

||| Symétrie



Positioning hexapods catalog



Welcome

Welcome to this catalogue where you will find the best positioning solutions to cater to your demanding applications.

Always looking to increase the performances of our hexapods, our growing team works hand in hand to integrate the latest available technology.

This is why SYMETRIE is first and foremost a R&D company, able to answer reactively to your needs thanks to a long experience providing hexapods for industry and research laboratories.

Olivier Lapierre & Thierry Roux
Co-founders

Contents

SYMETRIE company.....	3
A promising experience and vision.....	4
Hexapod technology.....	6
Glossary.....	8
Vacuum environment.....	9
NanoPos hexapod.....	10
BORA hexapod.....	12
BREVA hexapod.....	14
ZONDA hexapod.....	16
KUBAN hexapod.....	18
JORAN hexapod.....	20
SIRIUS hexapod.....	22
SURES hexapod.....	24
CAPELLA controller.....	26
ALPHA controller.....	27
VEGA controller.....	28
Controller technology.....	29
Controller technology.....	30
SYM_Positioning software.....	31
Hand-held control unit.....	32
Application Programming Interface (API).....	32
LabVIEW library for hexapod controller.....	33
C library for hexapod controller.....	33
Applications: Astronomy.....	34
Applications: Optical benches.....	35
Applications: Synchrotrons.....	36
Applications: Special projects.....	37
A worldwide presence.....	38

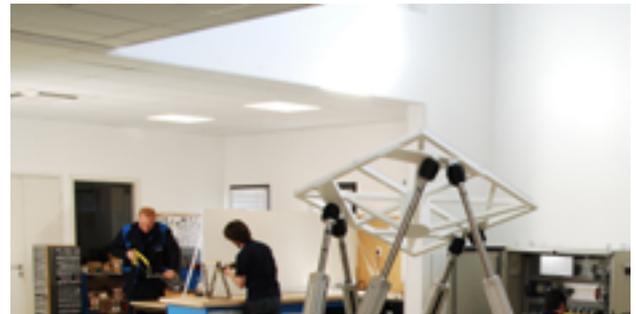


SYMETRIE company



Design department

SYMETRIE's engineering office consists of mechanical, electronic and software engineers. Our R&D department is continuously seeking for improvement, with a major effort on control software.



Workshops

All our hexapods and controllers are assembled in our mechanical and electronic workshops using standardized procedures.



Clean room

In our ISO 7 (class 10000) clean room, we mount the hexapods for applications which are sensible to environmental contamination, such as optics, space or particle accelerators. In a clean room the concentration of particles is controlled and minimized.



Metrology laboratory

To demonstrate high precision performances, SYMETRIE is equipped with a wide range of metrology tools: laser interferometers, laser trackers, coordinate measuring machine (CMM), electronic inclinometers, capacitive sensors.



A promising experience and vision

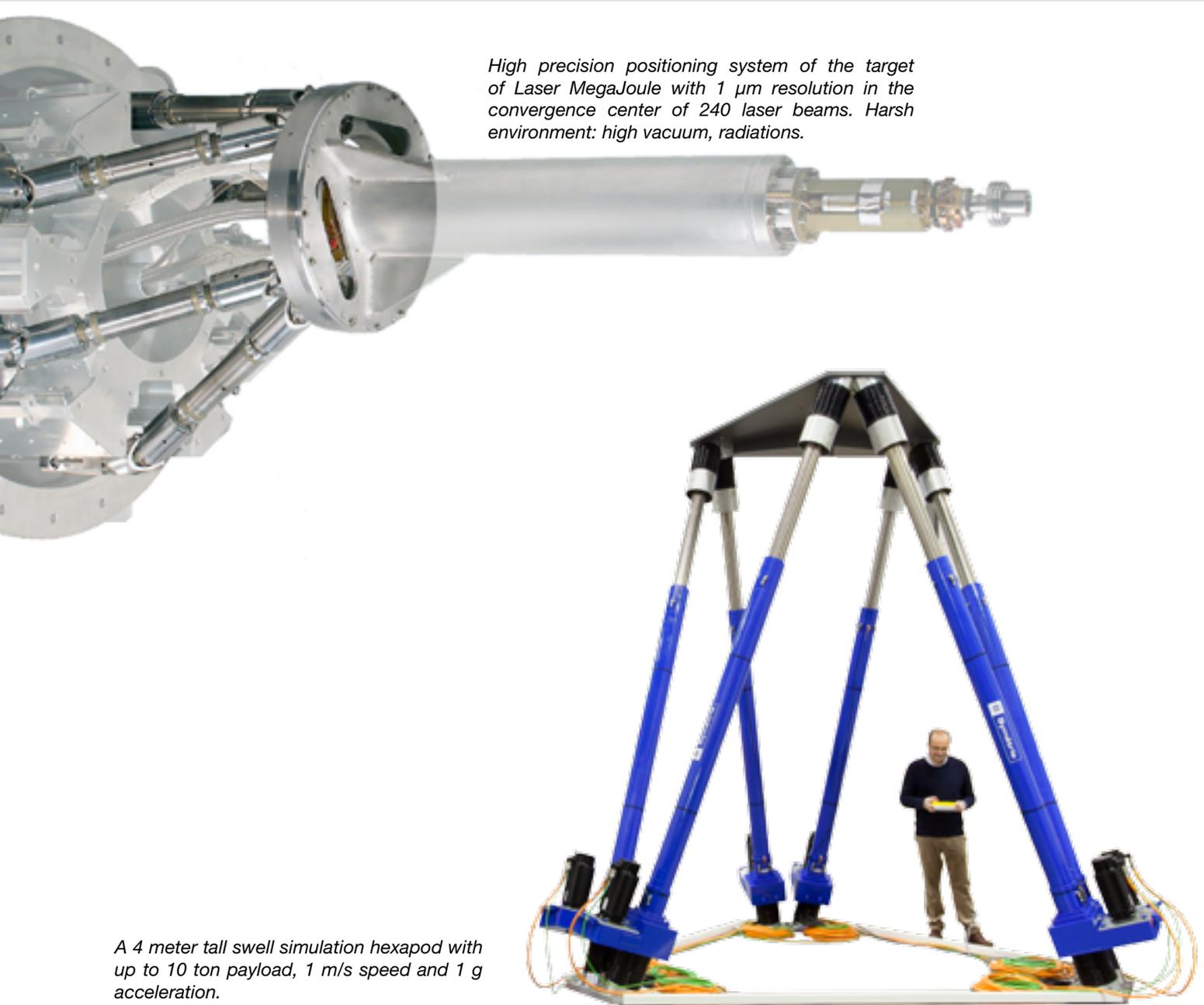
SYMÉTRIE's trusted R&D skills led to the birth of the positioning and motion hexapods

SYMÉTRIE was created in 2001 with the hexapod technology as a baseline. This innovative system was quickly spotted by the highest research institutions which asked SYMÉTRIE for a high precision hexapod to position the target of the MegaJoule Laser, a high energy inertial confinement fusion device in France.

The following contracts, still more ambitious, trusted the company to add dynamic motion capabilities to its hexapods systems. SYMÉTRIE succeeded once again in delivering up to 1g acceleration to slosh 10 ton liquid gas tanks for maritime transportation.

The acquired experience and trust built among a nascent network of customers were the beginning of an involvement in a wide array of technological projects, such as the Gaia satellite and the James Webb Space Telescope among others.

Innovation is a key factor of our development. Our R&D department works every day to improve our technologies and control systems using the latest generation components and techniques for higher quality products.



High precision positioning system of the target of Laser MegaJoule with 1 μm resolution in the convergence center of 240 laser beams. Harsh environment: high vacuum, radiations.

A 4 meter tall swell simulation hexapod with up to 10 ton payload, 1 m/s speed and 1 g acceleration.

