

# ENGINEERED-TO-SPEC MOTION SYSTEMS



## COMPETENCES



# INTRODUCTION



PM is the leading European manufacturer of precision linear bearings, linear slides, rotation bearings, sub-assemblies and motion systems. With a long history of over 50 years, PM products are known for their high precision and quality. One of PM's unique selling points is the flexibility to supply customized and complex products within a short time frame. For selected OEM customers PM is a preferred technology partner in which we closely cooperate to develop precision products for new applications. This enables customers who rely on state of the art products to maintain their position as industry leader.

Our flexible approach and expertise allow us to design, manufacture and integrate complex motion systems with relatively short lead times.



Linear bearing manufacturing is one of PM's core competences. Our expertise starts in our R&D center located in our manufacturing facilities in Dedemsvaart (The Netherlands). New products are designed, simulated and tested before they are launched on the market. Modern design and simulation software allows us to insure product quality before manufacturing is started.





# MANUFACTURING EXPERTISE

## VERTICAL MANUFACTURING INTEGRATION

PM has unmatched in-house manufacturing expertise. With this know-how we offer flexibility to the customers and ensure a consistent high quality of products. We control each step in the manufacturing process. Another advantage is the flexibility to implement design changes in a fast way to our manufacturing process and keep lead times as short as possible. With vertical integration we offer more responsibility, more flexibility, lower cost and one main project contact person.

## MANUFACTURING

Our manufacturing plant includes modern machines for different kind of operations;

- Turning
- Milling
- Drilling
- Heat treatment
- Electro chemical machining
- Flat and cylindrical grinding

With the wide range of machines PM has in-house manufacturing capacity for all critical elements. Stage components, wafer chucks, holders and vacuum chambers for motion systems are all produced in-house.

All critical production steps are done in-house which mean that we have full control of every step in production and take care of every detail that matters.

## LARGE MACHINING



For the manufacturing of motion system related products PM has ultra-large machining capabilities. Vacuum chambers, accurate frame elements and structural components as large as 10.5 x 3 x 1.3 m can be machined with high-precision

and quality. These products can be cleaned and integrated with the delivery of the precision motion systems.

## HEAT TREATMENT



For the linear bearing manufacturing we have in-house heat treatment capacity available. After heat treatment of the rails an accurate Rockwell hardness testing is performed. PM uses heat treatment for a variety of purposes to control mechanical properties of materials.

## QUALIFICATION FOR EXCELLENT PRODUCTS



For both component and motion system qualification PM has inspection equipment in house. This guarantees that only products that are within specification leave our factories. Examples of available measuring equipment are:

- 3D Coordinate measuring machines
- Surface inspection microscopes
- High resolution laser interferometers
- Capacitive sensors
- Autocollimators
- Vibrometers



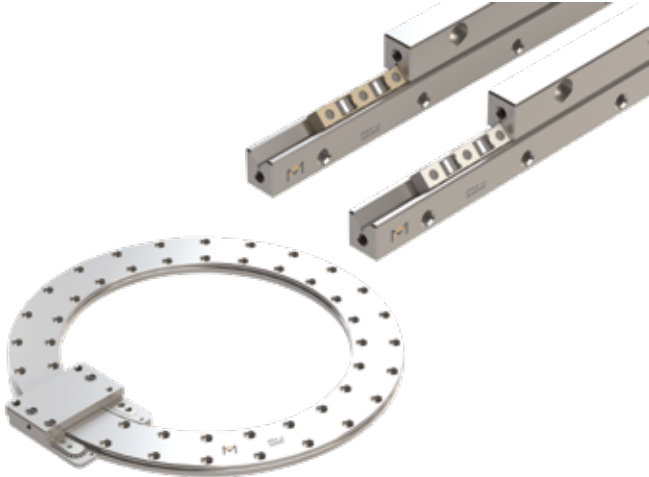
## TECHNOLOGY EXPERTISE

### DESIGN AND ENGINEERING EXPERTISE

Our team of engineers in R&D, design and production have in-depth application knowledge. They combine manufacturing with design expertise to deliver effective motion solutions. Some of the tools we use are listed below.

