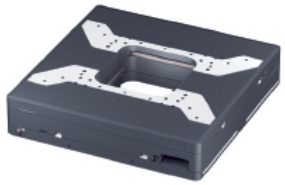
“PI’s vision on precision automation;

Cliff Jolliffe – what are current market demands, how do we fulfill these, and what will be the future demands?

Motorised Standard Product Overview

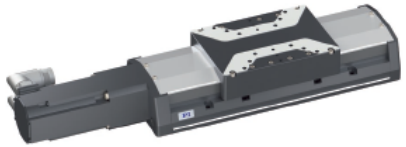
XY Stages

- Screw or direct drive
- Mechanical or air bearing
- Incremental or absolute encoders
- Optional aperture



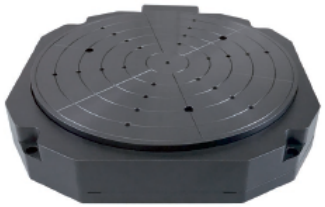
Linear Stages

- Travel range up to several 100 mm
- Screw or direct drive
- Mechanical or air bearing
- Incremental or absolute encoders
- Vacuum or clean room compatible



Rotary Stages

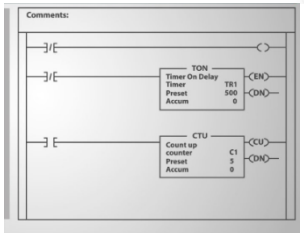
- 360° or goniometer stages
- Worm or direct drive
- Mechanical or air bearing
- Incremental or absolute encoders
- Vacuum or clean room compatible



Industrial Motion Control

What‘s happening?

- Historically very distinct automation platforms. For example PLC versus Motion Controller
  - Very different platforms for “general automation systems” versus “high precision motion” requirements
  - Different language disciplines – PLC language, G code, Motion control script language, High level (.net)
- Industrial versus Research customers
  - Research customers had there own frameworks, (EPICS and TANGO)




```
191  G90 ; switch back to absolute positioning
192  G28 X0 Y0 ; home X and Y axes at the same time
193  M104 S190 T0 ; starting heating the extruder temperat
194  M140 S60 ; start heating the bed temperature to 60 de
195  M190 S60 ; wait for the bed to reach 60 degrees befor
196  M109 S190 T0 ; wait for the extruder to reach 190 degr
197  G1 X5 Y5 F2400 ; move to start of priming location
198  G1 Z0.5 F600 ; slowly lower for priming
     G92 E0 ; zero extruded length (set E axis to zero)
```

Industrial Motion Control

What‘s happening?

- Merging and blurring of the previous situations
  - Customers don’t see/ want the differential between these previous ideals
  - Understanding that some devices are functionally better than others (generic or vendor)
  - Different parts of the automation system may have higher and lower performance requirements

- What might this mean?
  - Functions that are historically found on a general automation system should also found on a motion controller – Functional safety
  - Both systems co-exist on the same network and are able to exchange data easily – Industrial networks

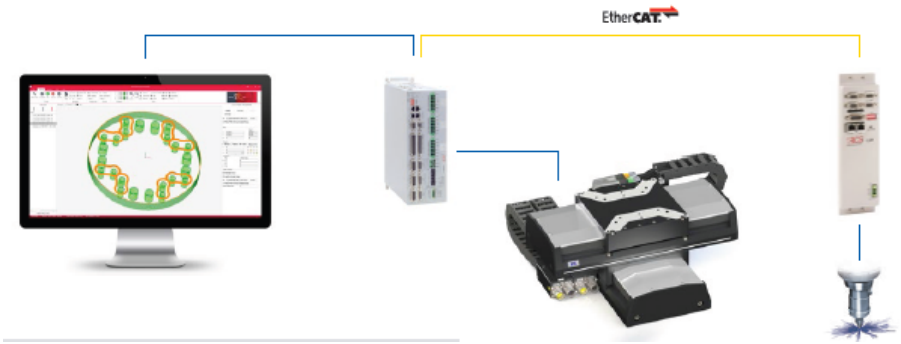
Industrial Motion Control

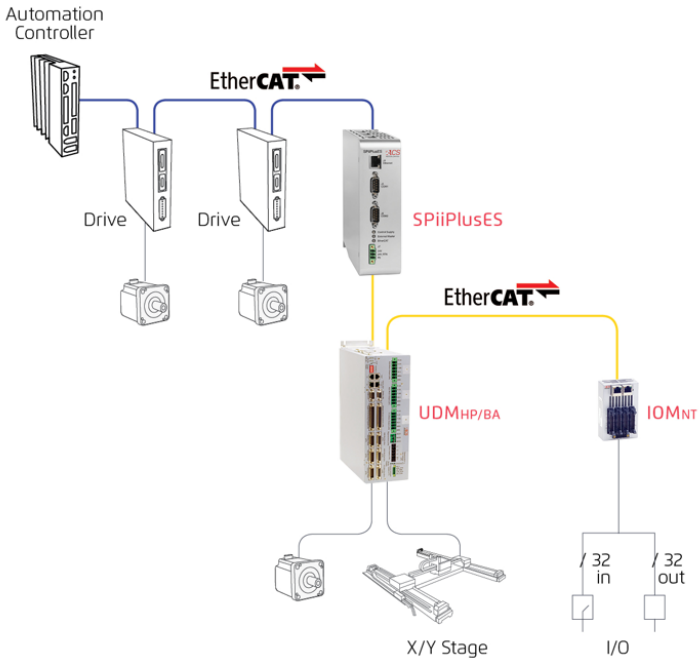
What is PI doing?

