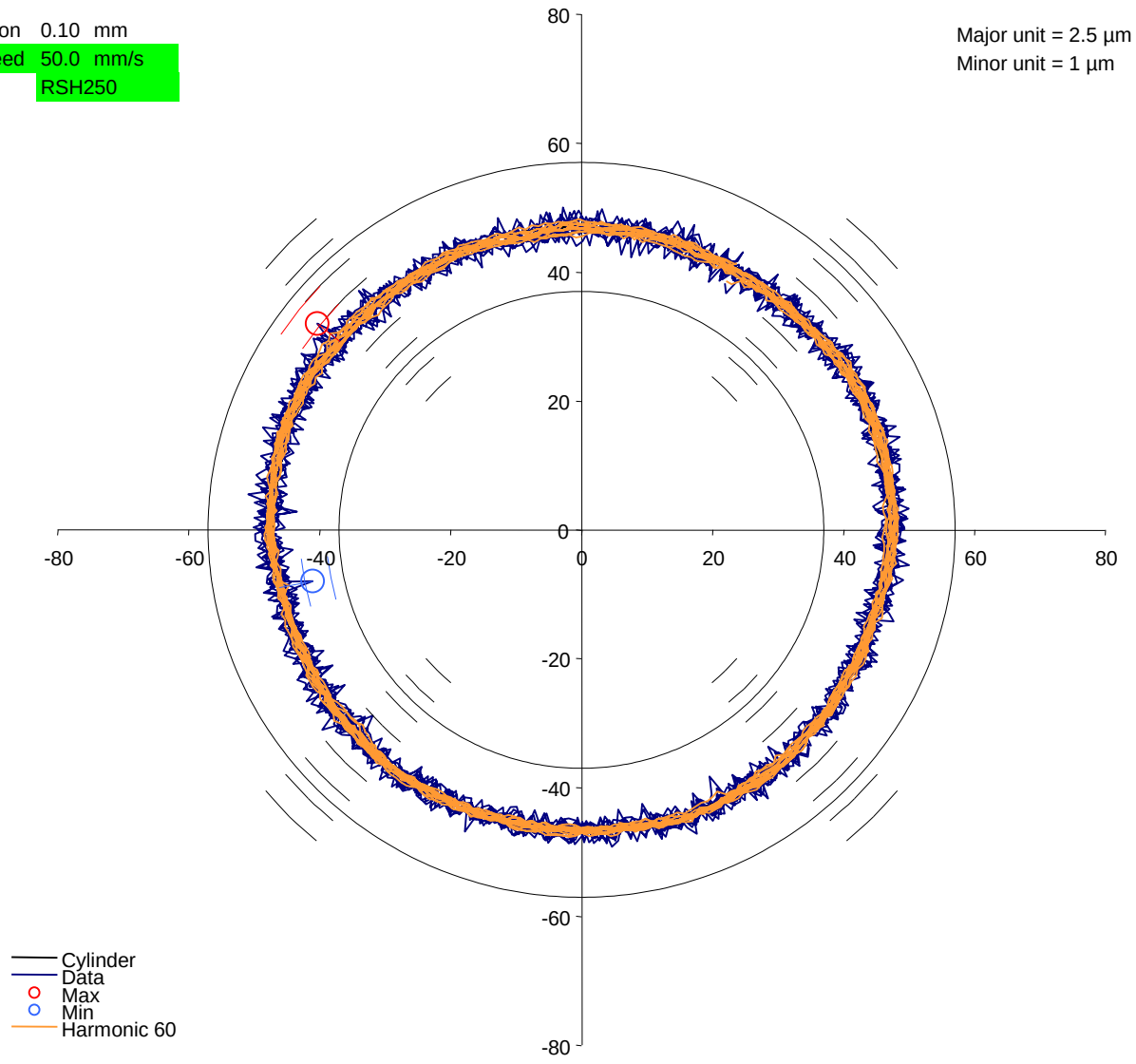
RMS	**0.31**	0.16
Max	**1.1**	0.49
Min	**-1.3**	-0.63
Span	**2.4**	1.13
HF Noise Rms Value		0.21

Harmonic filter Order = 60 upr
Cut off *wc = 376.99 rad*
(upr = Undulation Per Revolution)

Form identification	A	Phy
Ellipse (n=2)	0.08 µm	117.07 °
Tri-lobe (n=3)	0.07 µm	349.69 °
Quadri-Lobe (n=4)	0.02 µm	54.79 °

A.Sin(n.x+Phy)

Data collected with	3522	*points*
	10	*turns*



REVO 500 mm/s ring scan at head angles A=0, B=0

Date Time :	19-Apr-2007	
Ring Gauge Ø	100.0008	mm
Stylus ball Ø	6.0004	mm
Theorical Radius	47.0002	mm

Deflection	0.10 mm
Speed	500.0 mm/s
	RSH250

Best Fitted Cylinder

x	139.6433	mm
y	200.8312	mm
z	42.9530	mm
Radius	47.0005	mm
nx	0.000 037	
ny	0.000 071	
nz	1.000 000	

Radius Error

0.30	µm

Form errors (µm)

RMS	**0.38**	0.30
Max	**1.2**	0.90
Min	**-1.4**	-0.98
Span	**2.5**	1.88
HF Noise Rms Value		0.14