From standard hexapods to custom designs

To cater to your needs in the smoothest way, SYMETRIE offers a range of turnkey hexapods.

- Better price and lead time: We look forward to offering hexapods which have already been designed.
- Ease project definition: Offering **a coherent range** where the hexapods differentiate between each other with unique features allows you to easier select and understand the capabilities that you will get.

SYMETRIE remains a trustworthy designer for customized solutions and can provide custom designs in a short time thanks to an in-house software enabling to quickly create a hexapod geometry with respect to the customer's input parameters.

With more than 10 years hexapod background, SYMETRIE is experienced in choosing and using the most adapted technologies in terms of motors, encoders, joints... according to the customer's application.



Our roots: metrology specialists with innovative minds

The two co-founders of SYMETRIE, Olivier Lapierre and Thierry Roux, were previously working for LNE, the French national metrology and testing laboratory. Specialized in **dimensional metrology**, they were looking for an innovative and efficient 6 DOF measurement system to quickly calibrate machine-tools and thought of the hexapod as a perfect solution.

This idea led them to create SYMETRIE to develop high precision hexapods as well as other complementary activities in the metrology and positioning fields:

- 3D metrology services on customers' sites to calibrate their machine-tools or measure 3D parts and assemblies with laser interferometers, laser trackers and other metrology devices.
- Distribution of high precision electronic levels (inclinometers) and piezo stages.

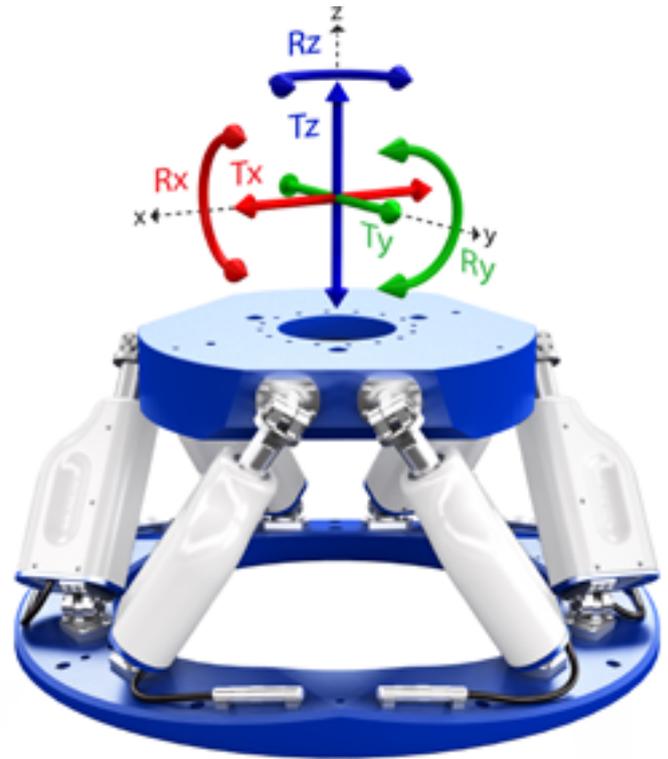
These activities which have made the hexapod vision become true are still thriving today. The dimensional metrology grain remains running through the veins of SYMETRIE at each one of its footsteps. Thanks to an experienced metrology staff, SYMETRIE knows how to qualify and test the hexapods before delivery to validate conformity.

Hexapod technology

6 Degrees Of Freedom

A hexapod is a parallel kinematic structure composed of a mobile platform linked to a fixed platform with 6 actuators.

This design allows to move an object placed on the mobile platform with 6 DOF (Degrees Of Freedom). In other words, the hexapod can move an object along the 3 translations (T_x , T_y , T_z) and the 3 rotations (R_x , R_y , R_z); any combination is possible.



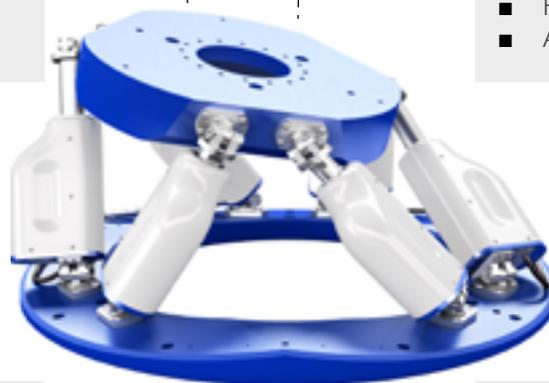
A scalable solution

Environment

- Vacuum (down to 10^{-9} mbar)
- Clean room

Payload

- From few grams to several tons
- Any orientation available



Performances

- Resolution
- Repeatability
- Accuracy
- Stiffness
- Stability
- Speed

Workspace

- From few μm to several hundred mm
- From few μrad to 45°

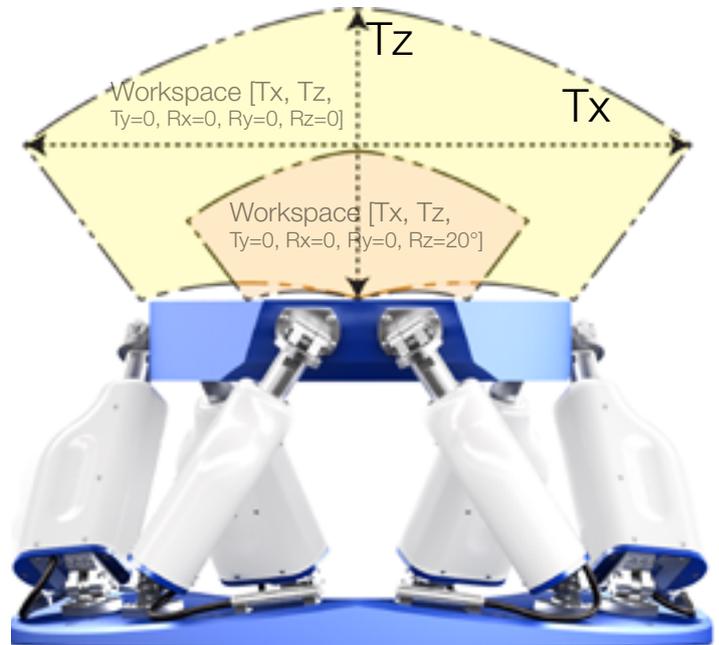
Workspace

A workspace defines all reachable positions of the mobile platform for specified degrees of freedom. An infinity of workspaces exists depending on which DOF are set to be swept and which DOF are set to be constant among Tx, Ty, Tz, Rx, Ry, Rz.

Example of two workspaces:

- In yellow, the workspace [Tx=swept, Tz=swept, Ty=0, Rx=0, Ry=0, Rz=0].
- In orange, the workspace [Tx=swept, Tz=swept, Ty=0, Rx=0, Ry=0, Rz=20°].

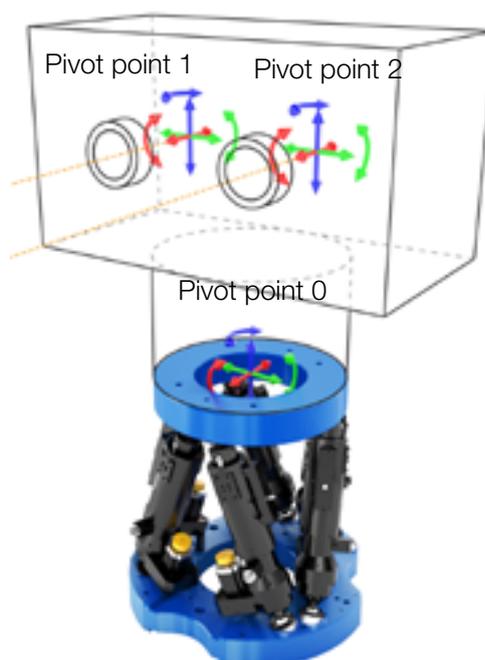
The orange workspace is smaller than the yellow workspace because the Rz rotation requires extra actuators' length.