- PI known for highest performance motion products
- However PI controllers were “standalone” communicated by *serial based communications* to each other or other parts of the machine.
- PI acquisition of ACS, significant event in our approach to Industrial motion control
  - ACS high performance motion controllers use EtherCAT as their industrial network
  - Adoption of EtherCAT across product line in progress
  - Technology transfer both ways between groups
- Allows modular approach to add devices simply and not specifically PI as the vendor

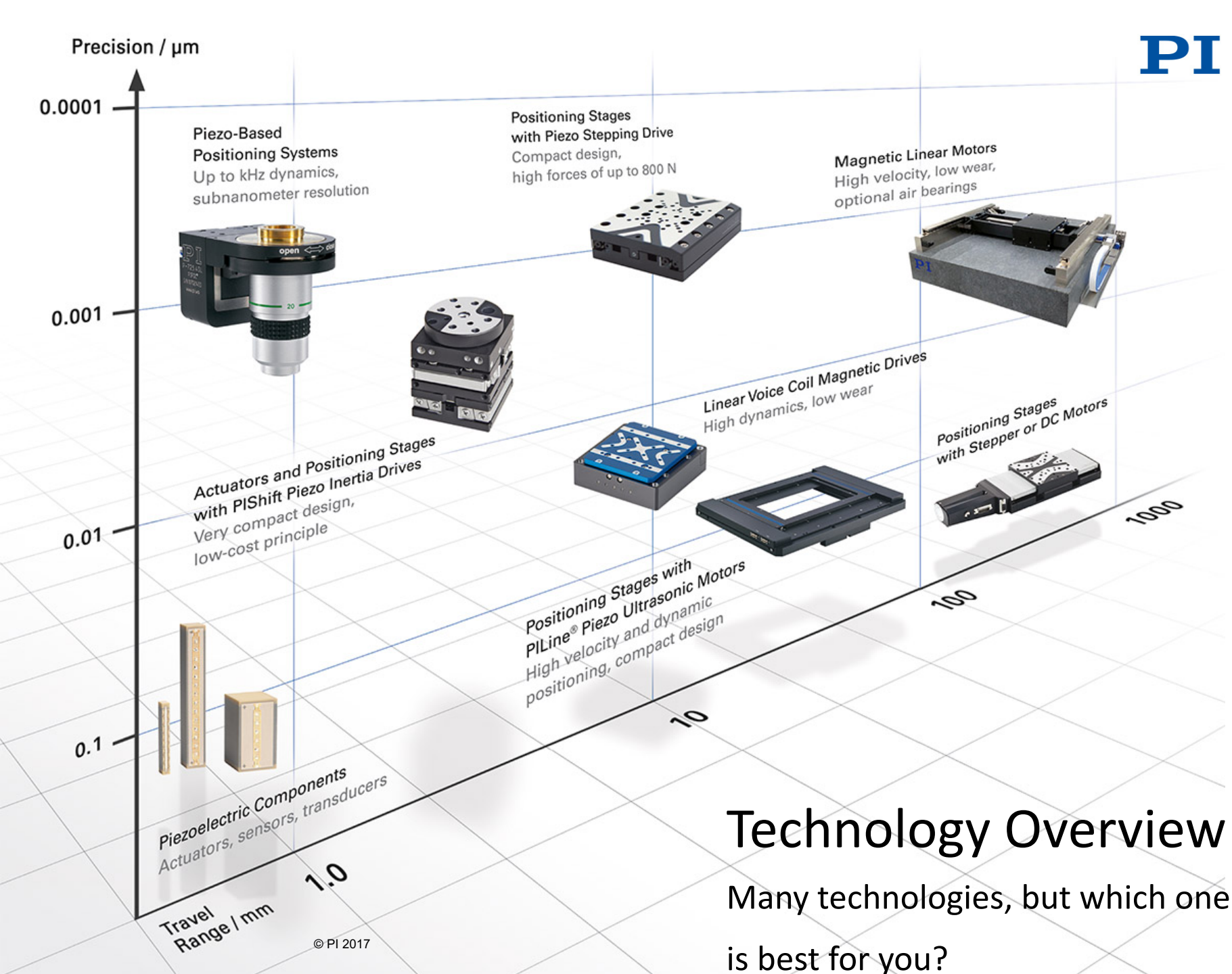
Industrial Motion Control

High Performance – EtherCAT – highly modular



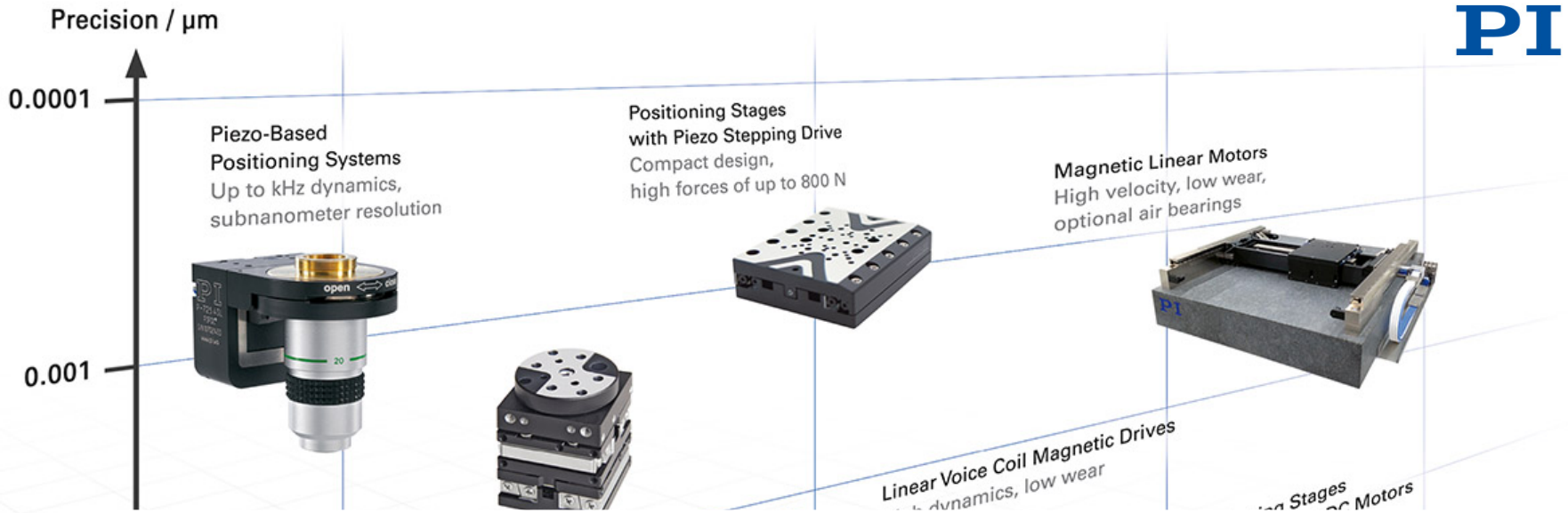


- Controller can be PLC, Windows PC, Standalone Controller, or combined drive controller
- Modular hardware design
