Improving Geometrical Set up of robot cells

Using Ball bars and probing

3DMC - 28th September 2023 - Bilbao

Mr Jean-Louis Grzesiak – IA Technical Director

Agenda

Improving Geometrical Set up of Robot cells

Need — **Off-line Programming?**

Close it! — **The metrology Loop !**

Tool Box — **Instrument & solution**

Q&A if time permits

Our service, your solution

Applications engineering

Custom turnkey solutions

End user retrofits

Hardware

Consultancy

Consumables supply

OEM fitment

Advanced products

Worldwide service and support

Software

Customer training

An industrial problem: Spot Welding with Offline Programming

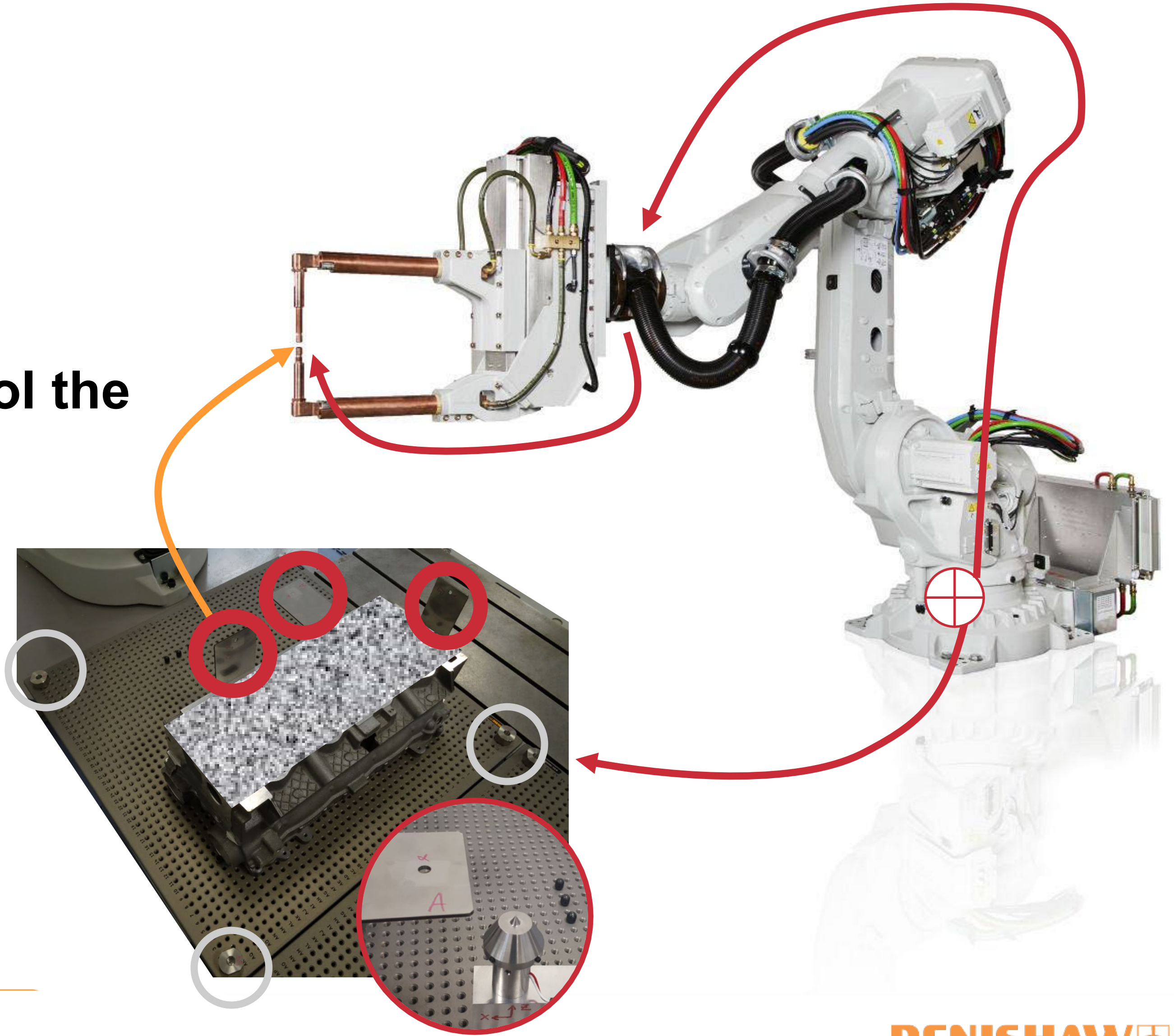
We calibrated a palette under CMM

- with Target points for welding
- with Reference Points

To execute the program, I need to control the tool in the part coordinate system:

- Where is the Electrode from the robot end?
- Where is the Part from the robot base?
- Can we trust the Robot?
- **We need to close the metrology loop!**