Configurable pivot point

In order to orientate the mobile platform in the desired way, a 3D rotation center has to be defined. This point is not limited to the center of the mobile platform and can be placed wherever the user needs it to be.

Hexapod designed and built for MAX IV Laboratory synchrotron. Special rotation centers have been defined to adjust easily a polarimeter with respect to the beam position.





Glossary

Metrology

Abbe Error

Angular deformation in bearing ways lead to a positional error of the point of interest.

Accuracy

Difference between the actual position and the desired position. Defined by standard ISO 230-2.

Cross coupling

When commanded to move on a single axis, defines the deviation of the hexapod position on the other axes.

Backlash error

Clearance or lost motion in a mechanism caused by gaps between the parts.

Drift

It is a modification of position which includes different effect changes like environmental effects. The drift is often caused by thermal effect and by electronics.

Dimensional metrology

Science of calibrating and using physical measurement equipment to quantify the physical size of an object or the distance and angle from any given object.

Hysteresis error

It is a deviation between the actual and commanded position at the point of interest caused by elastic forces and friction forces.

Repeatability

Deviation from the average of actual positions when the system is commanded several times to go at a desired position.

Resolution

Resolution is seen as minimum incremental motion (MIM). It is the smallest motion increment that the system is able to achieve in a consistent and detectable manner.

Stability

Defines how much the hexapod deviate from its position over time without any new command.

Stiffness

Defines how much the hexapod deforms when subject to an applied force. Stiffness is determinant to increase the natural frequency.

Straightness

Defines the deviation of the hexapod position from its trajectory when commanded to move on a straight line.

Various

Application Programming Interface (API)

A command line interface which allows to communicate with the hexapod controller.

Graphical User Interface (GUI)

An intuitive interface which allows the user to control the hexapod.

Absolute encoder

Position feedback sensors keeping position data during loss of power.

Hexapod

Parallel kinematics system composed of six struts to provide motion and accuracy for positioning following the six degrees of freedom also called Gough-Stewart platform or Stewart platform.

Invar

Invar is a nickel-iron alloy (Fe₃₆Ni - 64FeNi in the USA) notable for its uniquely low coefficient of thermal expansion. The name Invar comes from the word invariable, referring to its relative lack of expansion or contraction with temperature changes.

Parallel kinematics

Compared to a serial kinematics system in which each degree of freedom is dependent, the degrees of freedom in a parallel kinematics system are interdependent.

Pivot point

Center of rotation around which the hexapod moves. It can be configured virtually via software.

Six Degrees Of Freedom (6 DOF)

It refers to the freedom of movement of a body in three dimensional spaces. The body is free to move forward/backward, up/down, left/right combined with rotation about three perpendicular axes, often termed pitch, yaw and roll.



Vacuum environment

A vacuum environment is a space empty of matter. The perfect vacuum is an ideal concept and cannot be practically attained. However, it is possible to approach this ideal in laboratory in decreasing the pressure of a system. Indeed, lower is the pressure of a system, closer it is to the perfect vacuum.

At SYMETRIE, we provide hexapods that are designed to operate in such environments. Regarding vacuum projects we take a particular care during assembly and select specific materials and treatment such as:

- Vacuum compatible motor, ball screw, encoder
- Vacuum compatible lubrication
- Use of Teflon or Kapton cables
- Specific roughness of parts
- All holes are vented
- Specific cleaning of parts in an ultrasonic bath

For each hexapod in this catalogue, we can implement vacuum options to cater to your specific needs:

- Low Vacuum Option (10^{-3} mbar)
- High Vacuum Option (10^{-6} mbar)
- Ultra High Vacuum Option (10^{-9} mbar) upon request



BORA hexapod for 10^{-6} mbar vacuum applications

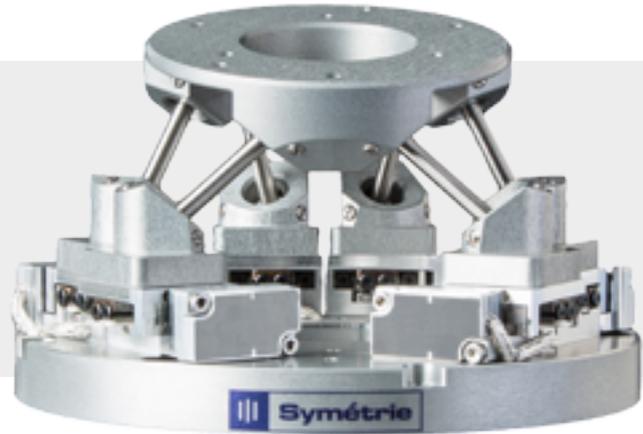


NanoPos hexapod

Nanometer resolution miniature hexapod

KEY FEATURES

- Payload capacity up to 500 g
- Linear resolution 10 nm
- Angular resolution 1 μ rad
- Height in middle position 65 mm



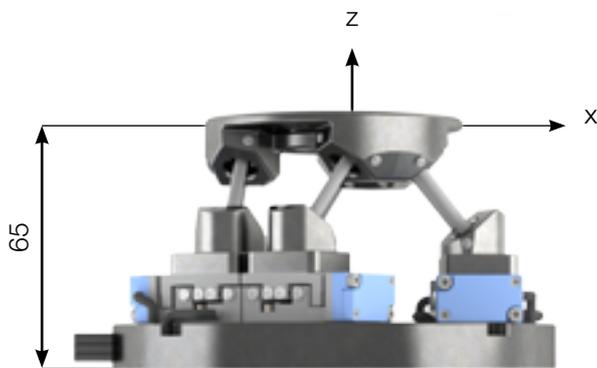
APPLICATIONS

- Instrumentation
- Optics
- Testing laboratories
- Semiconductors
- Synchrotrons
- Microscopy
- Nanotechnologies

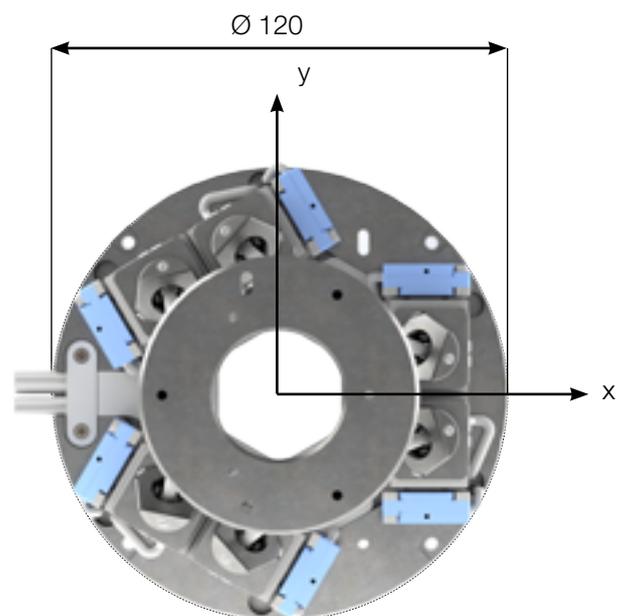


NanoPos	
Motion and positioning	
Travel range Tx, Ty (mm)	± 5
Travel range Tz (mm)	± 4
Travel range Rx, Ry (deg)	± 7
Travel range Rz (deg)	± 10
Resolution Tx, Ty, Tz (nm)	10
Resolution Rx, Ry, Rz (μrad)	1
Repeatability Tx, Ty, Tz (nm)	± 75
Repeatability Rx, Ry, Rz (μrad)	± 2
Speed (mm/s; deg/s)	1; 1
Mechanical properties	
Payload capacity (g) (vertical orientation)	500
Motor type	Piezo motor
Miscellaneous	
Operating temperature range (°C)	+ 5 to + 40
Materials	Aluminum, invar, ceramic, stainless steel
Size mobile platform (mm)	Ø 70
Central aperture (mm)	Ø 32
Height in middle position (mm)	65
Mass (g)	505
Cable length (m)	1.2
Options	<ul style="list-style-type: none"> Customized platform design Larger travel range Scalable size Vacuum compatibility Non magnetic
Controller	
Controller type	CAPELLA
Interface	Ethernet, USB, Serial (RS-232)
Power supply	110-240 VAC / 50-60 Hz

The performances are specified for single axis motions, with all other axes at midrange and for a rotation center in the middle of the mobile platform.