Harmonic filter Order = 60 upr

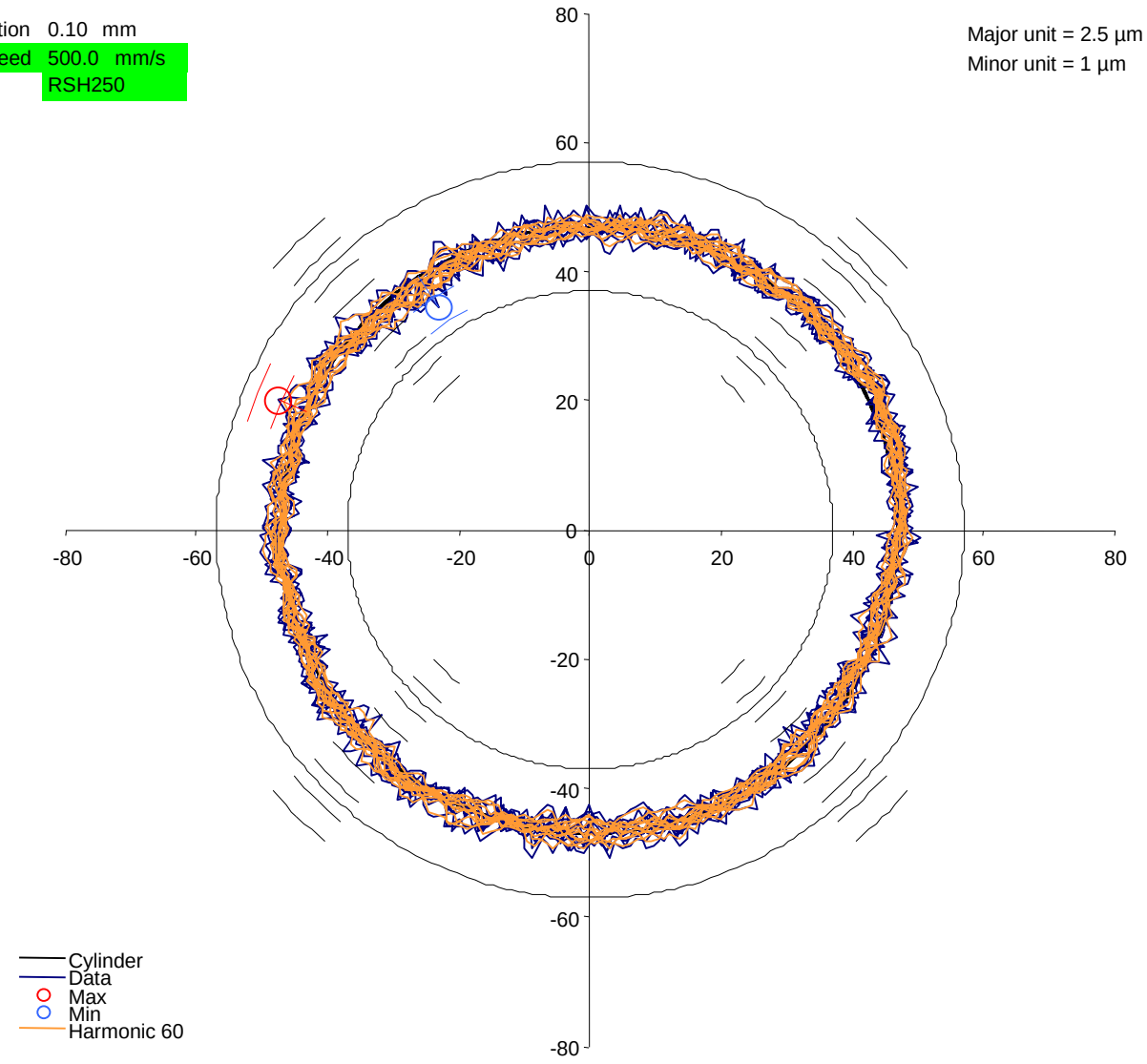
Cut off *wc = 376.99 rad*

(upr = Undulation Per Revolution)

Form identification	A	Phy
Ellipse (n=2)	0.16 µm	19.80 °
Tri-lobe (n=3)	0.08 µm	333.60 °
Quadri-Lobe (n=4)	0.02 µm	24.08 °

A.Sin(n.x+Phy)