We test by driving a pin into a hole



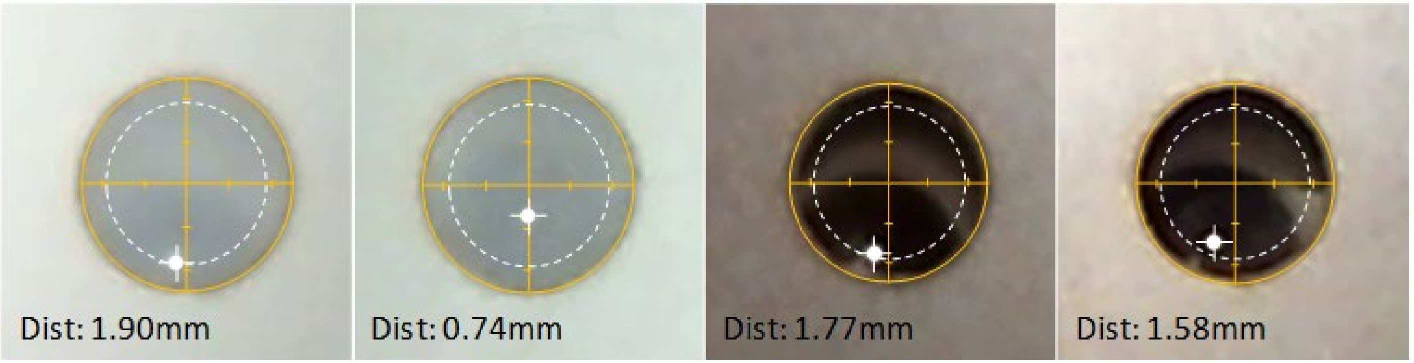
The standard Pin to Pin Method

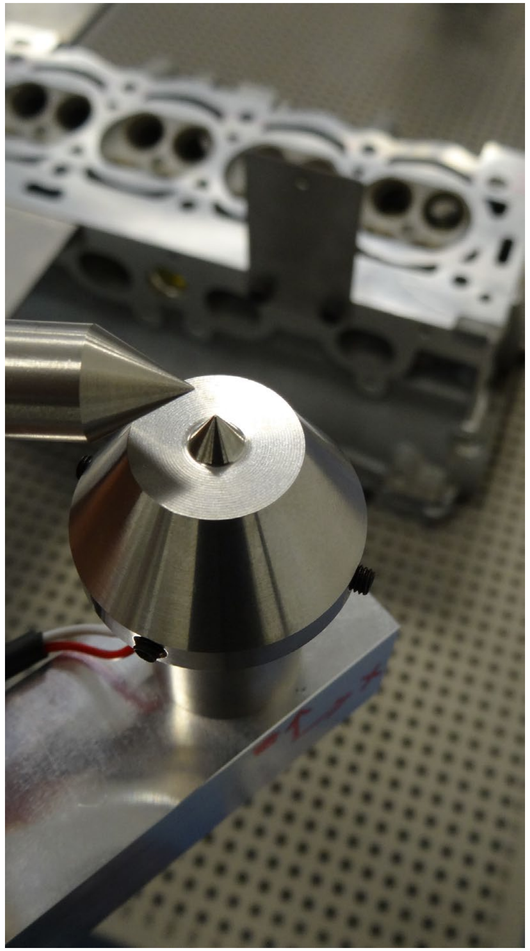
We visualy determine the frames with the out of the box robot tools