- PLM software
- CAD software
- Matlab
- FEA capabilities (Structural/Dynamic/Thermal/Flow)
- Collaborative change management
- Programming

### LINEAR BEARING AND ROTATING BEARINGS



PM offers over 50 year experience in manufacturing of precision linear bearings for motion systems and rotating bearings for turntables. PM offers products which are considered best in class. Standard and customized products are available to match the customer requirements. We offer also:

- SF-class technology: optional in our precision linear bearings. This unique option offers unmatched surface finishing. The roughness of the contact surface of the rails is reduced to  $< 0.05$  Ra which looks like a mirror. This offers high precision and smooth motion during processes such as scanning and measuring.
- PM's Anti Cage Creep (ACC) mechanism offers a robust solution for high-dynamic applications. It keeps the roller cage centered, even in extreme environments.

### VACUUM EXPERTISE



In industries such as medical, photonics, semiconductor and life science, there is an increasing number of processes that must be performed under vacuum conditions. PM manufactures linear bearings and motion systems which are used in applications such as Scanning Electron Microscopy, Electron Beam Processing, EUV Lithography, Electron Beam Lithography, Focussed Ion-Beam Systems and Semiconductor Manufacturing Processes.

#### **PM offers extensive expertise for motion systems that are used in high vacuum and ultra-high vacuum environments:**

- Material selection
- Design consideration vented holes/integrated venting paths or slots
- Lubricant selection
- Cage material selection
- Motor and encoder components selection
- Bake out
- Vacuum quality testing (RGA)
- Leak detection
- Ultrasonic cleaning
- UV-cleanliness inspection
- Cleanroom (ISO class 6 + 7) assembly
- Testing and qualifications
- Double bag packaging



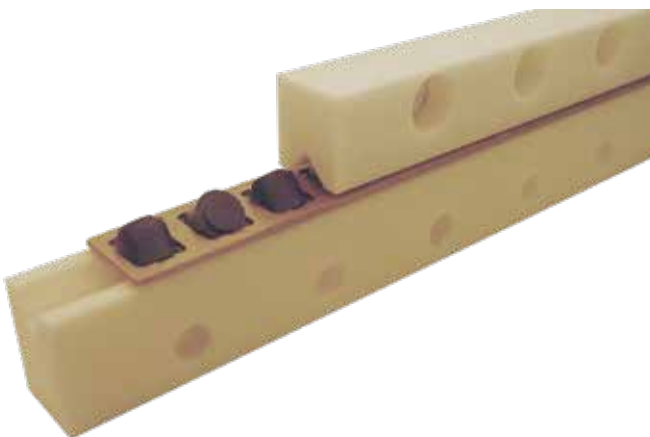


## DRIVE TECHNOLOGY EXPERTISE



For the selection of drive mechanisms (linear motors, piezoelectric motors, DC and stepper motors), encoders, cables and switches we rely on long term expertise. The selection of components is based on (but not limited to) stroke, velocities, resolutions and loads. PM engineers and designers have knowledge and experience in this field.

## NON-MAGNETIC EXPERTISE



In 2005 PM was the first linear bearing manufacturing company which realized practical use of ceramic linear bearings in high-precision motion systems operating in extreme environments. They are used in applications which require low magnetic permeability, minimum to zero lubrication or operation at high temperatures.

Most popular ceramic materials are:

- Silicon Nitride ( $\text{Si}_3\text{N}_4$ )
- Alumina ( $\text{Al}_2\text{O}_3$ )
- Zirconia ( $\text{ZrO}_2$ )

## CLEANROOM EXPERTISE



High-tech applications in the semiconductor and medical industry require assembly conditions which allow a limited contamination of particles. Depending on requirements we offer certified ISO class 7 and 6 assembly room and assembly cell capacity, all according to the standard ISO 14644-1. Parts and products do not leave the cleanroom area until they are qualified and packed.