Data collected with	3320	*points*
	10	*turns*



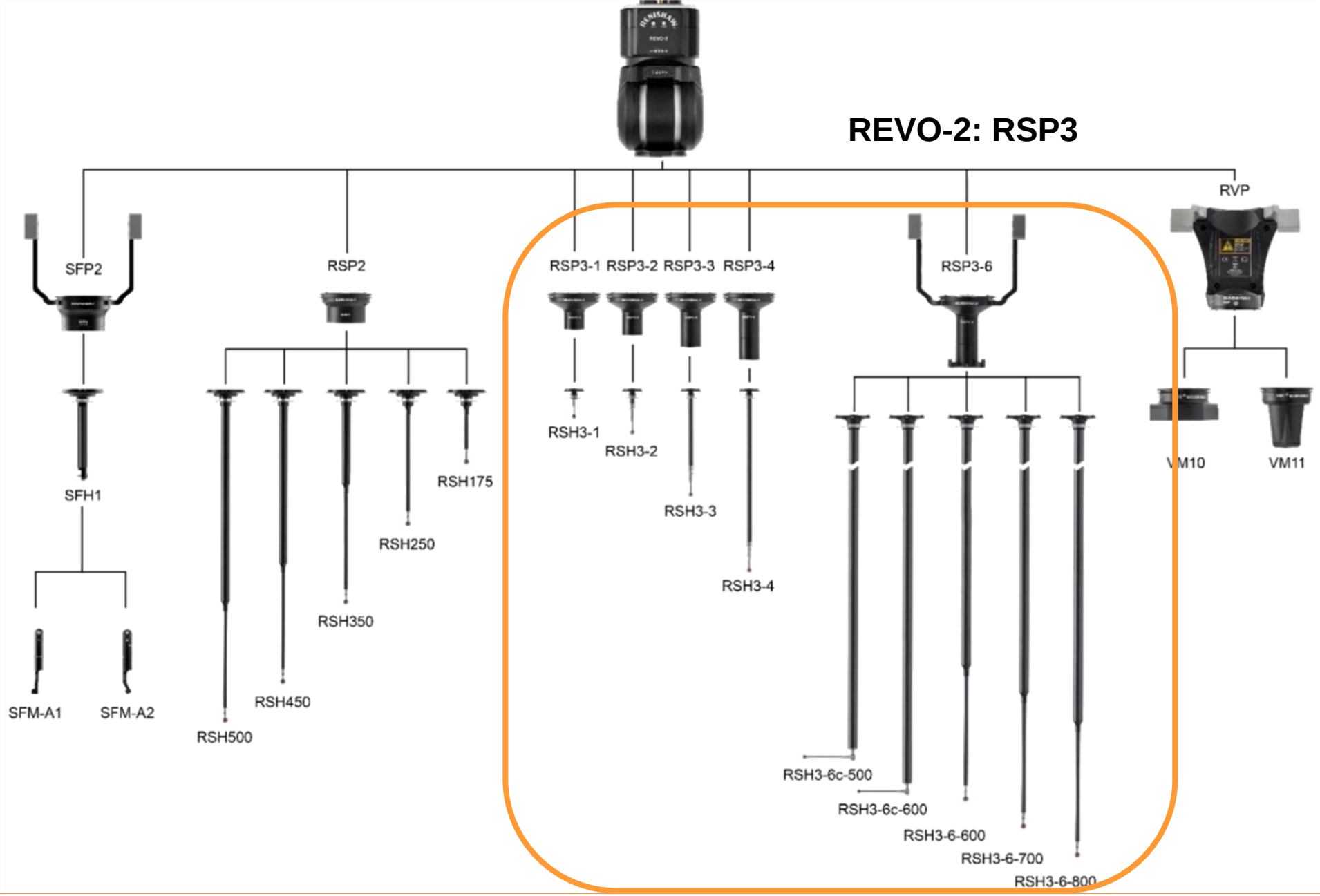
Revo Speed Variance Test

Ran 100 times at each speed

Characteristic Description	Speed mm/s	Average	Range	Range of Averages
CYLINDER BORE DIAMETER	50	106.9990	0.0021	0.0014
CYLINDER BORE DIAMETER	100	106.9992	0.0024	
CYLINDER BORE DIAMETER	150	106.9994	0.0024	
CYLINDER BORE DIAMETER	200	106.9996	0.0029	
CYLINDER BORE DIAMETER	250	106.9998	0.0034	
CYLINDER BORE DIAMETER	300	107.0001	0.0037	
CYLINDER BORE DIAMETER	350	107.0003	0.0033	
CYLINDER BORE DIAMETER	400	107.0004	0.0030	
CYLINDER BORE DIAMETER	450	107.0003	0.0027	
CYLINDER BORE DIAMETER	500	107.0004	0.0030	
CYLINDER BORE ROUNDNESS REF	50	0.0088	0.0005	0.0003
CYLINDER BORE ROUNDNESS REF	100	0.0089	0.0005	
CYLINDER BORE ROUNDNESS REF	150	0.0088	0.0004	
CYLINDER BORE ROUNDNESS REF	200	0.0088	0.0004	
CYLINDER BORE ROUNDNESS REF	250	0.0086	0.0004	
CYLINDER BORE ROUNDNESS REF	300	0.0086	0.0005	
CYLINDER BORE ROUNDNESS REF	350	0.0087	0.0004	
CYLINDER BORE ROUNDNESS REF	400	0.0086	0.0004	
CYLINDER BORE ROUNDNESS REF	450	0.0086	0.0004	
CYLINDER BORE ROUNDNESS REF	500	0.0086	0.0004	