- The Tool Centre Point (TCP)
- The part alignment
- Residual MAX error : 0.31mm

We visit our 4 positions and…

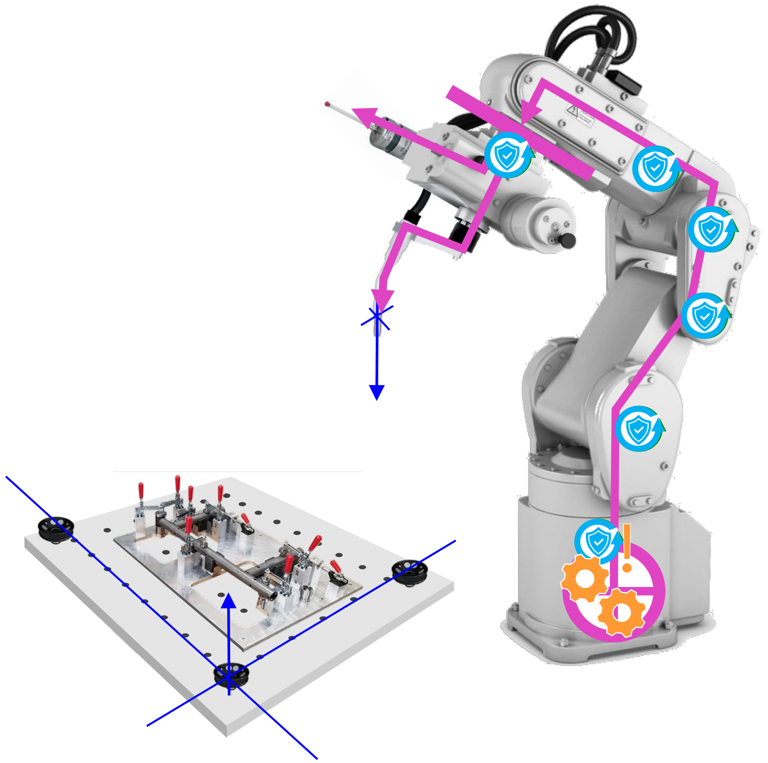
- We witness a max error of 1.9mm

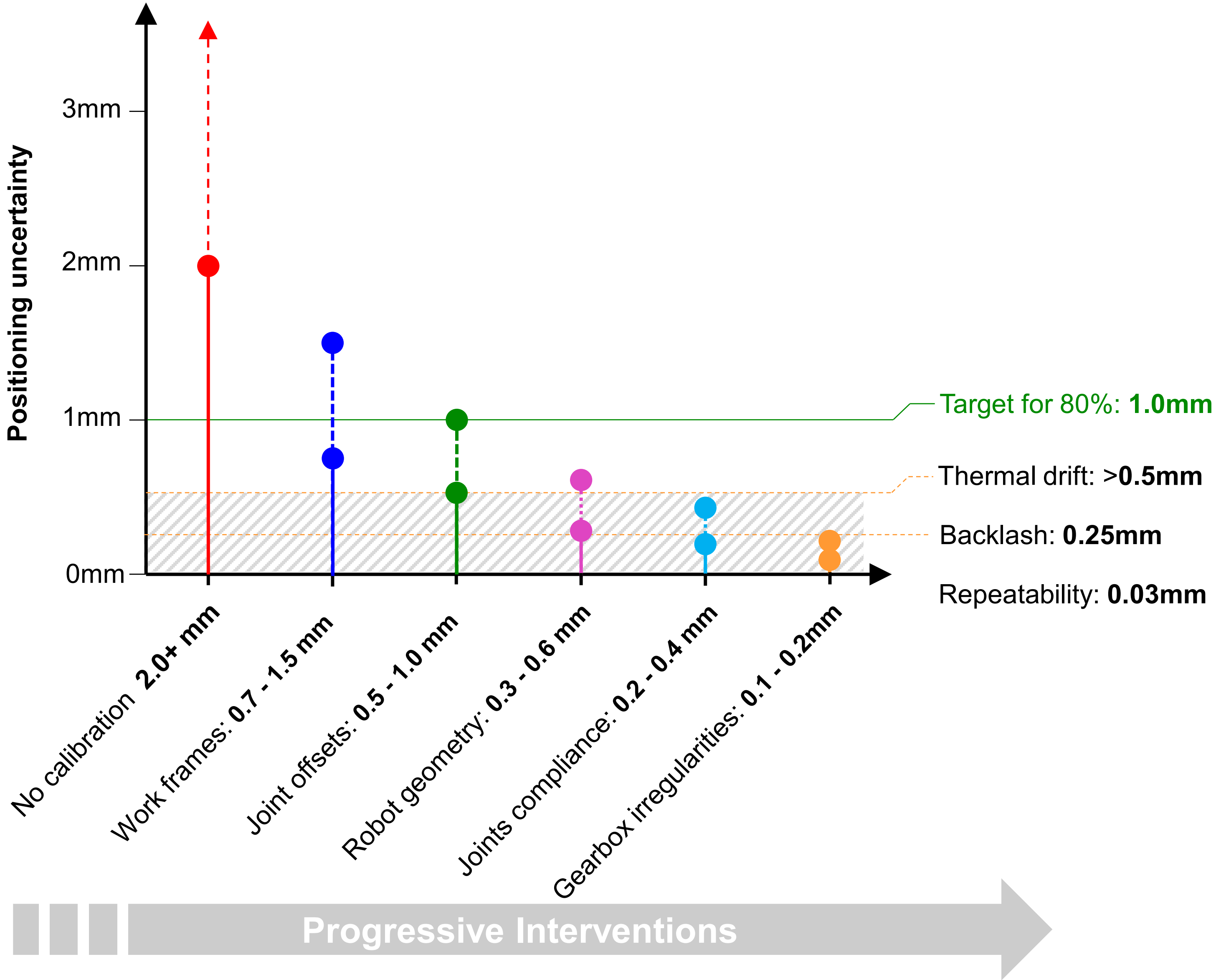




Improving Performance

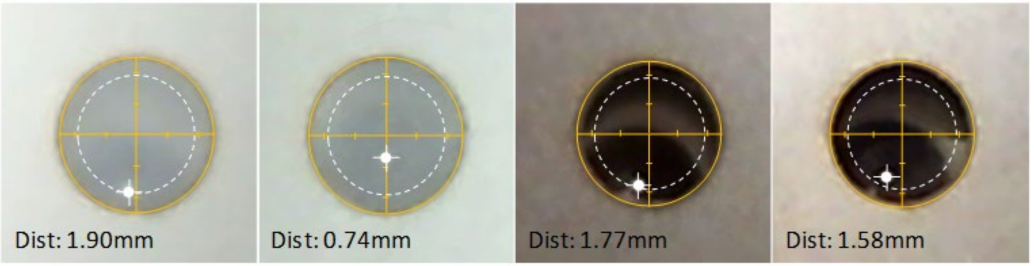
Through progressive interventions



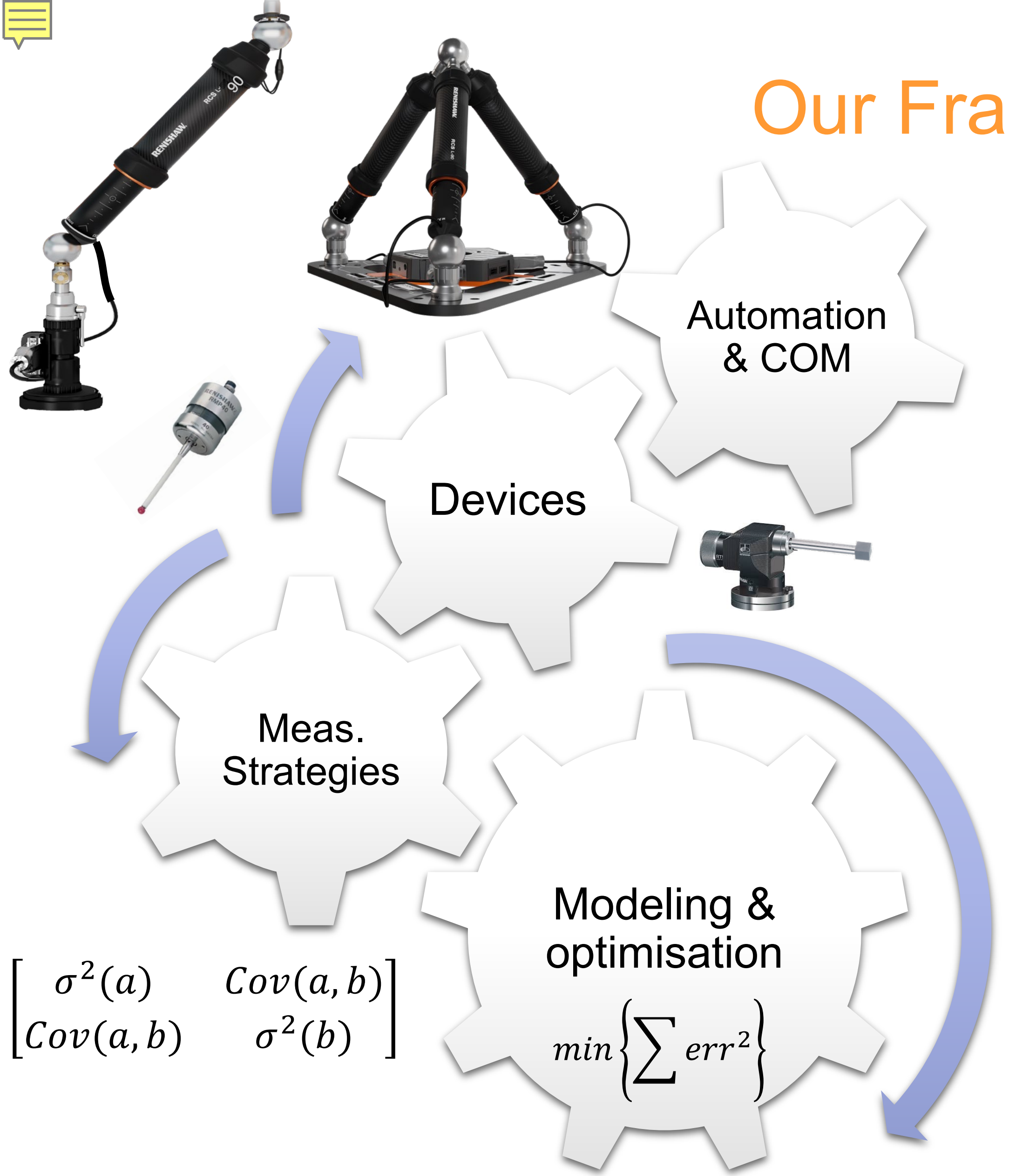


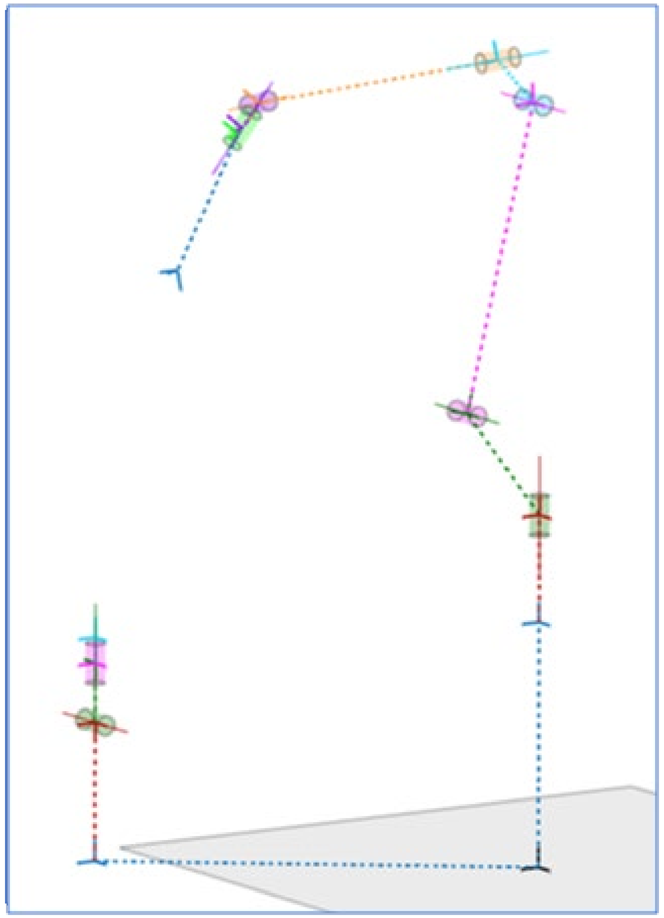
Using Renishaw Tools for Robots…