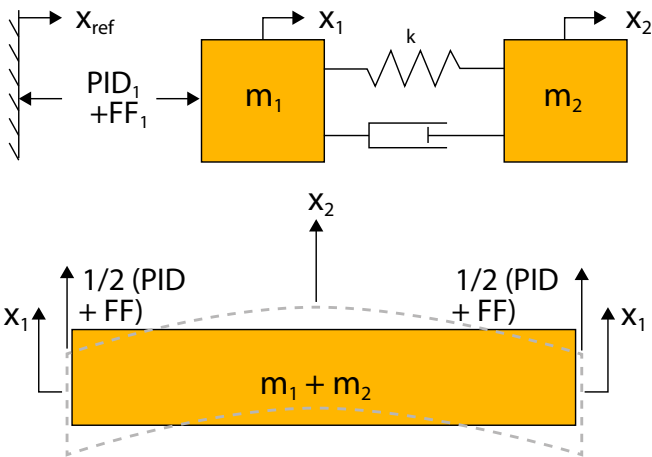
# ENGINEERING COMPETENCES

## DEFINING REQUIREMENTS

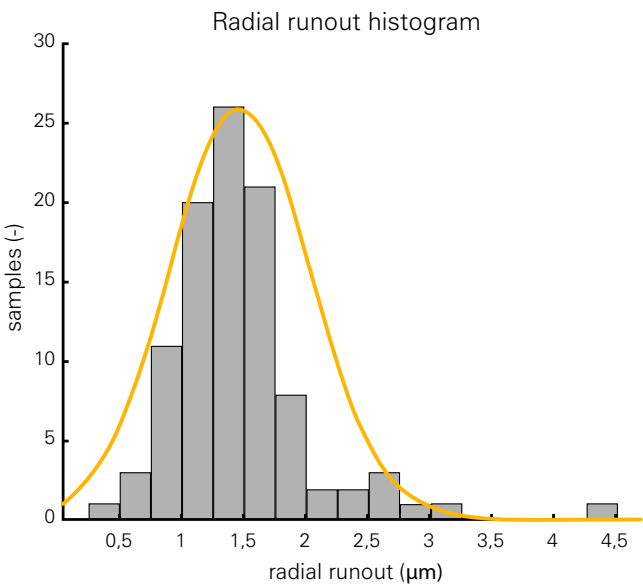


Whether your core business is to develop wafer inspection tools, lithography machines, electron microscopes or medical inspection equipment, you will probably need a motion system in your machine. At PM we understand that each of these systems requires a dedicated motion solution to achieve maximum performance. Please contact PM to discuss the opportunities to cooperate. We will be happy to investigate and complete your list of requirements.

## CONCEPTUAL DESIGN



Once requirements are clearly understood and agreed upon, engineers at PM start to investigate your specific challenges during the conceptual design phase. This activity supports the creation of a system architecture that is customized to your specific demands.



During the conceptual design phase, engineers at PM can benefit from the historical production data that's been gathered over the past 50 years. Whether it is the runout of a rotating bearing, the straightness of motion of a linear type, the running characteristics or the stiffness, all this available data can be used to select the best components for your motion system. The in-house design and production facilities offer opportunities to develop fully customized products, ensuring maximum system performance.



# ENGINEERED MOTION SYSTEMS EXPERTISE



XY2Z-Theta system for wafer inspection with high throughput

2Z-Theta module

## ENGINEERED-TO-SPEC MOTION SYSTEM - FROM FIRST IDEA TO DELIVERY

From the very beginning that a project for an engineered-to-spec motion system starts to take shape, a project leader and a lead engineer with extensive experience are appointed. They will be the main contacts at PM and make sure that all requirements are understood. With regular meetings we keep the customer informed of the project.