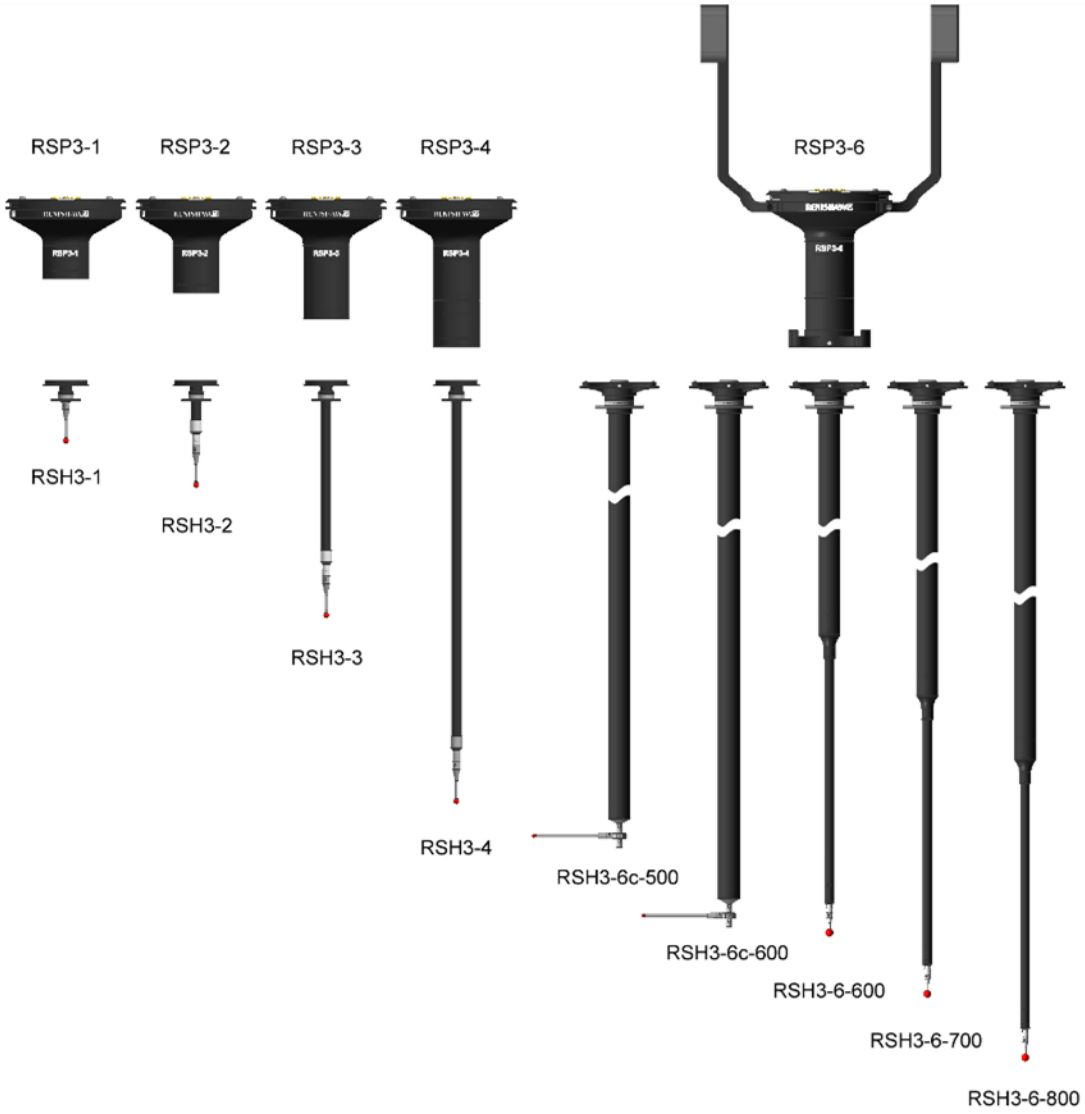
Characteristic Description	Speed mm/s	Average	Range	Range of Averages
CAM JOURNAL DIAMETER 50	50	54.1198	0.0004	0.0023
CAM JOURNAL DIAMETER 100	100	54.1198	0.0003	
CAM JOURNAL DIAMETER 150	150	54.1200	0.0004	
CAM JOURNAL DIAMETER 200	200	54.1203	0.0004	
CAM JOURNAL DIAMETER 250	250	54.1206	0.0003	
CAM JOURNAL DIAMETER 300	300	54.1208	0.0063	
CAM JOURNAL DIAMETER 350	350	54.1217	0.0004	
CAM JOURNAL DIAMETER 400	400	54.1219	0.0004	
CAM JOURNAL DIAMETER 450	450	54.1221	0.0004	
CAM JOURNAL DIAMETER 500	500	54.1221	0.0004	
CAM JOURNAL ROUNDNESS 50	50	0.0102	0.0004	0.0012
CAM JOURNAL ROUNDNESS 100	100	0.0102	0.0005	
CAM JOURNAL ROUNDNESS 150	150	0.0103	0.0006	
CAM JOURNAL ROUNDNESS 200	200	0.0104	0.0009	
CAM JOURNAL ROUNDNESS 250	250	0.0106	0.0005	
CAM JOURNAL ROUNDNESS 300	300	0.0114	0.0011	
CAM JOURNAL ROUNDNESS 350	350	0.0107	0.0005	
CAM JOURNAL ROUNDNESS 400	400	0.0110	0.0004	
CAM JOURNAL ROUNDNESS 450	450	0.0110	0.0005	
CAM JOURNAL ROUNDNESS 500	500	0.0110	0.0006	

REVO-2: RSP3



Multi-sensor capability – RSP3 family

3D scanning and cranked stylus carrying capability based on SP25M technology.