Pin to Pin Method	Part Frame Pin to Pin Method	TCP Pin to Pin Method Residual « 0.31mm »	Error 1.90mm



Our Framework for Robots





Renishaw RCS P-Series Probe Calibration

From the model to the identification with a probe on a robot

$$err = \sqrt{\left\|\overrightarrow{CP}\right\| - R}$$

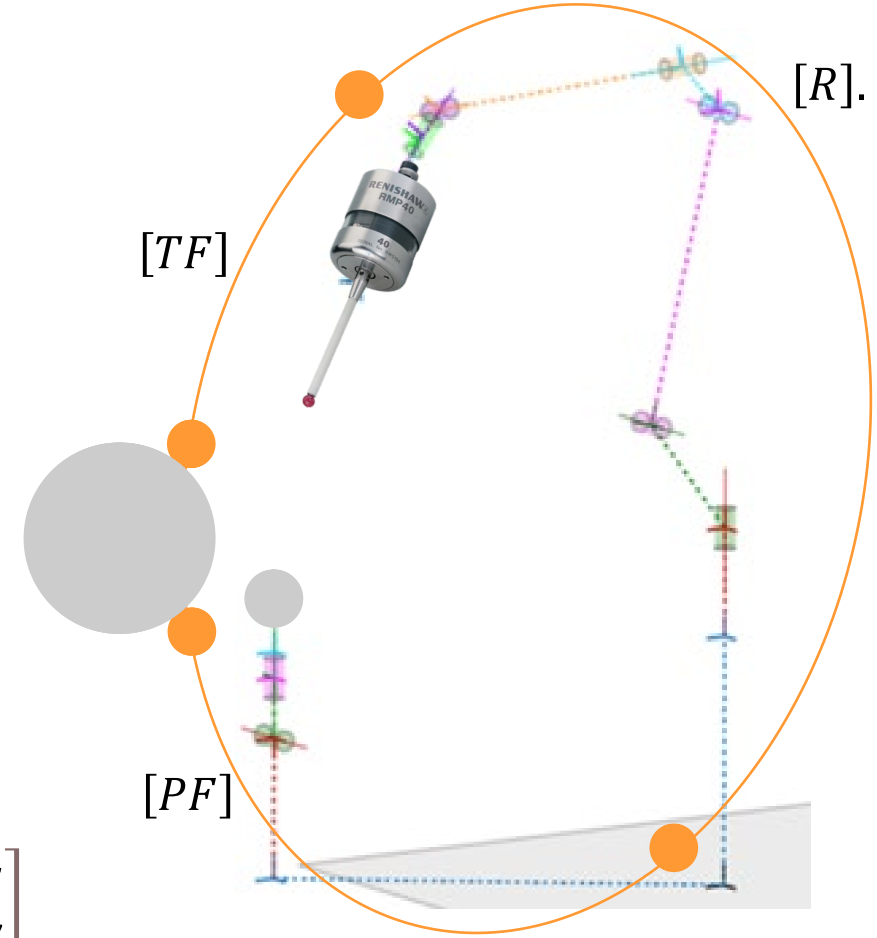
$$err = \sqrt{\left\|\overrightarrow{Tr}([PF]^{-1}.[R].[TF]) - \overrightarrow{OC}\right\| - R}$$