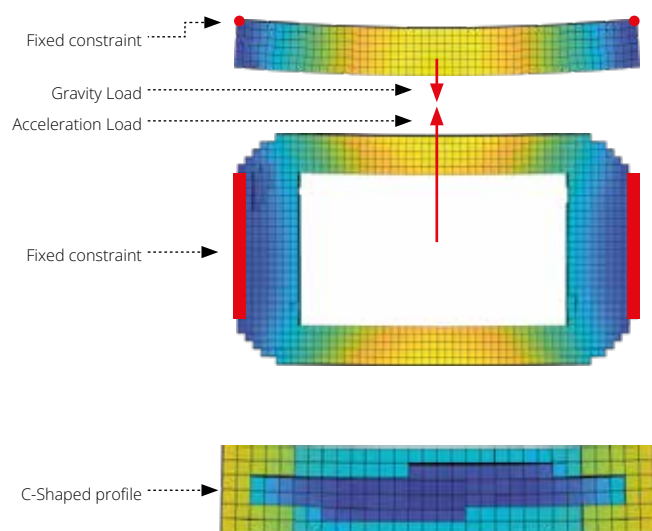
1. The first step is the definition of system requirements. They will be formally documented such that there can be agreed upon. PM creates documents that describe the application, determine the project requirements and deliverables.
2. The requirements are turned into a feasibility document resulting in a conceptual design.
3. A technical and business proposal is presented.

4. After approval of the proposal, PM starts to develop a design according to the steps that are presented at these pages. Finally, this leads to detailed drawings and instructions for inspection and assembly.
5. After final design approval by the customer we start with production and assembly.
6. PM performs all of the specified tests to verify compliance with project requirements.

7. PM finalizes all design details, process documentation and engineering change requests (ECR) from manufacturing and assembly for repeat orders in cooperation with the customer.



## TOWARDS A DETAILED DESIGN



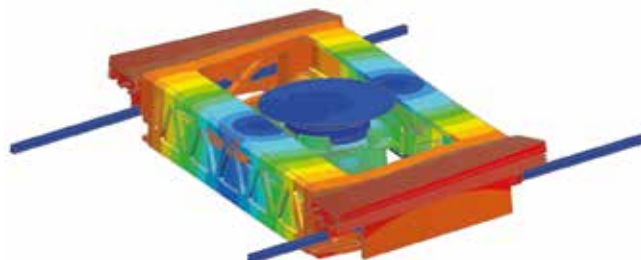
Working towards the detailed design of a motion system, various in-house developed tools are used. Above you see an example of how the gantry of the stage in the center of this page is rudimentarily designed using topology optimization software. This software has the ability to maximize the stiffness to mass ratio while keeping manufacturability in scope. By doing so, the computer has a decision in which direction to head into with the detailed design.

## DETAILED DESIGN

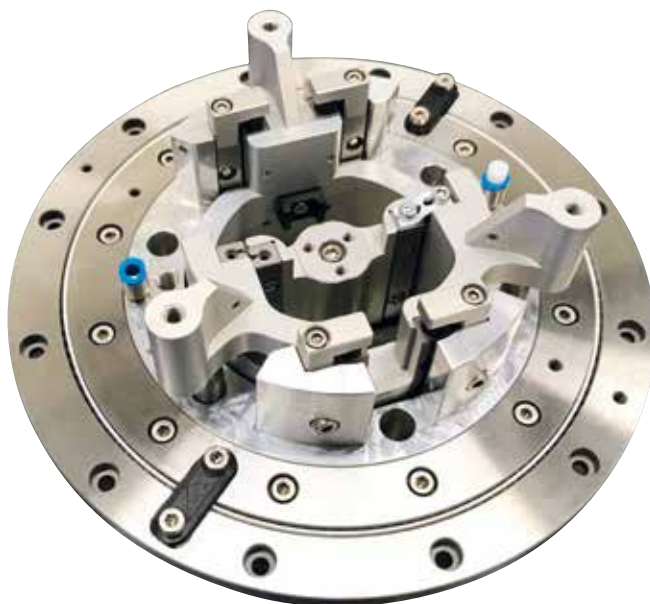


Once sufficient design decisions have been made regarding architecture, selection of components and the rudimentary design of structural parts, a design will be fully detailed in the latest CAD software. An adequate PLM database keeps track of the developed parts and makes sure that no data is lost or altered unintendedly.