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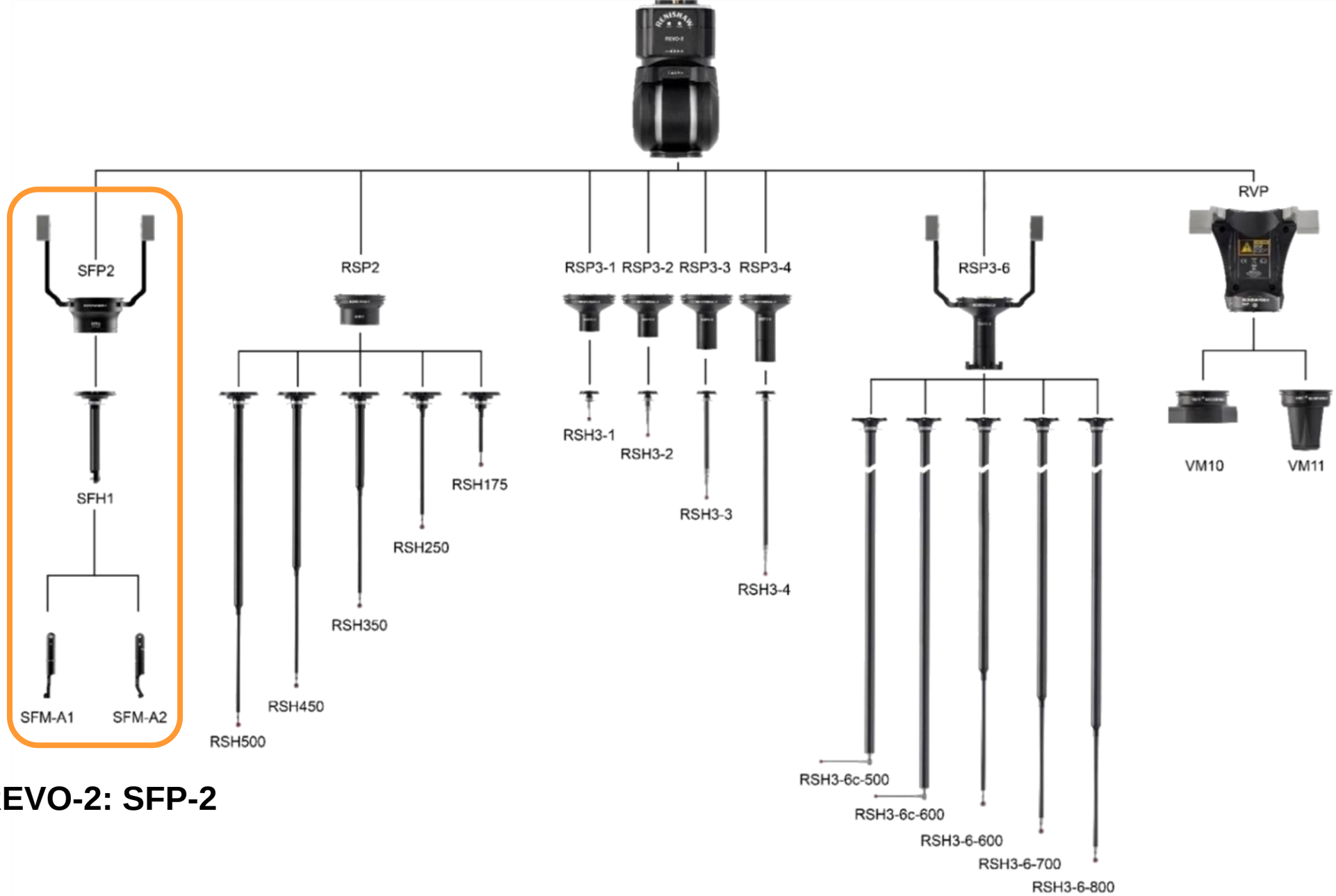
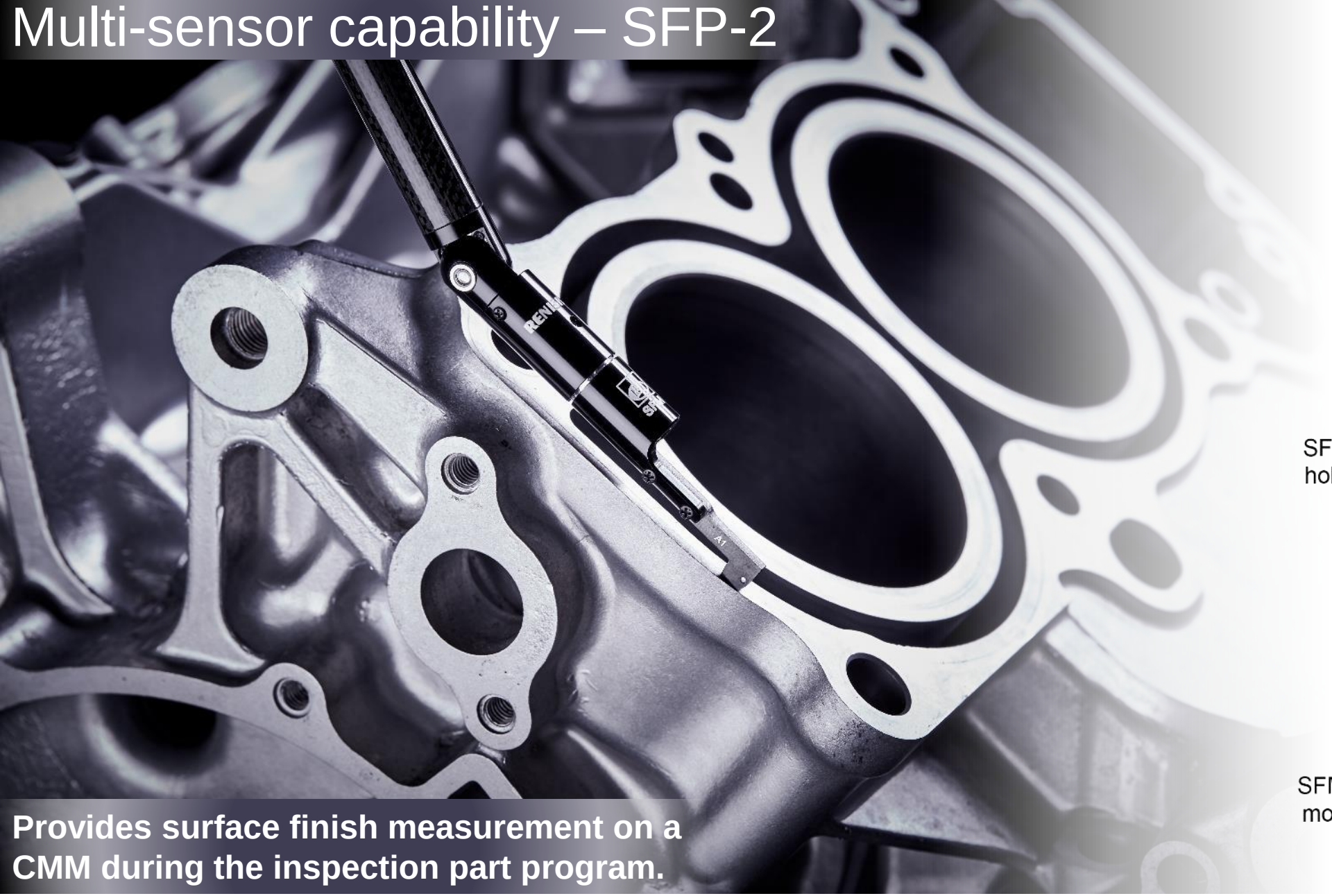


REVO-2: SFP-2

Multi-sensor capability – SFP-2



Provides surface finish measurement on a CMM during the inspection part program.

SFH-1
holder

SFH-2
holder

SFM-A1
module

SFM-A2
module

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REVO-2

Surface Profile Analysis functionality (Standard):

Form Removal:
RemoveMean, RemoveLine
RemoveLineWithRotation

Filtering:
Gaussian, ISO13565,
DiscardEndRegions

Standard Parameters:
Ra, Rq, Rt, Rp, Rv, RzDIN, Rpm, Rvm, Rsk, Rku

Bearing Ratio Parameters:
RmrPeakReferenced,
RmrMeanReferenced

Profile Analysis functionality (Advanced):

Rk Parameters:
Rk Family (Rk, Rpk, Rvk, Rmr1, Rmr2)