Hexapod in middle position





BORA hexapod

High resolution hexapod small size

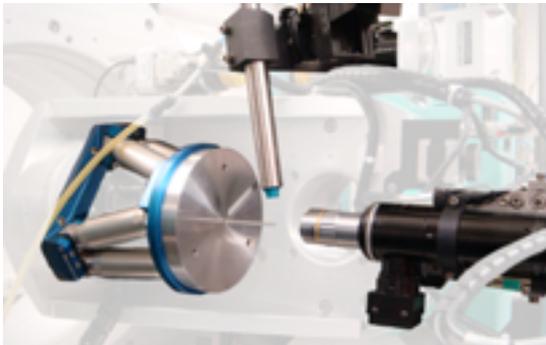
KEY FEATURES

- Payload capacity up to 10 kg
- Linear travel range ± 20 mm
- Angular travel range $\pm 15^\circ$
- Height in middle position 145 mm

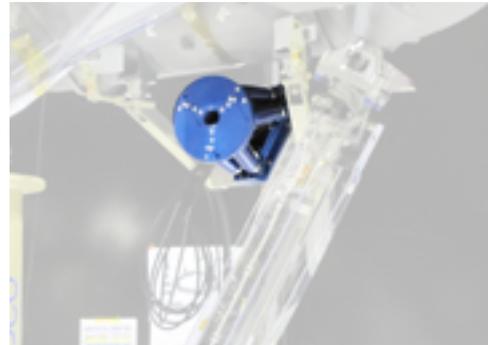


APPLICATIONS

- Instrumentation
- Optics
- Testing laboratories
- Synchrotrons
- Aeronautics and spatial
- Metrology
- Semiconductors



This hexapod places a sample at the centre of two large rotation stages. With this installation, hexapod mounting orientation varies between 0° and 90° . Advantages of the hexapod are: high stability, stiffness and repeatability of the sample position with respect to the rotation stages independently of their orientations.



Alignment of a mirror with high precision on a space telescope. When the hexapod has correctly positioned the mirror, the user fixes the mirror and takes the hexapod off the structure.



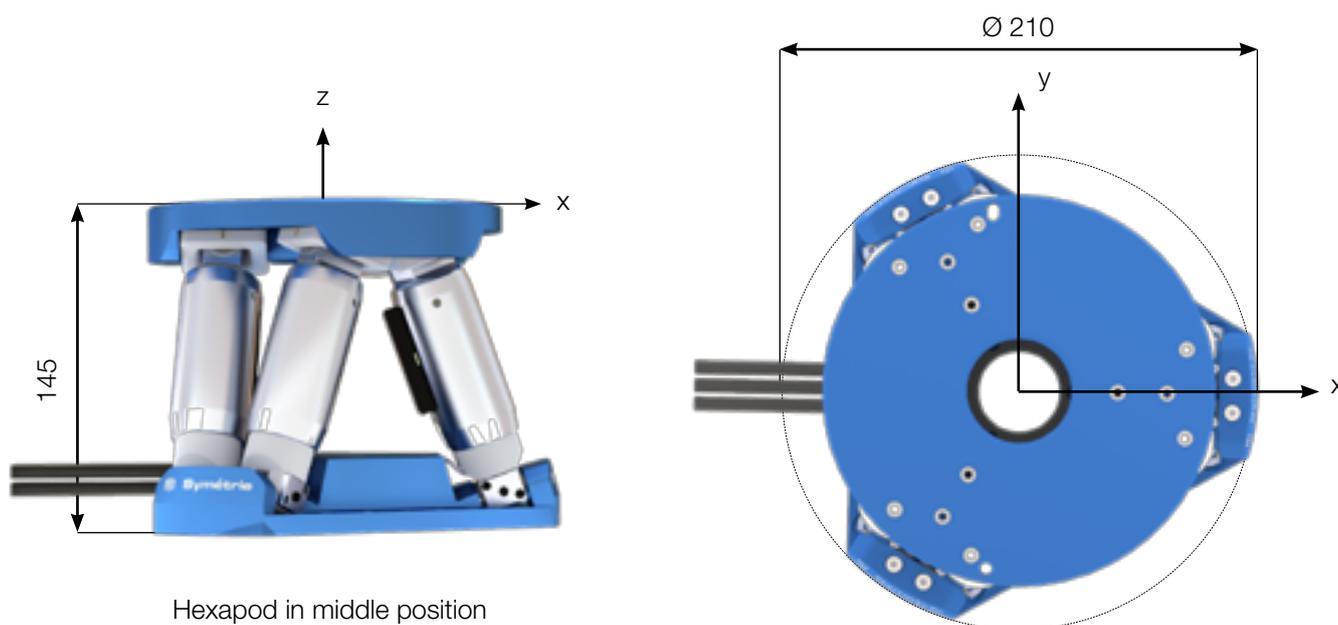
Two BORA hexapods position Kirkpatrick-Baez (KB) mirrors with high stability and resolution to improve the beam quality on a synchrotron beamline.



10^{-6} mbar vacuum version to align a mirror on a satellite in a vacuum chamber during mounting and testing phases.

BORA	
Motion and positioning	
Travel range Tx, Ty (mm)	± 20
Travel range Tz (mm)	± 10
Travel range Rx, Ry (deg)	± 10
Travel range Rz (deg)	± 15
Resolution Tx, Ty, Tz (µm)	0.1
Resolution Rx, Ry, Rz (µrad)	2
Repeatability Tx, Ty, Tz (µm)	± 1.5
Repeatability Rx, Ry, Rz (µrad)	± 6.5
Speed (mm/s; deg/s)	2; 2
Mechanical properties	
Stiffness X, Y (N/µm)	1
Stiffness Z (N/µm)	10
Payload capacity (kg) (vertical orientation / horizontal orientation)	10 / 5
Motor type	DC motor, gearhead
Miscellaneous	
Operating temperature range (°C)	0 to + 50
Materials	Aluminum, steel, stainless steel
Size mobile platform (mm)	Ø 160
Central aperture (mm)	Ø 43 for mobile platform ; Ø 36 for fixed platform
Height in middle position (mm)	145
Mass (kg)	4.3
Cable length (m)	3
Options	Vacuum compatibility Customized platform design
Controller	
Controller type	ALPHA
Interface	Ethernet, USB
Power supply	110-240 VAC / 50-60 Hz

The performances are specified for single axis motions, with all other axes at midrange and for a rotation center in the middle of the mobile platform.