- Open architecture for third party EtherCAT drivers
- Universal support of multiple motor and feedback types
- HMI for CNC user operations or graphical interface



Technology Overview

Many technologies, but which one is best for you?



Any or multiple types connected by one network

Technology Overview

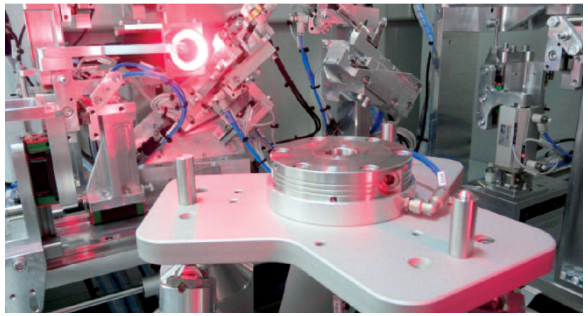
Many technologies, but which one is best for you?

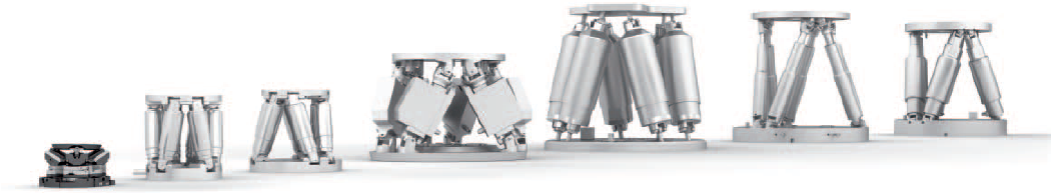
Hexapods

High Stiffness – Freely Definable Pivot Point – Compact Design

Key Features of Hexapods

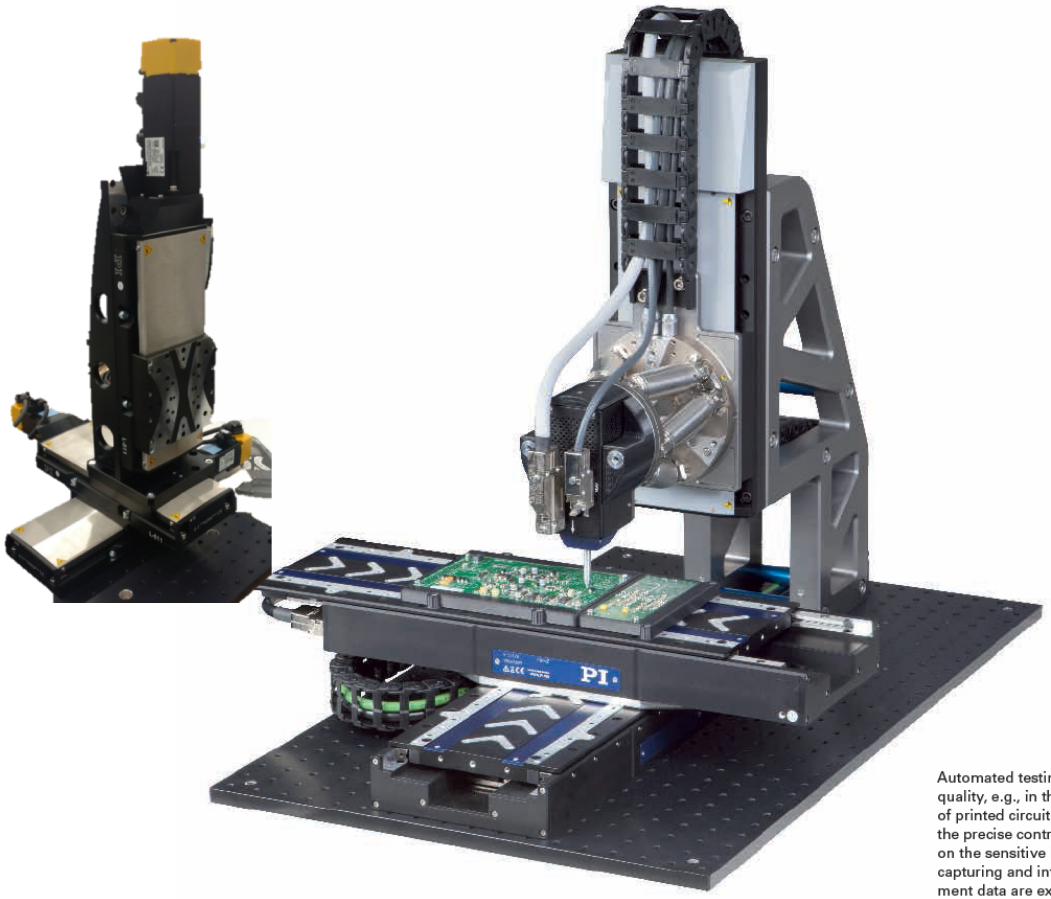
- Three linear axes XYZ, three rotational axes Roll, Pitch and Yaw
- High stiffness
- Low moving mass, low inertia
- Excellent dynamic behavior, fast step-and-settle
- Excellent repeatability
- Small installation space
- Large central aperture
- No moving cables