$$err = \sqrt{\left\|\overrightarrow{Tr}([PF]^{-1}.[R].[TF].[\Delta TF]) - \overrightarrow{OC}\right\| - R}$$

$$err = \sqrt{\left\|\overrightarrow{Tr}([PF]^{-1}.[R].[TF].[\Delta TF]) - \overrightarrow{OC}\right\| - R}$$

$$min\left\{\sum err^2\right\}$$

$$[H] = \begin{bmatrix} [Rotation] & \begin{vmatrix} Tx \\ Ty \\ Tz \end{vmatrix} \\ 0 \quad 0 \quad 0 & 1 \end{bmatrix}$$



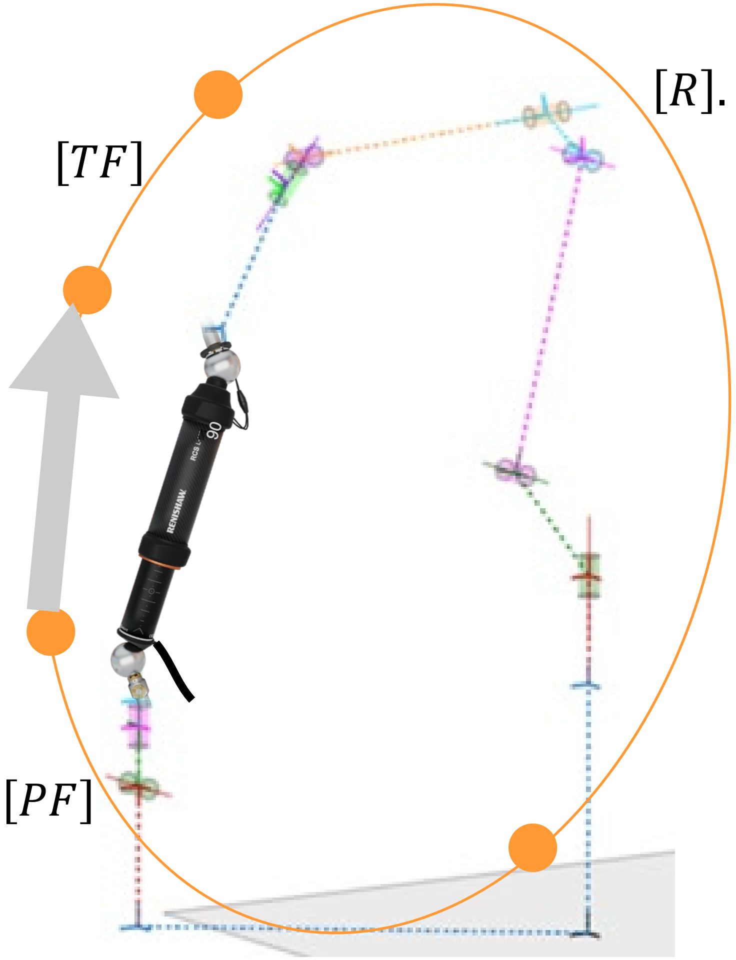
Renishaw RCS L-90 for a TCP identification

From the modelling to the identification with a ball bar

$$err_i = \left(\overrightarrow{Tool_i} - \overrightarrow{Pivot}\right).\overrightarrow{Dir} - Length_i$$

$$err_i = \left(\overrightarrow{Tr}([PF]^{-1}.[R].[TF]) - \overrightarrow{Pivot}\right).\overrightarrow{Dir} - Length_i$$

$$min\left\{\sum err^2\right\}$$



Renishaw RCS T-90 for joint offset calibration

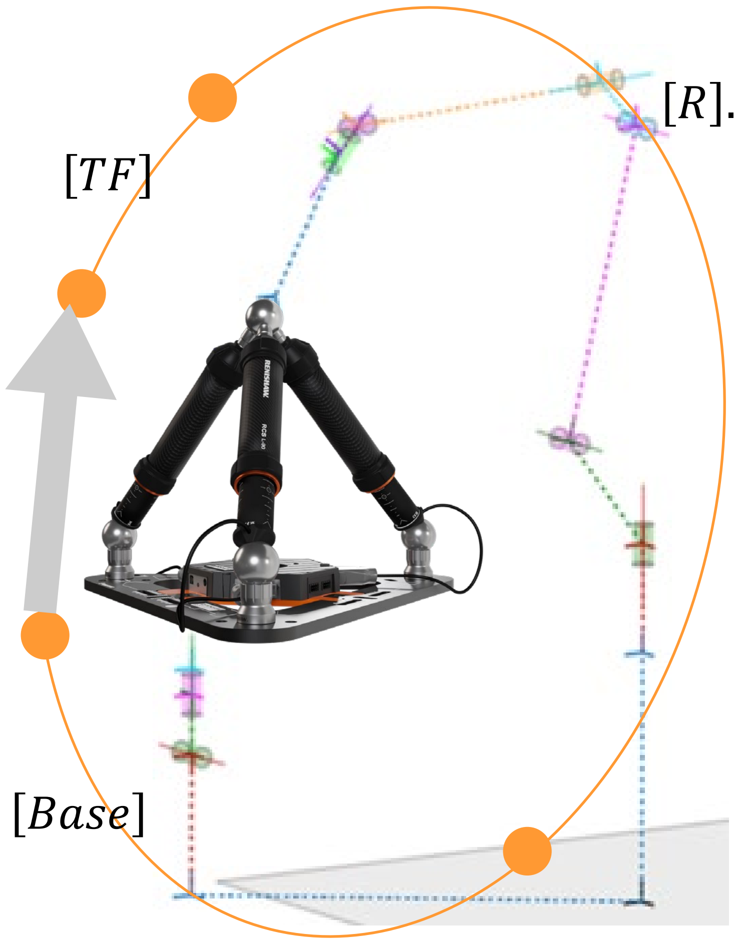
From the model to the identification with a tripod of ball bars