BREVA hexapod

High resolution hexapod medium size

KEY FEATURES

- Payload capacity up to 200 kg
- Linear travel range ± 75 mm
- Angular travel range $\pm 22^\circ$

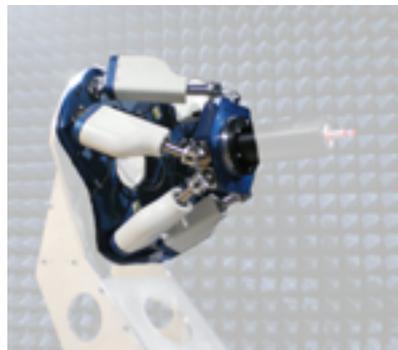


APPLICATIONS

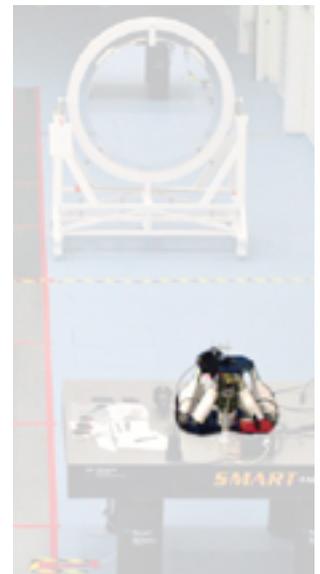
- Instrumentation
- Aeronautics and space
- Optics
- Metrology
- Testing laboratories
- Synchrotrons



This hexapod positions a vacuum chamber containing a gas sample and offers a $\pm 20^\circ$ angular range.



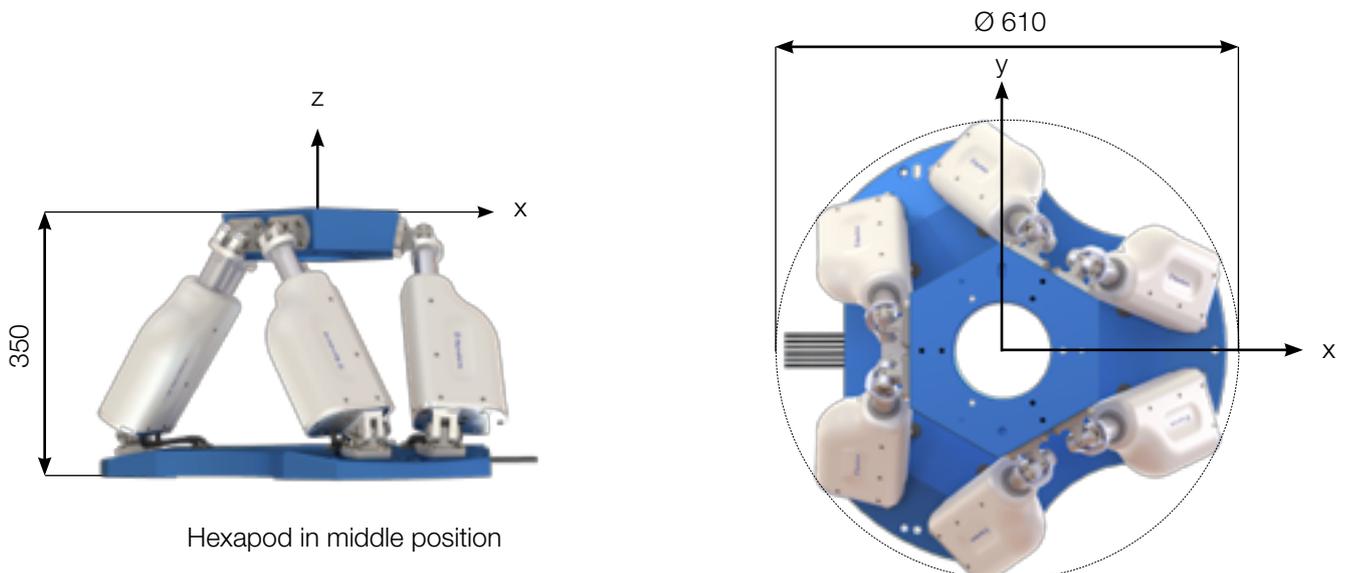
This hexapod integrates a 360° rotation in its mobile platform. It orientates a microwave source to qualify microwave antennas.



The BREVA hexapod is part of the ESA Star Tiger-2 test set-up to simulate a way to eclipse the Sun in space with two satellites flying in tight formation.

	BREVA DC	BREVA ST	BREVA BL
	for lighter payload	for higher payload	for higher speed and payload
Motion and positioning			
Travel range Tx, Ty (mm)	± 75	± 75	± 75
Travel range Tz (mm)	± 50	± 50	± 50
Travel range Rx, Ry (deg)	± 20	± 20	± 20
Travel range Rz (deg)	± 22	± 22	± 22
Resolution Tx, Ty, Tz (µm)	0.5	0.5	0.5
Resolution Rx, Ry, Rz (µrad)	2.5	2.5	2.5
Repeatability Tx, Ty, Tz (µm)	± 1	± 1	± 1
Repeatability Rx, Ry, Rz (µrad)	± 5	± 5	± 5
Speed (mm/s; deg/s)	8; 2.5	0.8; 0.25	3; 1
Mechanical properties			
Stiffness X, Y (N/µm)	5	5	5
Stiffness Z (N/µm)	32	32	32
Payload capacity (kg) (vertical orientation / horizontal orientation)	25 / 10	200 / 80	200 / 80
Motor type	DC motor, gearhead	Stepper motor, gearhead	Brushless motor, gearhead
Miscellaneous			
Operating temperature range (°C)	0 to + 50	0 to + 50	0 to + 50
Material	Aluminum, steel, stainless steel, plastic	Aluminum, steel, stainless steel, plastic	Aluminum, steel, stainless steel, plastic
Size mobile platform (mm)	Ø 300	Ø 300	Ø 300
Central aperture (mm)	Ø150	Ø150	Ø150
Height in middle position (mm)	350	350	350
Mass (kg)	32	36	36
Cable length (m)	3	3	3
Options	Absolute encoder Clean room compatibility Vacuum compatibility Customized platform design		
Controller			
Controller type	ALPHA		
Interface	Ethernet, USB		
Power supply	110-240 VAC / 50-60 Hz		

The performances are specified for single axis motions, with all other axes at midrange and for a rotation center in the middle of the mobile platform.



Hexapod in middle position



ZONDA hexapod

Very stable hexapod with high precision

KEY FEATURES

- Very high stability
- Resolution 0.1 μm
- Payload capacity up to 500 kg
- Vacuum compatibility
- Large travel ranges



APPLICATIONS

- Synchrotrons
- Metrology
- Optics
- Instrumentation
- Tests laboratories
- Aeronautics and space
- Semiconductors