Industrial Manufacturing

Combining technologies



Automated testing procedures ensure quality, e.g., in the production process of printed circuit boards (PCBs). Thereby, the precise control of the forces acting on the sensitive boards as well as the fast capturing and interpretation of measurement data are extremely important

Linear Motor Stages

Hexapod

Voice Coil with force sensor

EtherCAT industrial Network

Laser Material Processing

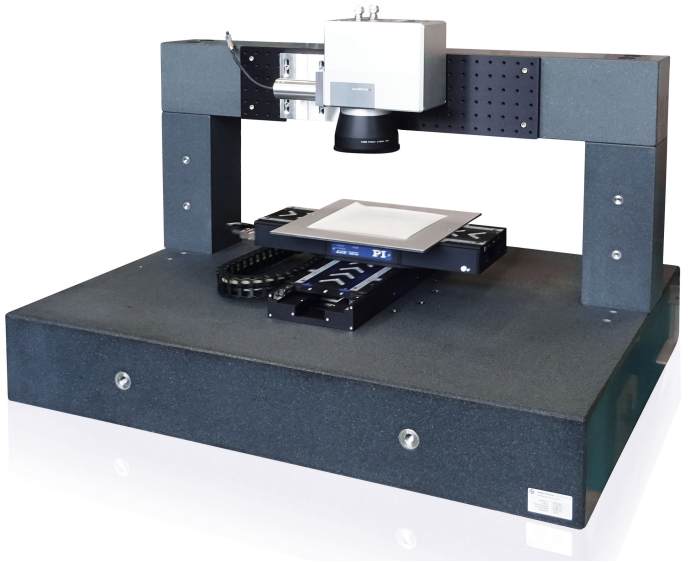
Debris Protection and ability to control Laser Power

Linear Motor / ball screw driven

Synchronized motion control

Laser or event triggering

ScanLab integration/ cooperation



Laser Machine Builder

Why do we make the best products for you and your customers!

PI's

XLSCAN

Z-Theta for micro-CT Scanning

System: Custom A-123 with Z Counterbalance, Custom A-623 Rotary, Brackets, with A-812 Controller..

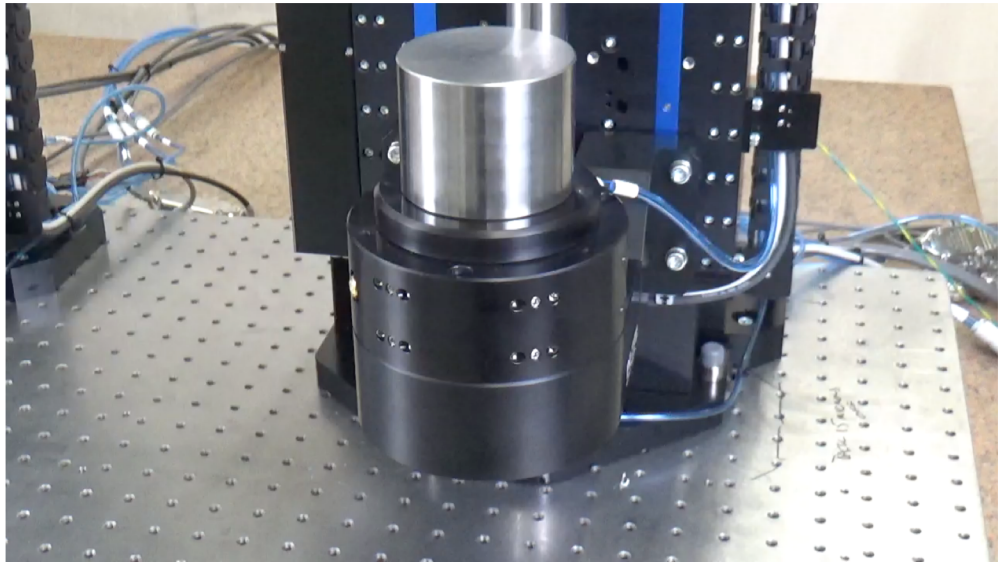
Smooth motion, high accuracy, stiff.