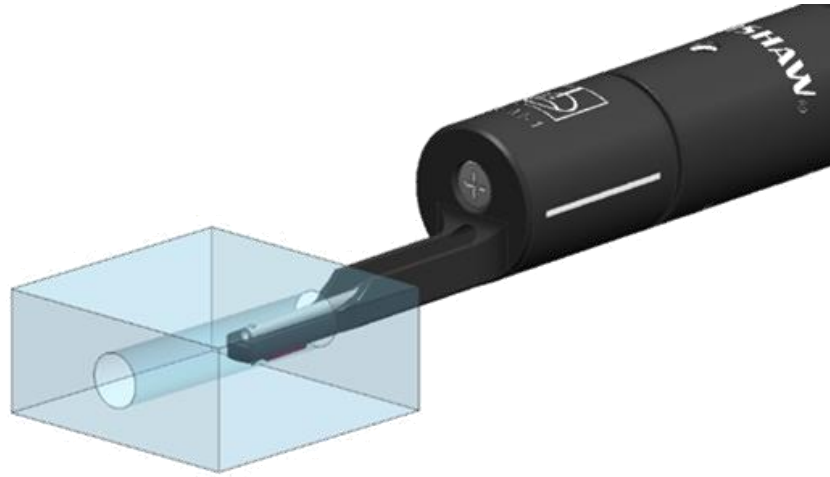
Advanced Filtering:
SplineFilter,
RobustSplineFilter

Probability Parameters:
RqFamily (Rpq, Rvq, Rmq)

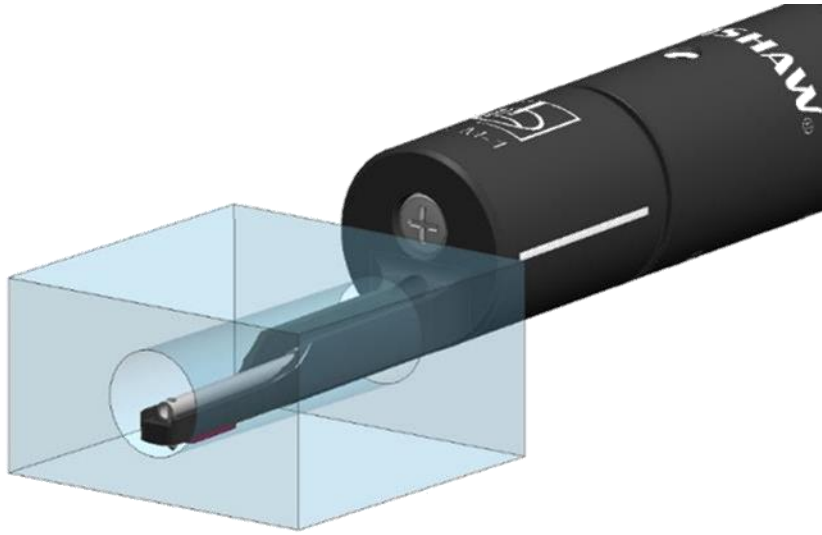
Morphological Waviness Parameters:
Wvoid, Wvdd, Wcvx