$$\overrightarrow{err_i} = \overrightarrow{Tr}([Base]^{-1}.[R_i].[TF]) - \overrightarrow{TriPod}$$

$$[R] = [A_1].[A_2].[A_3].[A_4].[A_5].[A_6]$$

$$\overrightarrow{err_i} = \overrightarrow{Tr}([Base]^{-1}.[A_1].[A_2].[A_3].[A_4].[A_5].[A_6].[TF]) - \overrightarrow{TriPod_i}$$

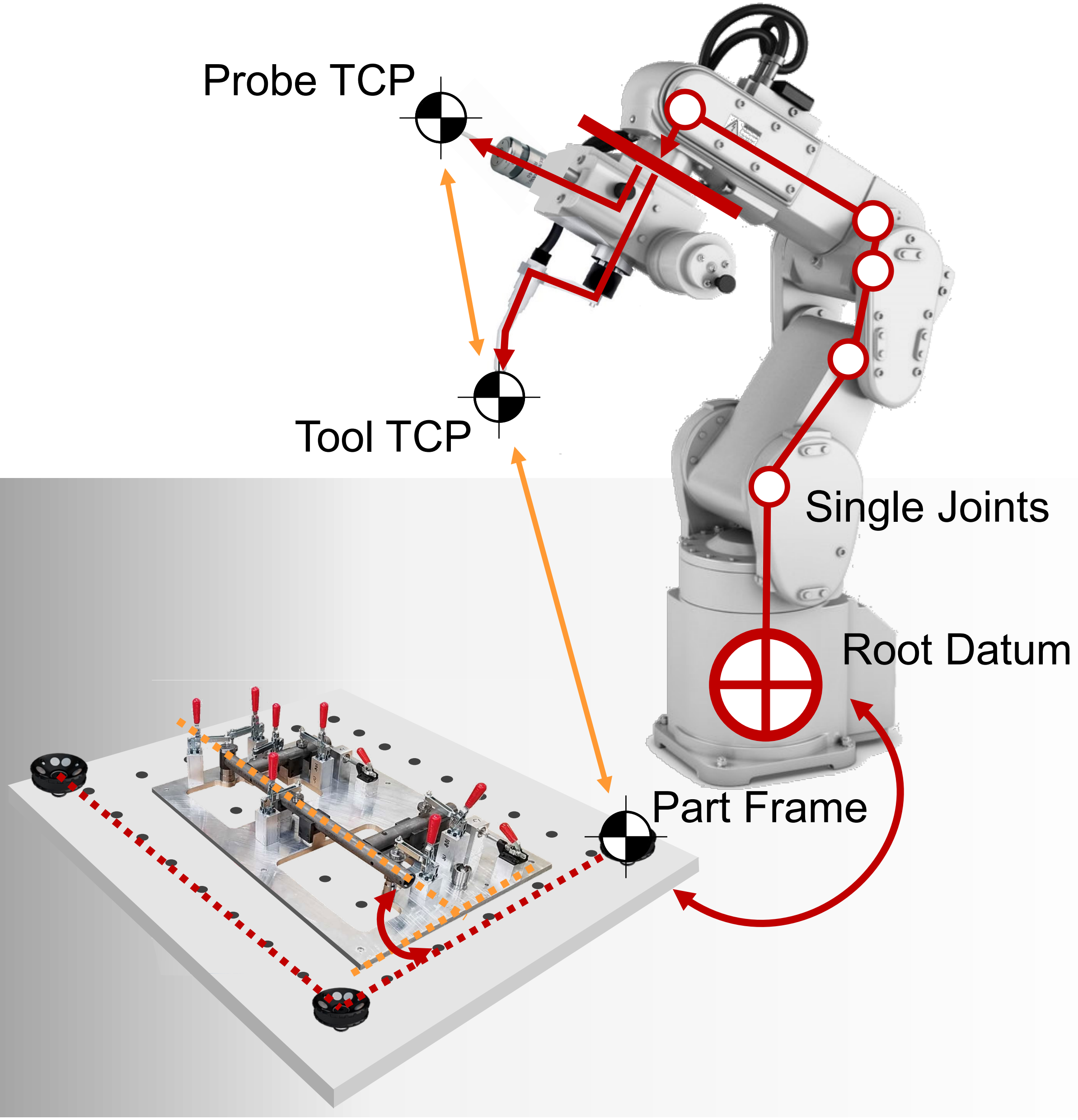
$$min\left\{\sum err^2\right\}$$



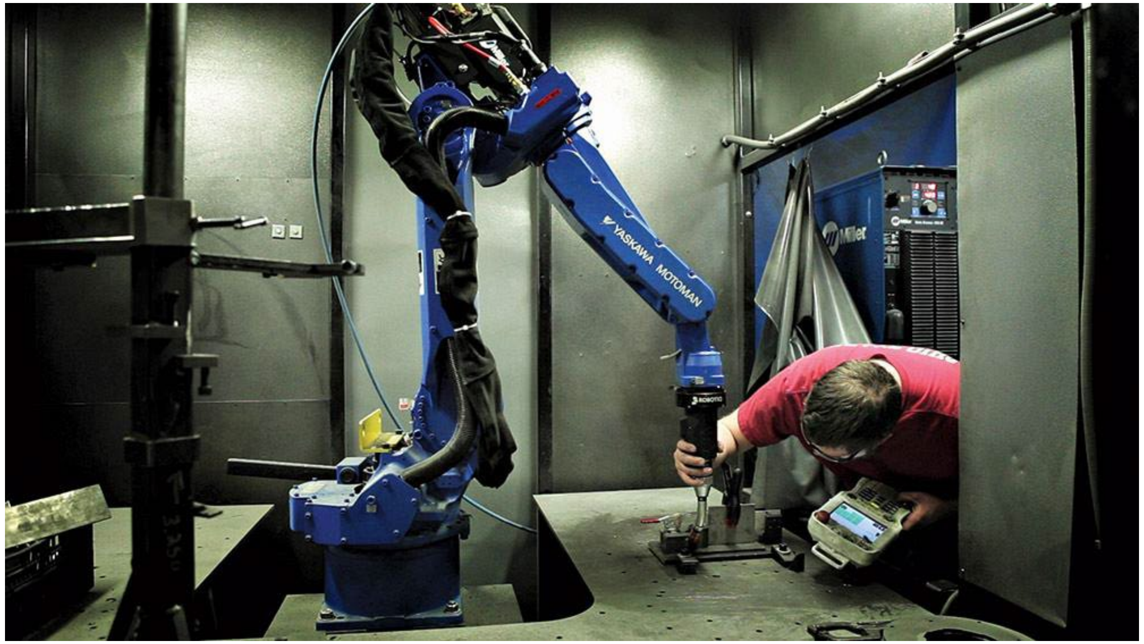
Closing the Loop

Applying sound metrology principles

- Offline Programming
- Zero Manual Intervention
- Automatic Cell Recovery



Manual and visual Pin to pin method



- **Out of the box method** – anything else?
- **Reproducible ?** – Not really