Optional XY Piezoelectric inertia drive

Q-motion stage mounted to Theta axis

Piezo inertia drives are space-saving with relatively high holding forces

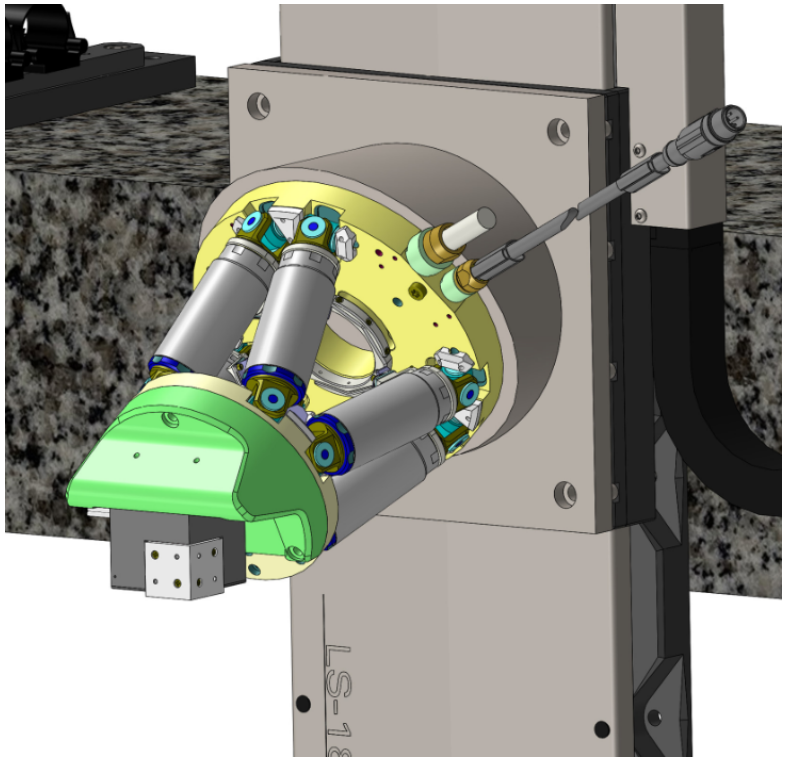
Vacuum and nonmagnetic environments



Alignment and Probing

Alignment and Packaging

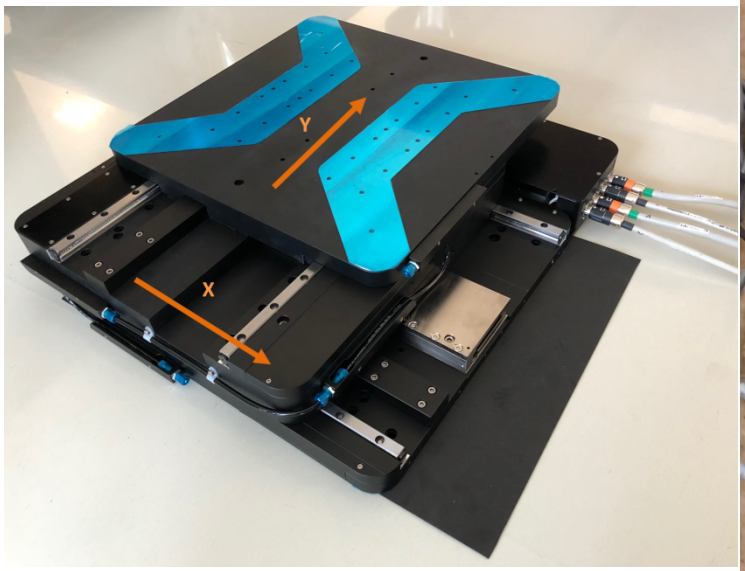
- **Hexapod**
- **Piezo**

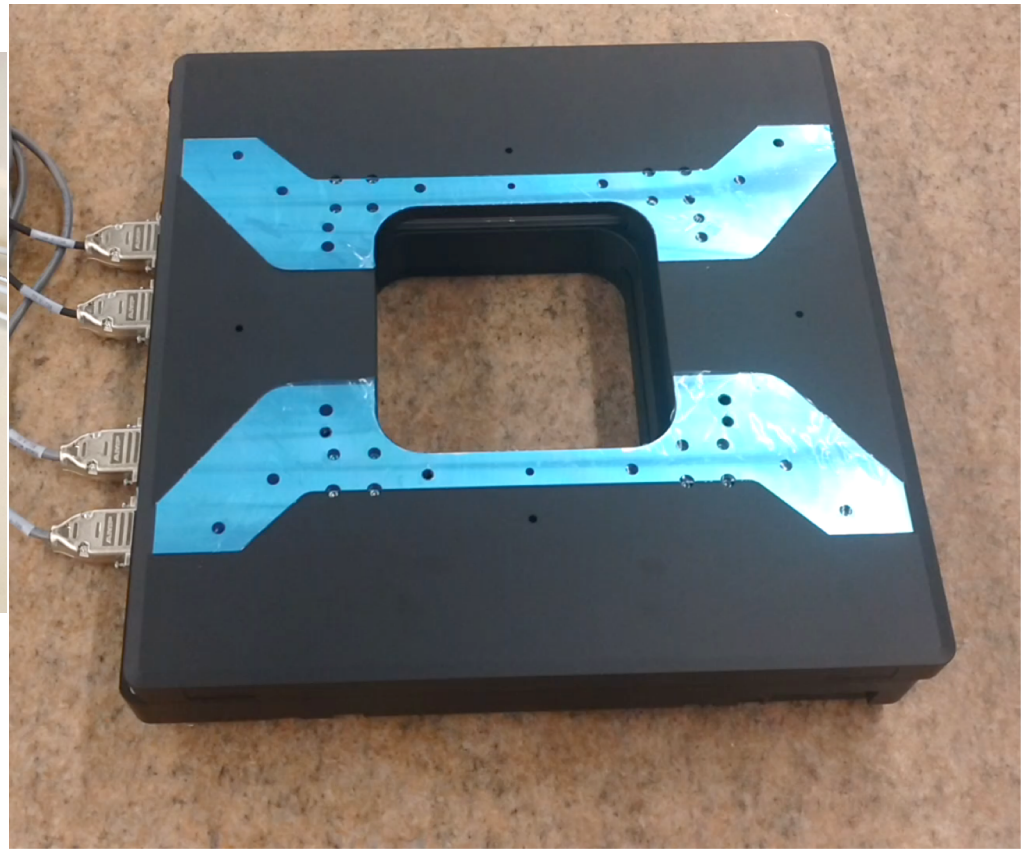


7-Axis system

System: Custom dual XYZ stacks with long travel 7th axis. System includes controls.
Why AB?: High acceleration, small moves, very repetitive, high duty cycle (3 cycles/second).
Customer does not want to deal with wear and noise.