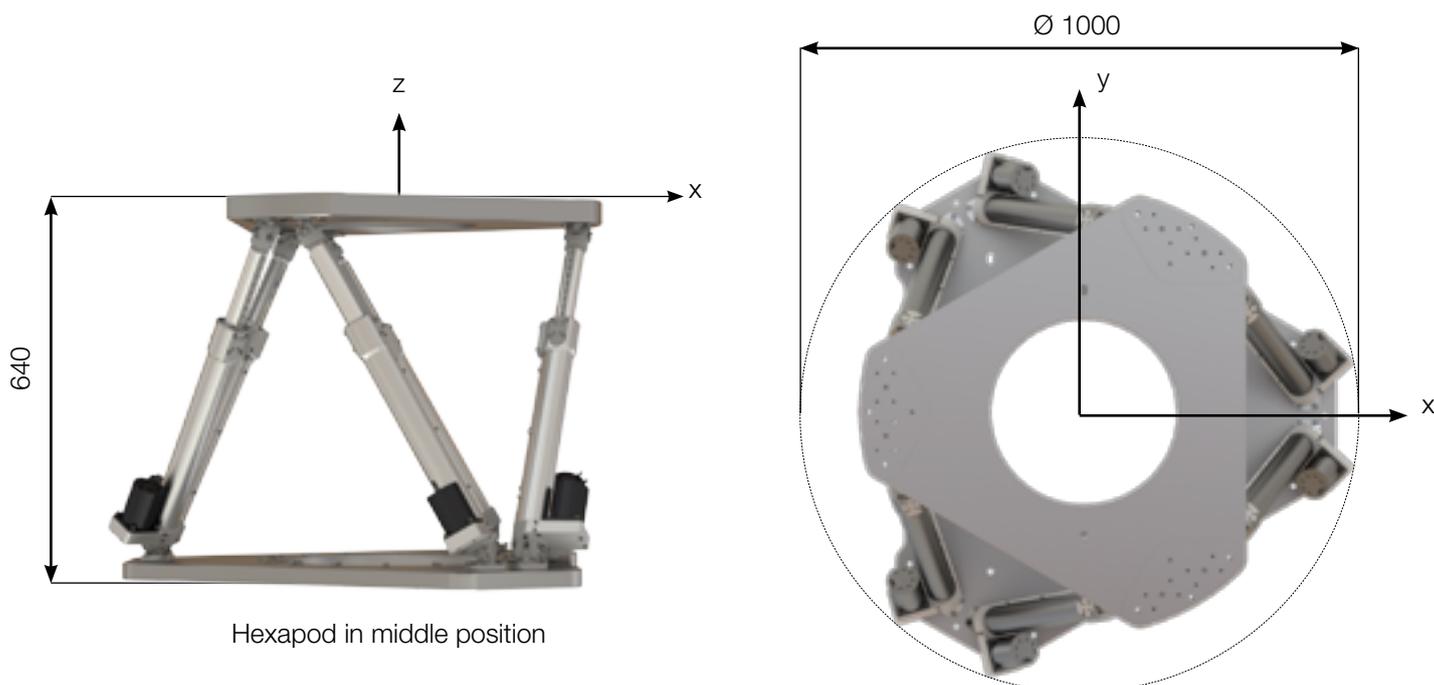
A vacuum compatible ZONDA hexapod is used at CSL to calibrate space optical instruments.



ISO5 clean room compatible hexapod to test space optical instruments for MTG (Meteosat Third Generation) satellites at BERTIN Technologies.

ZONDA	
Motion and positioning	
Travel range Tx, Ty (mm)	± 200
Travel range Tz (mm)	± 150
Travel range Rx, Ry, Rz (deg)	± 20
Resolution Tx, Ty, Tz (µm)	0.1
Resolution Rx, Ry, Rz (µrad)	0.5
Repeatability Tx, Ty, Tz (µm)	± 0.5
Repeatability Rx, Ry, Rz (µrad)	± 2
Speed (mm/s; deg/s)	0.6; 0.04
Mechanical properties	
Stiffness X, Y (N/µm)	8.5
Stiffness Z (N/µm)	30
Payload capacity (kg) (vertical orientation / horizontal orientation)	400 / 140
Motor type	Stepper
Encoder type	Absolute linear encoder
Miscellaneous	
Operating temperature range (°C)	0 to + 75
Materials	Aluminum, stainless steel, Invar, Peek
Size mobile platform (mm)	Ø 720
Height in middle position (mm)	640
Mass (kg)	96
Cable length (m)	< 5
Options	Clean room compatibility Vacuum compatibility Customized platform design
Controller	
Controller type	ALPHA
Interface	Ethernet, USB
Power supply	110-240 VAC / 50-60 Hz

The performances are specified for single axis motions, with all other axes at midrange and for a rotation center in the middle of the mobile platform.





KUBAN hexapod

High resolution heavy payload medium size

KEY FEATURES

- Height 600 mm
- Resolution 1.5 μ rad
- Repeatability $\pm 5 \mu$ rad
- Payload capacity up to 500 kg



APPLICATIONS

- Synchrotrons: mirror or chamber supports
- Optics



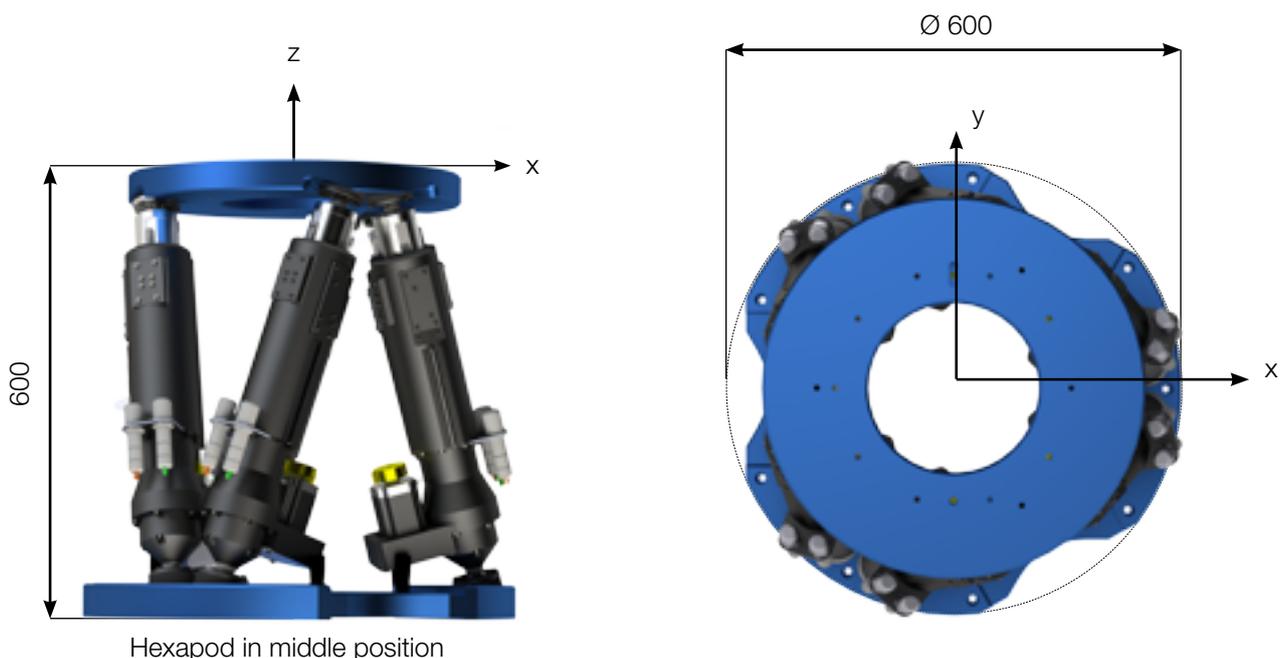
KUBAN hexapod positions a mirror inside of a vacuum chamber with high resolution. To be sure to avoid harming any part due to an unexpected over range, an inclination limit switch is installed under the hexapod mobile platform and stops the motion if the maximum roll angle is reached.



KUBAN hexapod aligns a polarimeter with high precision in a short time. This installation made by TOYAMA can be moved to be used on different beamlines at MAX IV Laboratory synchrotron.

KUBAN	
Motion and positioning	
Travel range Tx, Ty, Tz (mm)	± 25
Travel range Rx, Ry (deg)	± 2
Travel range Rz (deg)	± 3
Resolution Tx, Ty (µm)	0.2
Resolution Tz (µm)	0.1
Resolution Rx, Ry (µrad)	1.5
Resolution Rz (µrad)	2
Repeatability Tx, Ty (µm)	± 1
Repeatability Tz (µm)	± 0.5
Repeatability Rx, Ry (µrad)	± 5
Repeatability Rz (µrad)	± 8
Speed (mm/sec; deg/sec)	0.25; 0.05
Mechanical properties	
Payload capacity (kg)	500
Motor type	Stepper motor
Miscellaneous	
Operating temperature range (°C)	0 to + 50
Material	Aluminum, steel, stainless steel
Footprint (mm)	Ø 600
Height in middle position (mm)	600
Mass (kg)	200
Cable length (m)	5
Options	Customized platform design Absolute encoders Adjustable height Inclination limit switch
Controller	
Controller type	ALPHA
Interface	Ethernet, USB
Power supply	110-240 V AC 50-60 Hz

The performances are specified for single axis motions, with all other axes at midrange and for a rotation center in the middle of the mobile platform.