Robot unidirectional repeatability: <10µm

R&R on pin to pin TCP: 700 µm!

Introducing the RCS Product Line

Aiding the commissioning, diagnostics and service

- Global launch in May/June 2023
- Bringing Renishaw's proven technology, plus 50 years of metrology know-how, to Industrial Automation
- A Ballbar and Tri-ballbar kit for precise 1D and 3D tests - Automating calibration, setup, diagnostics and service
- A range of probing kits which are calibrated to 6DoF for alignment and automated recovery routines

Improving Geometrical Set up of robot cells

Process foundation

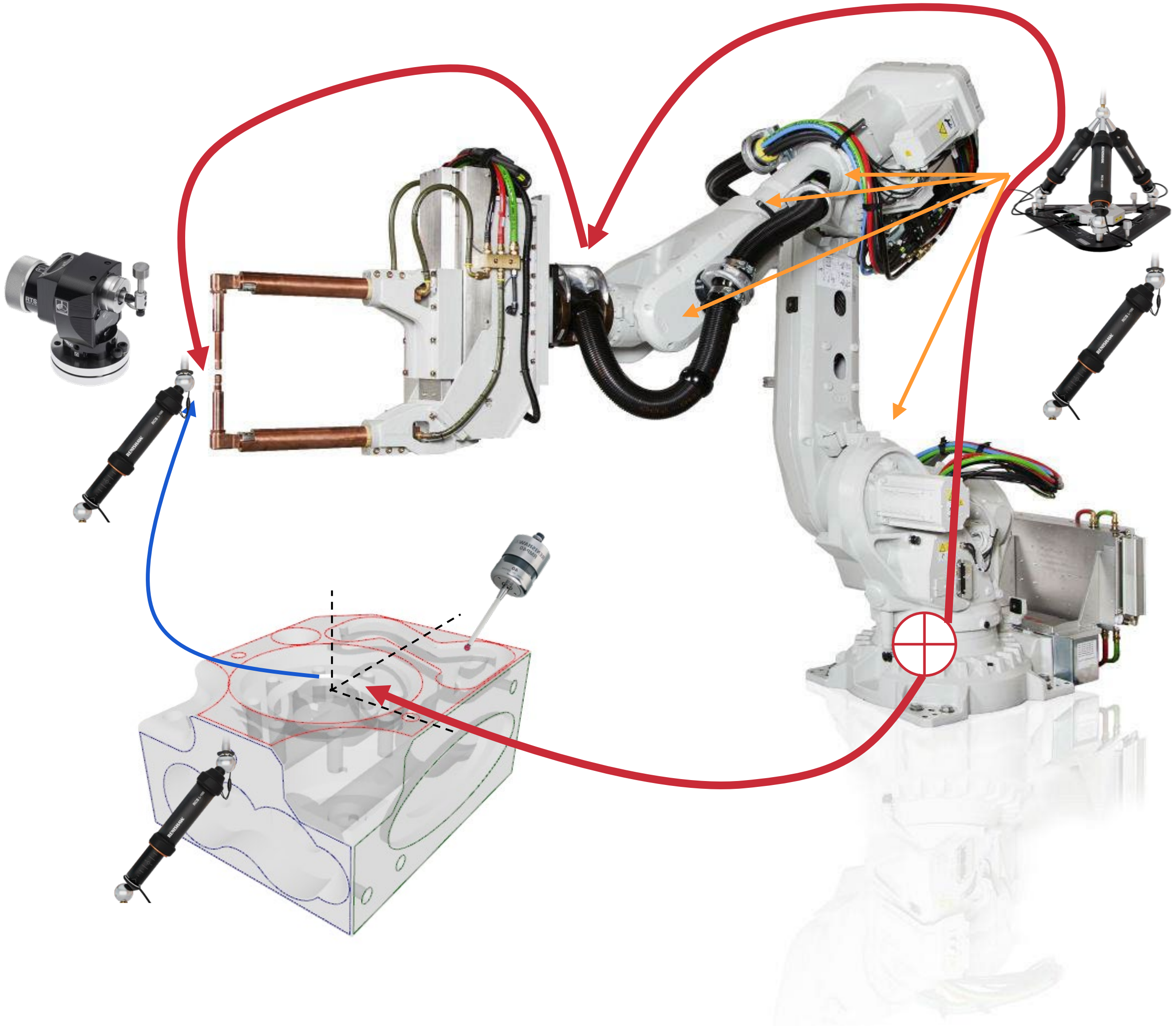
- Joint offsets
- Verification / Diagnostics