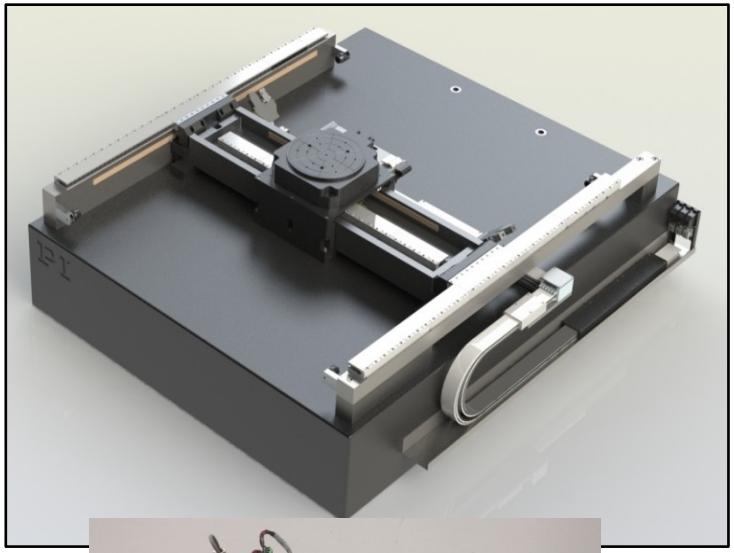
Automation – High performance cross roller bearing. Allows processing from either side
System: V-738 Open Aperture Linear Motor XY
Product under development with Velocity/ Position based function safety

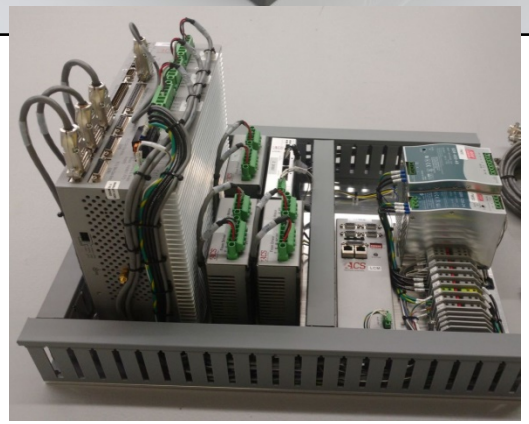


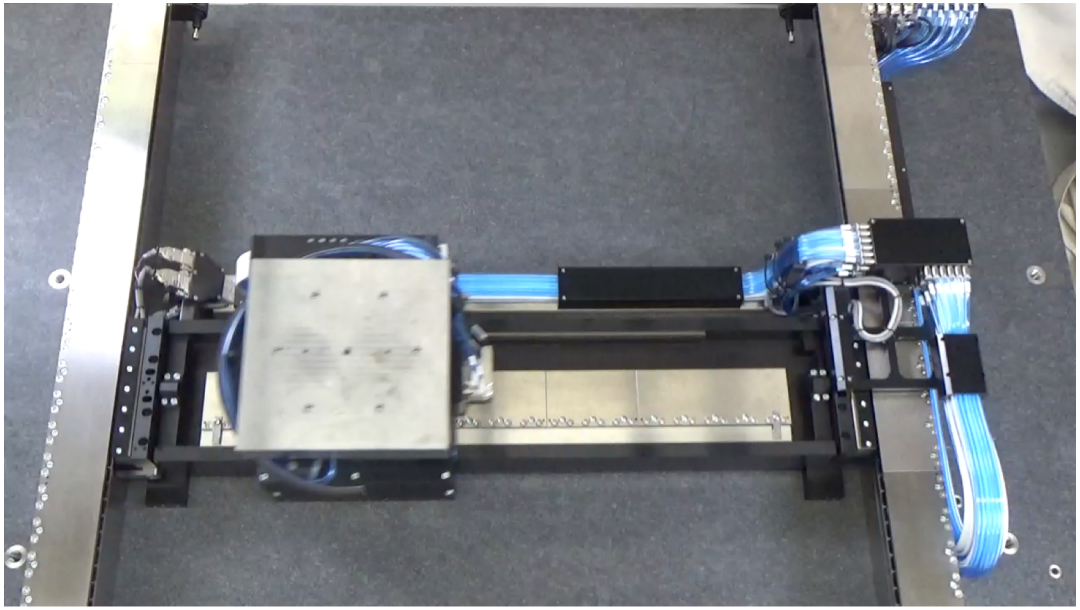


Wafer Scribing

System: Large Planar XY with Theta axis. Granite, motion axes, and controls. Includes ACS laser control firing module.
Why AB?: Accuracy and repeatability, straightness, high speed, high acceleration (2g).







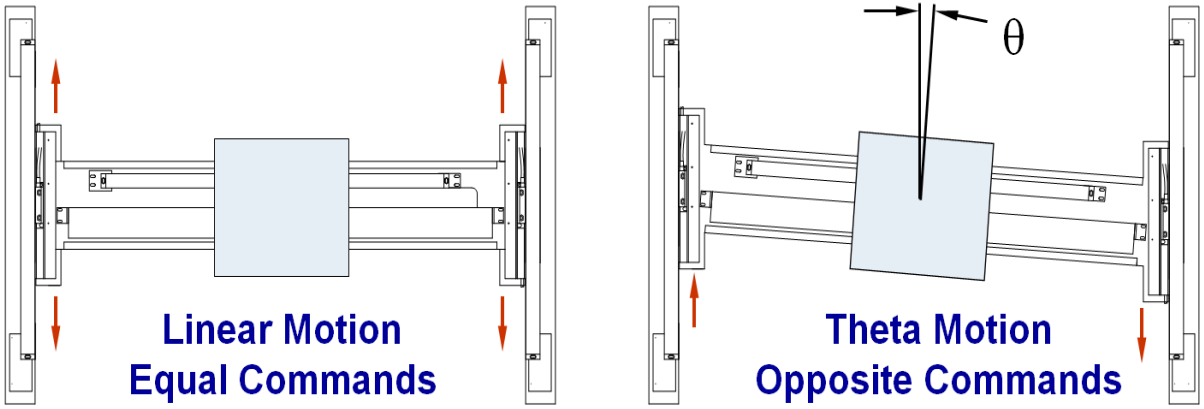
- **Large travel air-bearing XY optimized for flat panel processing**
  - 1500mm v 1800mm
- **<±0.1 µm accuracy and <±0.05 µm repeatability (650mm by 650mm)**
  - Considerably higher than competetion
- **Planar air-bearing systems designed for <±0.5 µm flatness**
- **Flatness compensation is available with additional Z axis**
  - Voice coil and Piezo