JORAN hexapod

High resolution ultra heavy payload large size

KEY FEATURES

- High stability
- Resolution 0.5 μ rad
- Large payload capacity 1500 kg (more upon request)



APPLICATIONS

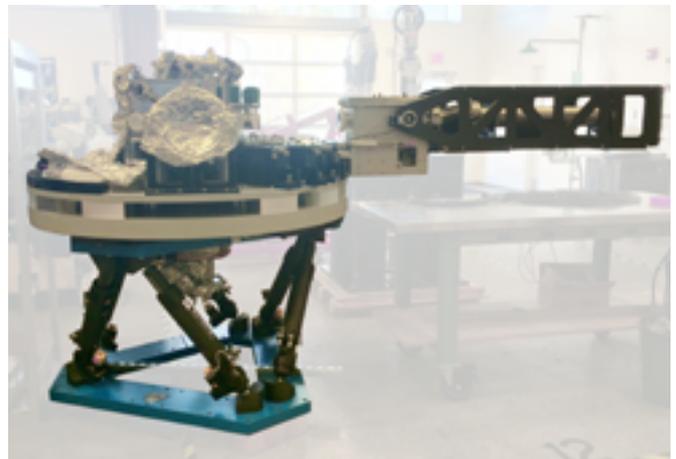
- Synchrotrons: mirror or chamber supports
- Optics



JORAN hexapod has been developed in collaboration with ESRF synchrotron to position mirrors with very high resolution.



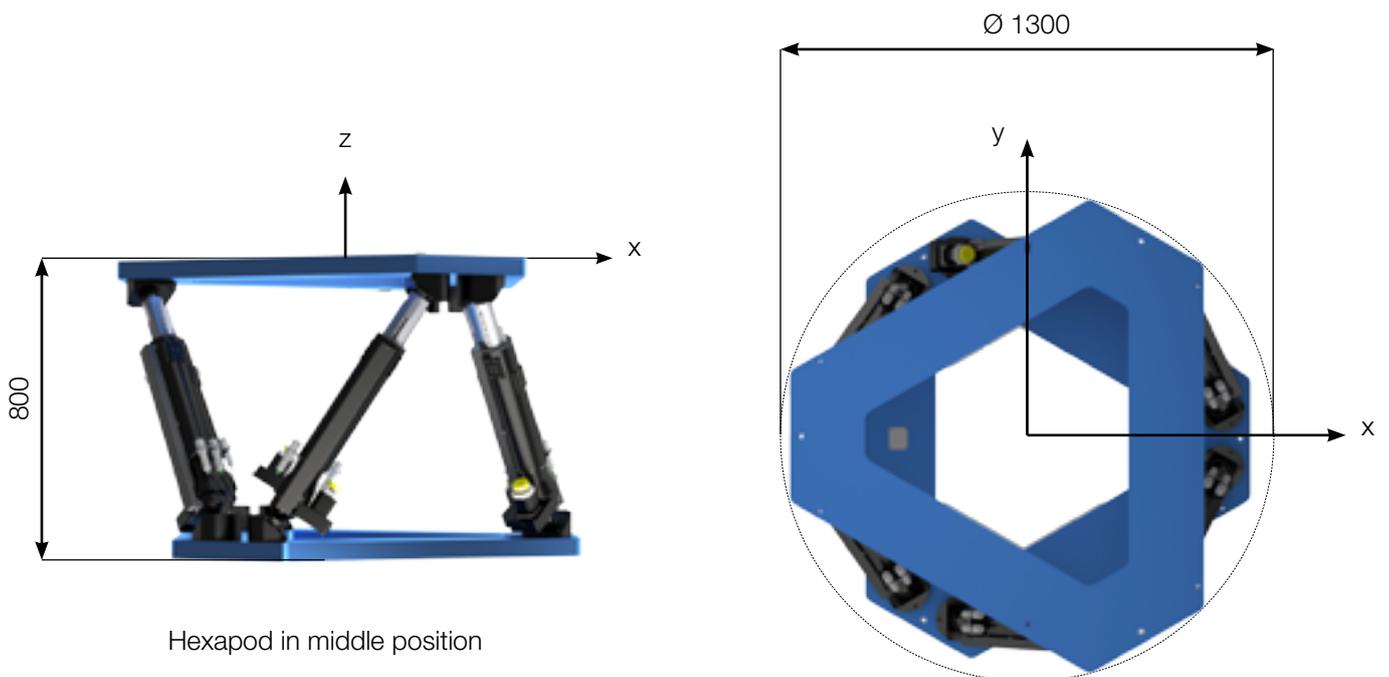
JORAN hexapod size has been adapted to the beam height of the Australian Synchrotron.



JORAN actuators at LBL are longer to enable a $\pm 12.5^\circ$ rotation around Z. This JORAN hexapod has also been customized to support a 3.2 tons payload.

	JORAN ST	JORAN BL
	for lower speed	for higher speed
Motion and positioning		
Travel range Tx, Ty (mm)	± 65	± 65
Travel range Tz (mm)	± 50	± 50
Travel range Rx, Ry, Rz (deg)	± 3	± 3
Resolution Tx, Ty, Tz (µm)	0.1	0.1
Resolution Rx, Ry, Rz (µrad)	0.5	0.5
Repeatability Tx, Ty, Tz (µm)	± 0.5	± 0.5
Repeatability Rx, Ry, Rz (µrad)	± 2	± 2
Speed (mm/s; deg/s)	0.25; 0.05	1; 0.2
Mechanical properties		
Payload capacity (kg) (vertical orientation)	1500	1500
Motor type	Stepper motor	Brushless motor
Miscellaneous		
Operating temperature range (°C)	0 to + 50	0 to + 50
Material	Aluminum, steel, stainless steel, ceramic	Aluminum, steel, stainless steel, ceramic
Footprint (mm)	Ø 1300	Ø 1300
Height in middle position (mm)	800	800
Mass (kg)	1500	1500
Cable length (m)	5	5
Options	Customized platform design Absolute encoders Adjustable height Heavier payload	Customized platform design Absolute encoders Adjustable height Heavier payload
Controller		
Controller type	ALPHA	ALPHA
Interface	Ethernet, USB	Ethernet, USB
Power supply	110-240 VAC / 50-60 Hz	110-240 VAC / 50-60 Hz

The performances are specified for single axis motions, with all other axes at midrange and for a rotation center in the middle of the mobile platform.



Hexapod in middle position



SIRIUS hexapod

High resolution hexapod large size

KEY FEATURES

- Payload capacity up to 200 kg
- Linear travel range ± 100 mm
- Angular travel range $\pm 20^\circ$



APPLICATIONS

- High precision positioning
- Optical adjustment
- Radio testing
- Antenna qualifications