## FINITE ELEMENT ANALYSES EXPERTISE



During the detailed design, analyses are performed continuously to ensure that requirements are being met once the design evolves. PM has competences in various fields of Finite Element Analyses. Structural, Dynamic, Thermal and CFD are all analyses that can be performed in-house and within the CAD environment to make sure that no precious time is lost. Additionally, PM is able to perform control simulations with either measured or simulated data. By doing so, you know exactly what will be deliver to you.



## PRODUCTION AND ASSEMBLY

After the detailed design phase is finished, the production phase will start. Everything from machining to assembly is entirely done in-house to ensure the highest quality standards possible. Once assembled, the motion system will be qualified to see whether all requirements are met in practice. To achieve this, our team of engineers have the availability of a vast amount of tools including laser interferometers, modal measurement equipment and motion controllers.





## EXPERTISE IN ENGINEERED-TO-SPEC MOTION SOLUTIONS

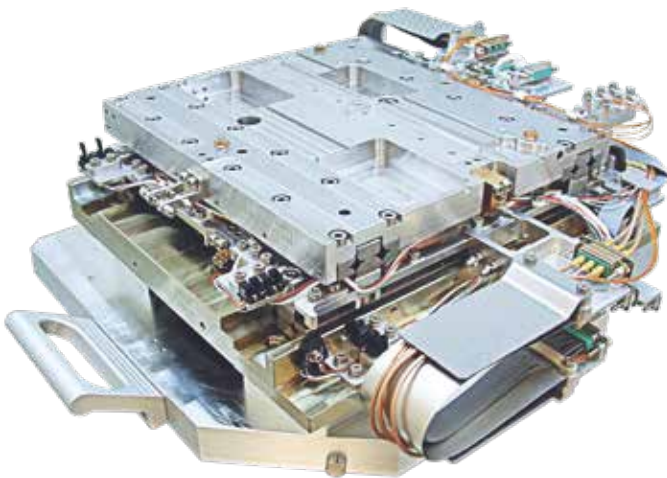
### EXAMPLES FROM RECENT PROJECTS

Our extensive expertise in the positioning and motion systems industry makes PM a valued partner for the development of high-precision motion systems.

#### Application expertise fields:

- Semiconductor (manufacturing, metrology, inspection)
- Life science: electron microscopy (TEM, SEM), micro manipulation
- Industrial: micro-assembly, quality inspection, surface inspection
- Photonics: test and inspection
- Medical: patient beds, CT-scanning, imaging, inspection, robot surgery
- Analytical: X-ray diffraction and X-ray fluorescence, spectrometry, raman spectroscopy

### XY(Z) FOR WAFER LITHOGRAPHY



This XY-positioning system with 200 x 200 mm effective travel, is used for wafer lithography. The Z-axis with 10 mm travel is optional. The system is compatible to UHV  $10^{-7}$  Torr. Cable management, switches and vacuum direct drive motors are included in the delivery. Anti-cage creep crossed roller linear bearings for smooth and repeatable precise motion are used.

### 5-AXIS SYSTEM FOR XRD



This 5 axis assembly is used in X-Ray Diffraction application and designed in close cooperation with the customer. The overall design features a small footprint. Motors, gearboxes and drives are integrated. The ring slide with 270 degrees rotary motion is custom designed for this system. The repeatability of this system is lower than 3 microns at center point of rotation. This system includes precision crossed roller linear bearings as well as mixed drive technologies with ball screws and worm gear transmissions.