Gantry Systems

Active Yaw and 3-Motor Gantry Control

The gantry is constructed using a 3-motor, 3-encoder gantry configuration. Three linear axes are coupled to create two axes of linear motion and one axis of rotational motion (X, Y, Theta-Z).

The X-Axis, Y-Axis, and Theta-Z Axis all have separate control loops for linear and rotational motion control. The stage is designed with a flexural coupling between the X and Y axes to allow Theta-Z rotation.

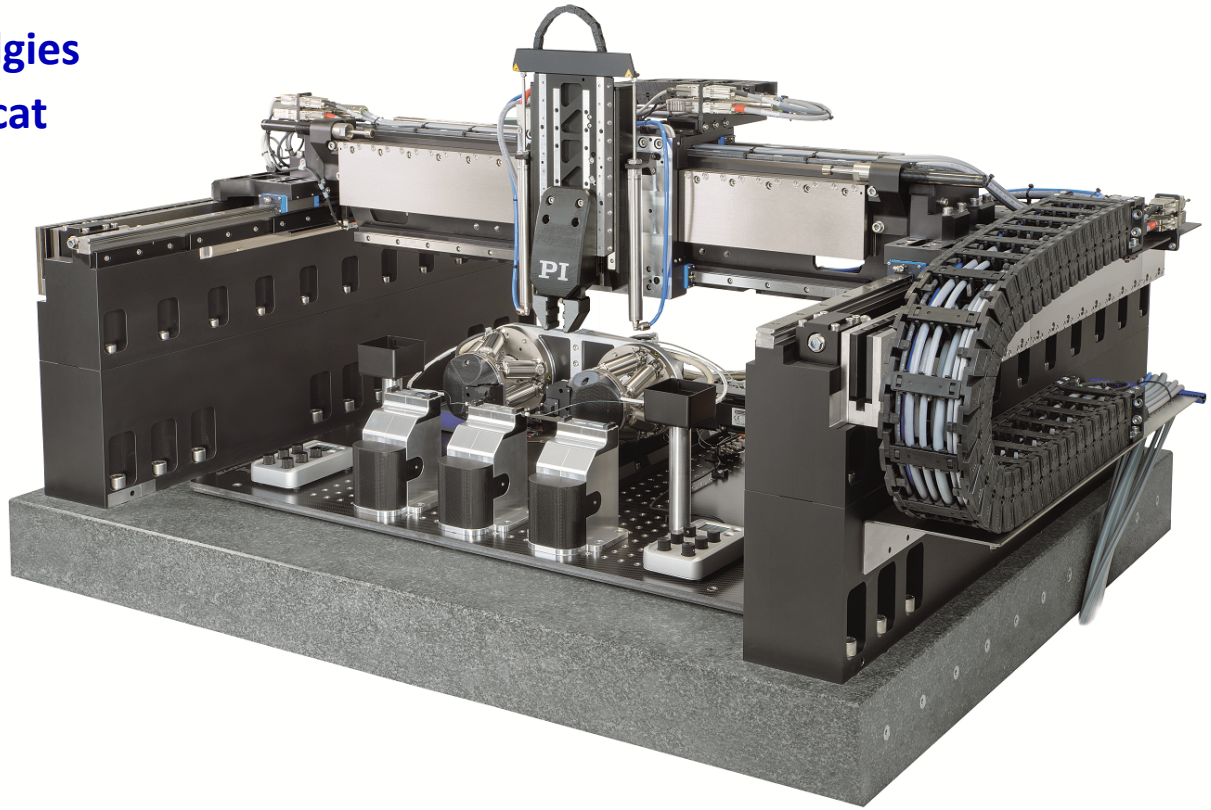


Ultra" Model. Enhances with the addition of a 4th motor and encoder (added to the X axis) for enhanced accuracy and repeatability. Applies yaw control to the cross axis