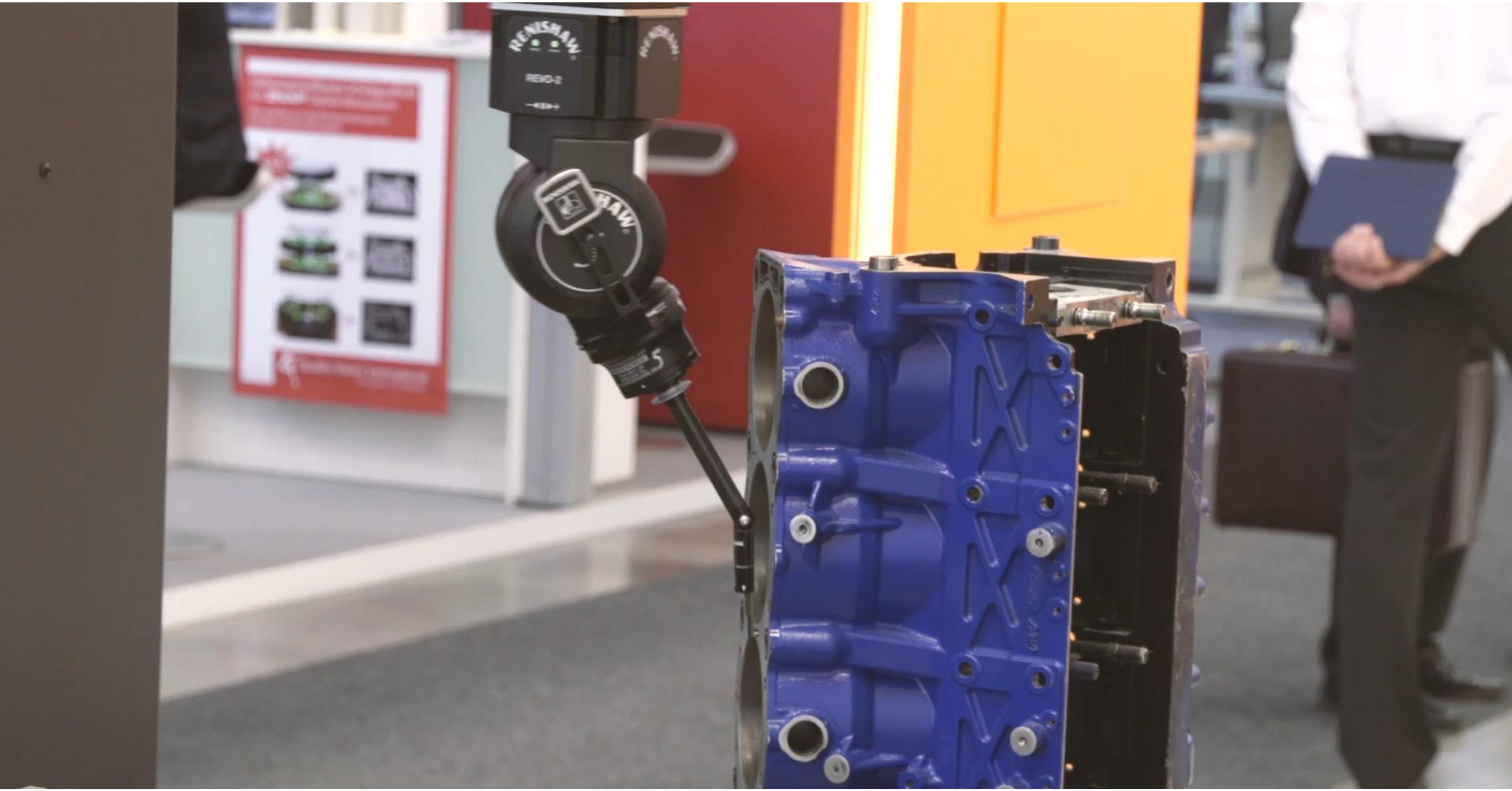
Advanced Parameters:
Rseg, Rc, Rsm

Dia 5* x 8 mm hole access (tbc)
**custom designs may enable this to be reduced*



Dia 6 x 20 mm hole access

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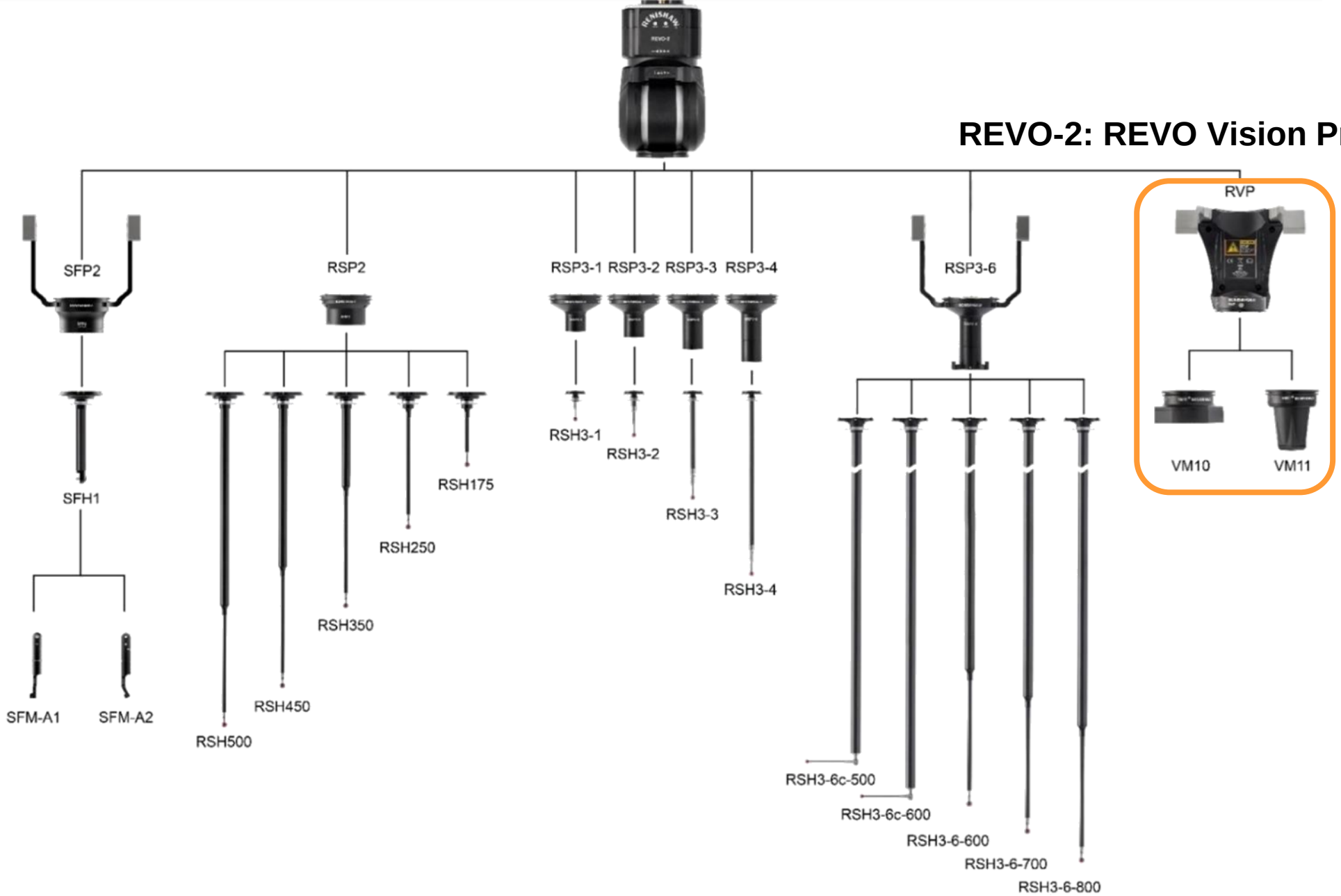
REVO-2: REVO Vision Probe (RVP)



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REVO Vision Probe (RVP) overview

- Increases the multi-sensor capability of Revo-2 by adding non-contact inspection.
- Utilizes REVO-2’s 5-axis positioning capabilities.
- Inspect high volumes of holes that could not be accurately measured with tactile probing or manual methods.
- A single common coordinate system and datum are used for all REVO-2 probes.

RVP component overview

REVO-2 head

High-speed communications for large data transfer required for new technology probes.

RVP Probe

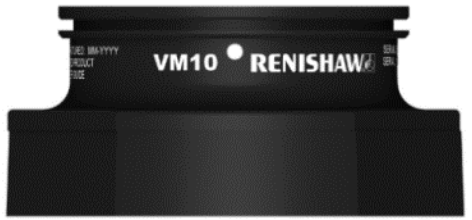
- Industry standard CMOS sensor.
- Real-time image processing.
- Global shutter technology.

- Two module variants.
- Different specification.
- Varied applications.