### XZ-THETA WAFER HANDLER



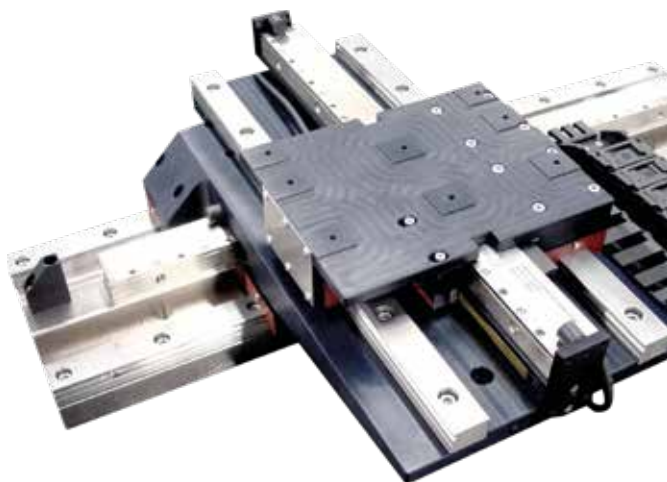
For wafer handling in ultra-high vacuum  $10^{-7}$  Torr we designed this 3 axis system. The Theta axis enables 360 degrees of motion and includes our flat mounted rotating bearing FMB with wobble error lower than 3 microns. On the Theta axis the Z-lift axis is mounted. The Z-axis uses precision crossed roller linear bearings for precise repeatable motion. On top the long travel X-axis is mounted which includes precision crossed roller linear bearings with low profile recirculating units. The system is supplied with motors, encoders, switches and cables.

## 5-AXIS MOTION SYSTEM



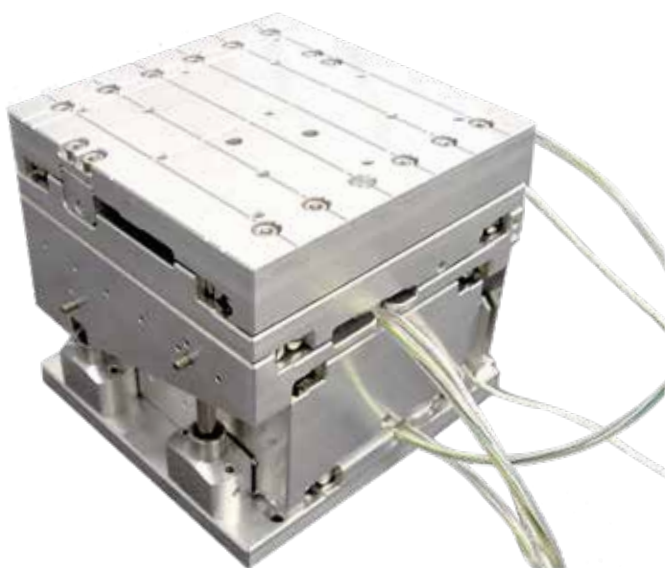
For next generation wafer metrology PM developed this motion system. This long-stroke inspection platform offers higher throughput than existing systems. The frame and motion system are designed with active vibration isolations units. Non-contact linear motors are integrated for fast and precise XY scanning. The Z-axis is guided by precision crossed roller linear bearings for ultra-smooth and precise motion. The assembly and testing is done in a cleanroom classified as ISO 7.

## LINEAR MOTOR STAGE FOR SEMICONDUCTOR



This low profile XY-stage has an effective travel of 200 x 175 mm. PM's bearings are integrated in the design to give the system an overall high accuracy. Ironless linear motors are used to realize high throughput figures. Typically, this stage is used in semiconductor industry in die attach or die bonding machines.

## XYZ-PIEZO DRIVEN STAGE



For an electron beam microscopy application PM developed a custom designed XYZ-stage that is capable of being operated in ultra-high vacuum environments down to  $10^{-7}$  Torr. This is a very compactly designed positioning system with a footprint of just 70 x 70 mm. Piezo motors and encoders are integrated in the design. Stroke 13 x 13 x 10 mm.

## PM.nl

DISCOVER PRECISION

advice. Whether you want to inquire for linear bearings or for complete motion solutions, do not hesitate to contact us.

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