Integration of technologies

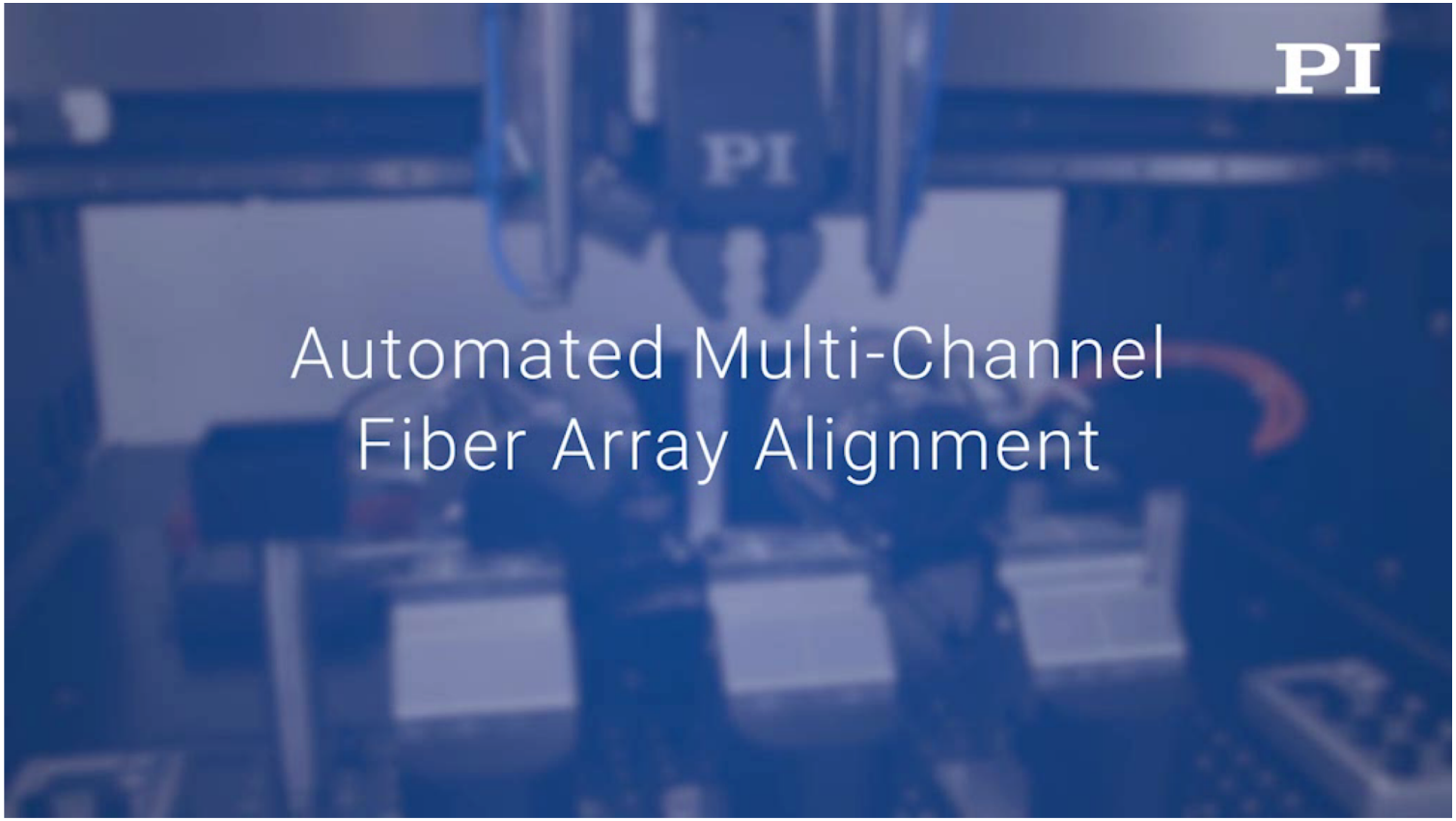
Pick and place and fibre Alignment

- **Multiple technolgies**
- **Linked via Ethercat**



Integration of technologies

Pick and place and fibre Alignment



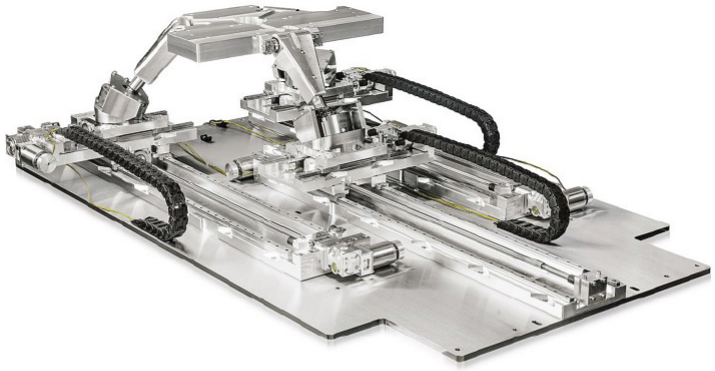
Vacuum and Clean Room

Ultra High Vacuum and non magnetic technologies

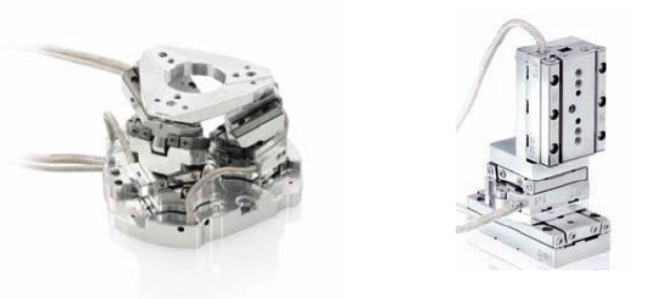
PI offers high-precision solutions for positioning in vacuum conditions to 10^{-10} hPa. Positioning solutions in a vacuum follow clearly defined constraints. This applies to the limited installation space, as well as prevention of contamination and excessive heat input.

Selection of the optimum drive technology for the respective application and the mechanical design must be matched exactly to the required load capacity and velocity as well as the intended operating and planned duty cycles.

The handling regulations for vacuum positioning systems are just as important as the design principles. Cleanrooms are available for assembling larger parts. Suitable packaging and the corresponding instructions for the recipient are part of shipping.



This example of a customized parallel-kinematic design for 6 axes of motion (SpaceFAB) is used in a beamline application. The high load capacity of up to 250 kg and the asymmetric layout with a long travel range in one direction, allows for positioning a sample in the synchrotrom beam, and removing it. The stage is intended for use in radiation environment



Minaturized piezo-motor driven 6-Axis and XYZ positioning solutions for vacuum applications

The future

Magnetic Levitation

The Future

PI is not a system Integrator

We produce excellent sub systems

What about other developments in market place

How can we work with you for your customer needs?