Vision modules

RVP vision modules

- Integrated LED lighting.
- Automated changing with dedicated rack ports.
- Currently two module types:
  - VM10 for features larger than 2mm with a maximum field-of-view of 40mm x 50mm.
  - VM11 for features 0.4mm and larger with a maximum field-of-view of 12.5mm x 10mm.
- Varying applications.
- Expanding RVP capability.



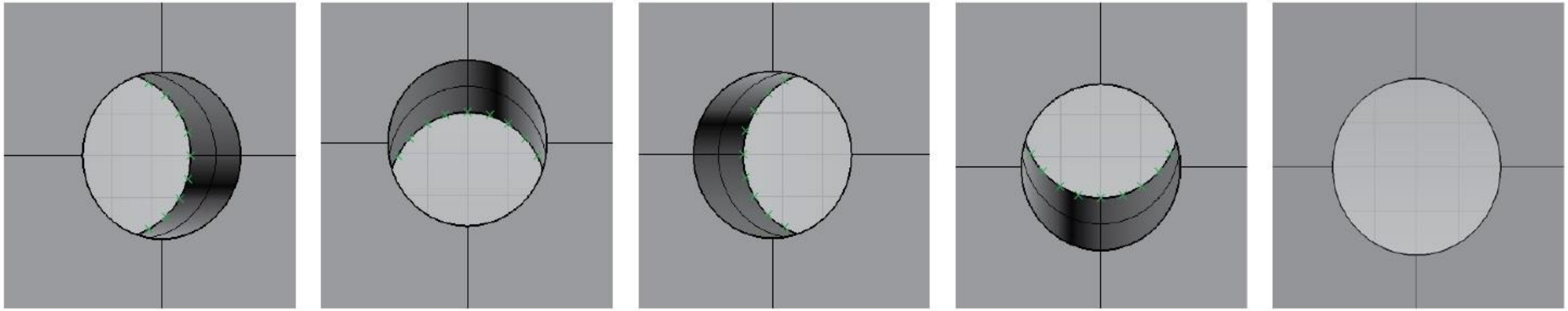
VM10 module

VM11 module

RVP vision modules

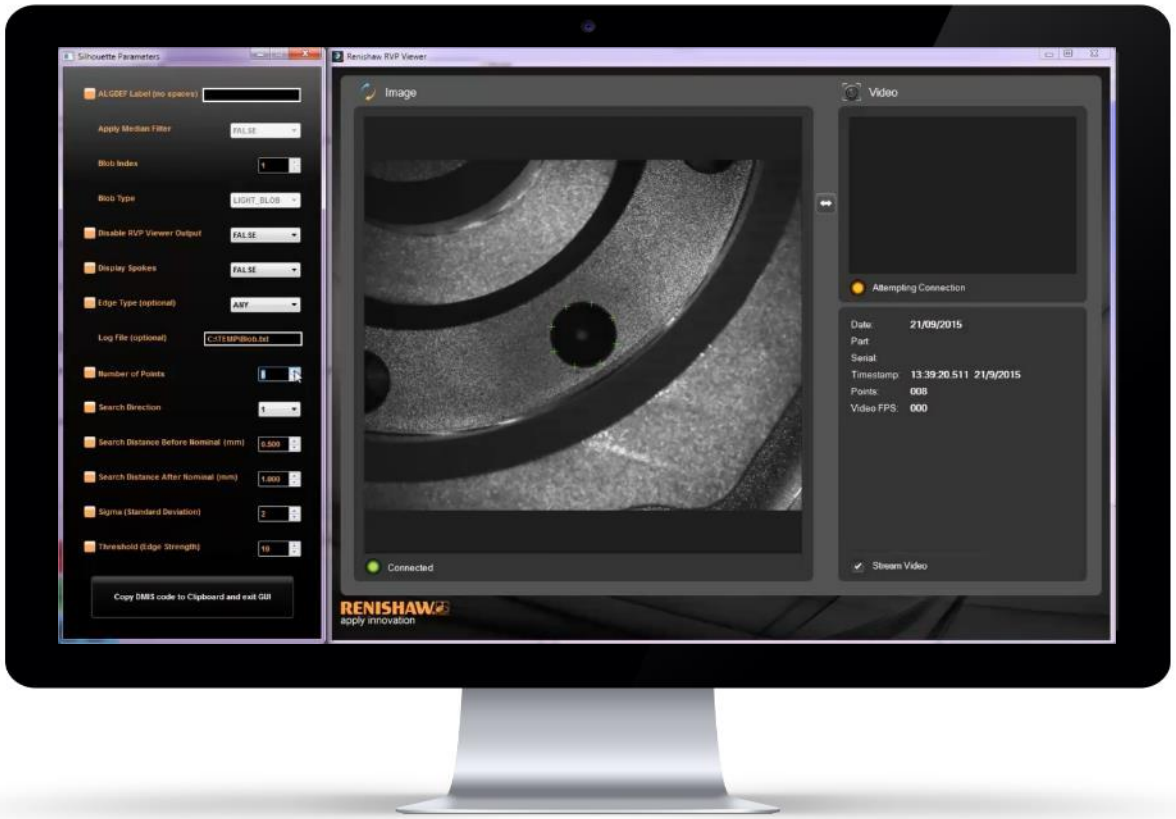
One technique possible with RVP is to use the infinite positioning capability of the REVO-2 system to capture multiple images of the same hole, to build up a complete reconstruction of the top and back of the feature, as well as the internal change in diameter if required.

The image below shows how the RVP can be orientated to capture the back edge of a hole from multiple angles that would not be visible from a nominal orientation to the feature.



RVP vision modules

- Fully integrated as an option within MODUS and UCC.
- Sensor settings intuitive and based on tool configuration.
- Comprehensive settings menu:
  - Exposure
  - Illumination
  - Light intensity
  - Region of interest
- Separate viewer application that runs in parallel to MODUS for live streaming and image processing results.



Thank you!