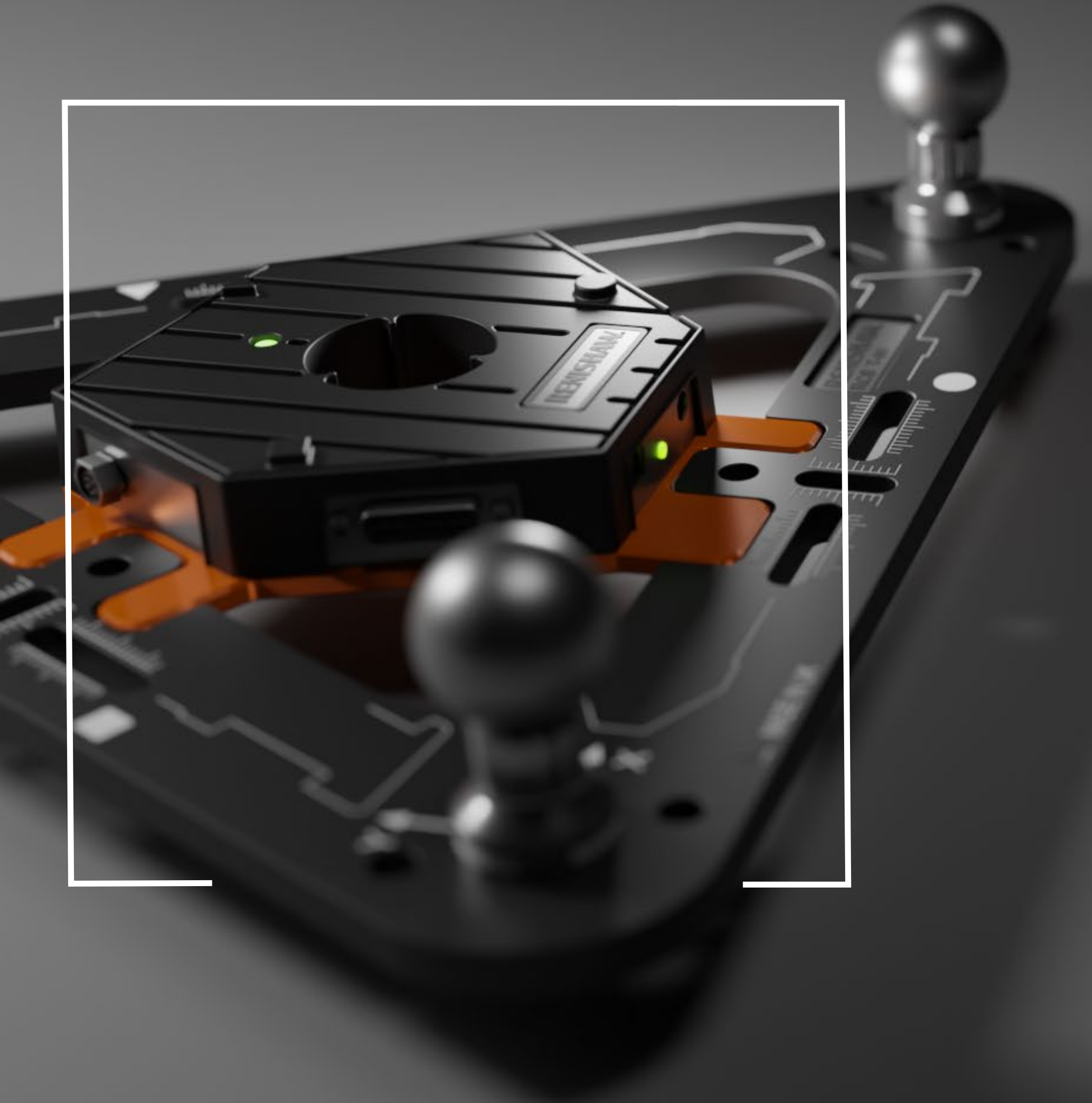
Process settings

- TCP
- Part Frame

In-Process Control

- Part Frame/ Tool Frame
  - Simple and complex alignment
- Measurements
  - Best Fit, distance, angle





Any questions?

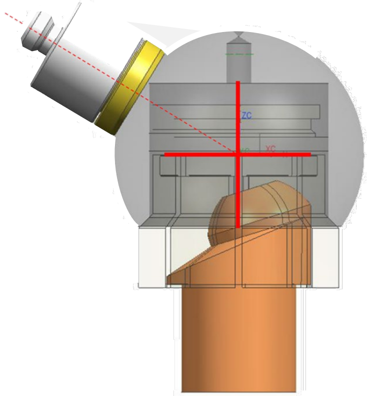
Improving Cell Initialisation Using Ball Bar and Probing

3DMC - 28th September 2023 - Bilbao

Mr Jean-Louis Grzesiak - IA Technical Director

RCS Products

Tools in a toolkit



RCS Products

Permanent in-process