Credits: Stéphane Lagoutte

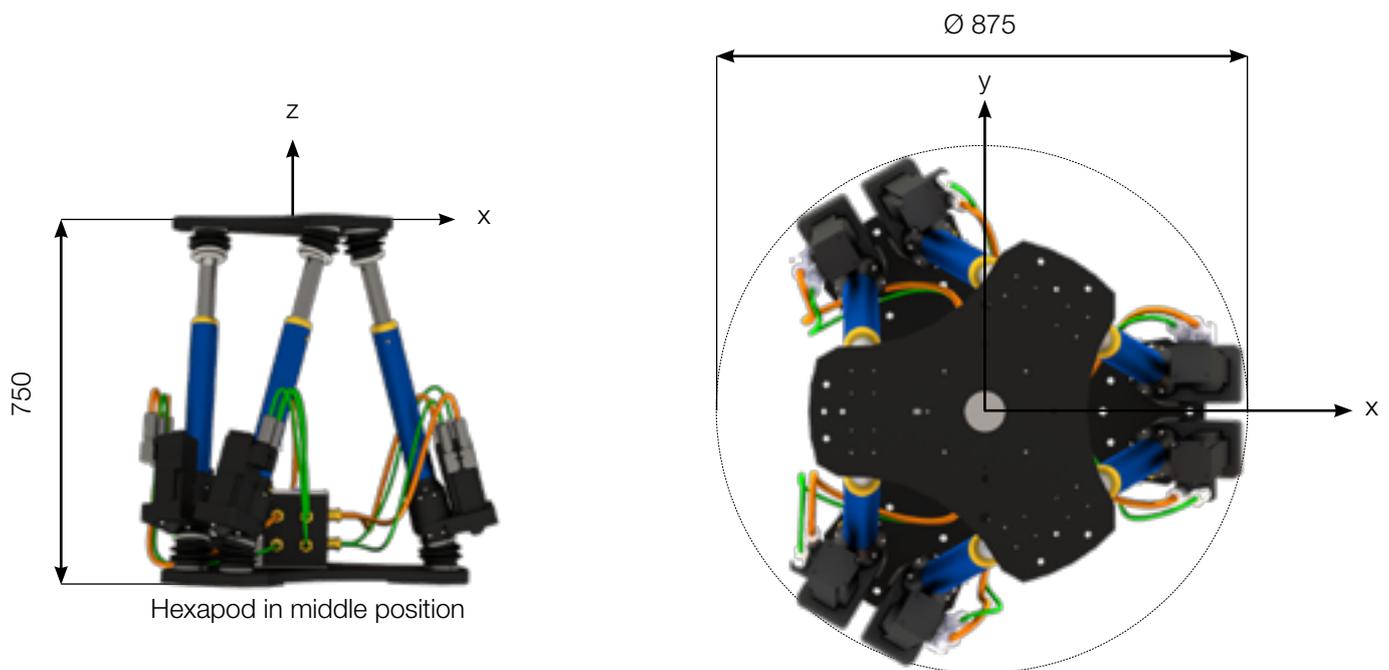
Four SIRIUS hexapods orientate the antennas of telecommunication satellite to test their performances before the launch. Thanks to the flexibility and pivot point configuration of these hexapods, this set up is adaptable to different satellite models.



This customized hexapod with extra travel range enables the qualification of space optical instruments. Hexapod height in middle position: 1400 mm / Payload: 200 kg.

SIRIUS	
Motion and positioning	
Travel range Tx, Ty (mm)	± 150
Travel range Tz (mm)	± 100
Travel range Rx, Ry, Rz (deg)	± 20
Resolution Tx, Ty, Tz (µm)	5
Resolution Rx, Ry, Rz (µrad)	10
Repeatability Tx, Ty (µm)	± 6
Repeatability Tz (µm)	± 4
Repeatability Rx, Ry (µrad)	± 20
Repeatability Rz (µrad)	± 35
Speed (mm/s; deg/s)	8; 2.5
Mechanical properties	
Payload capacity (kg) (vertical orientation / horizontal orientation)	200 / 80
Motor type	Brushless motor with absolute encoder
Miscellaneous	
Operating temperature range (°C)	0 to + 50
Materials	Aluminum, steel, stainless steel
Size mobile platform (mm)	Ø 520
Height in middle position (mm)	750
Mass (kg)	85
Cable length (m)	5
Options	Vacuum compatibility Customized platform design
Controller	
Controller type	VEGA
Interface	Ethernet, USB
Power supply	400 VAC (three-phase) / 50-60 Hz

The performances are specified for single axis motions, with all other axes at midrange and for a rotation center in the middle of the mobile platform.





SURES hexapod

High resolution high rigidity hexapod for astronomy

KEY FEATURES

- Payload capacity up to 500 kg
- Resolution 0.1 μm
- Low cross coupling motions
- Operational in all orientation



APPLICATIONS

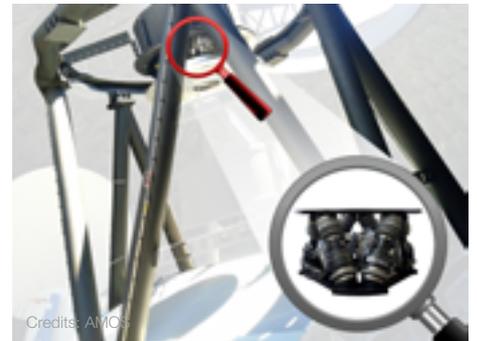
- Positioning of mirror of telescope
- Radio testing
- High accuracy positioning
- Antenna qualification
- Optical adjustment



SURES hexapod positions the 450 kg secondary mirror of OAJ T250 telescope in Spain with 0.35 μm linear and 0.5 arcsec angular resolutions. The SURES hexapod for OAJ has a 920 mm diameter.



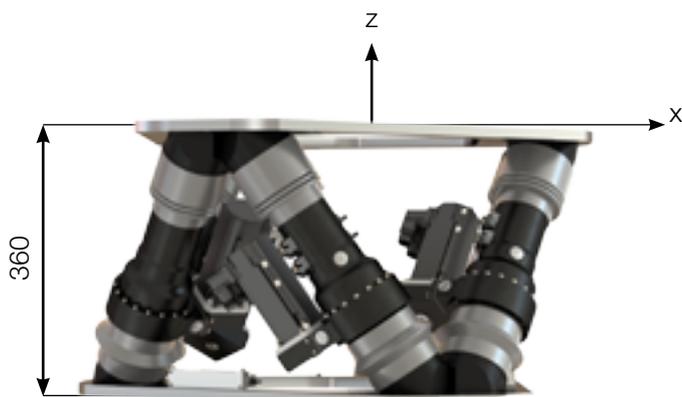
ARIES telescope is installed in Nainital in India. With a primary mirror of 3.6 m diameter, it is the largest optical centre in the country. Cross-coupling of SURES hexapod is less than 0.7 arcsec in tip-tilt during centering or focus.



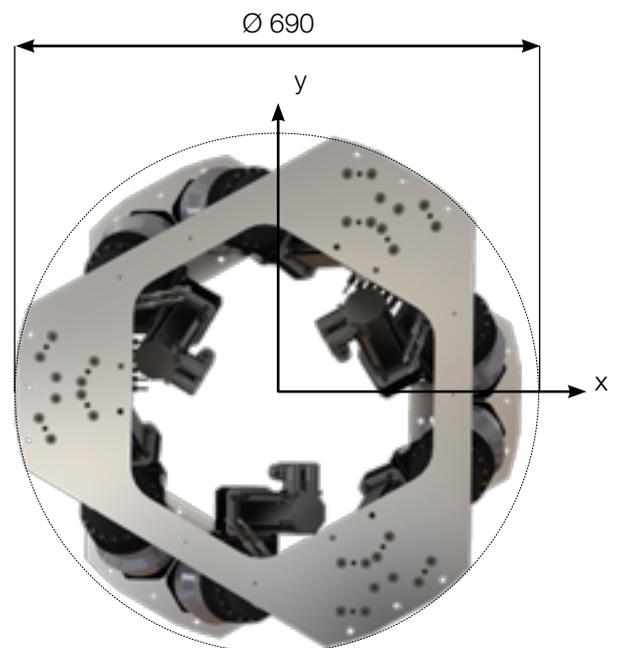
The hexapod is installed on Pan-STARRS-2 telescope at an altitude of 4267 m on Maui, Hawaii. A smaller version of SURES has been adapted as the secondary mirror is 600 mm diameter and weighs less than 110 kg.

SURES	
Motion and positioning	
Travel range Tx, Ty, Tz (mm)	± 12
Travel range Rx, Ry, Rz (°)	± 1.5
Resolution Tx, Ty, Tz (µm)	0.1
Resolution Rx, Ry, Rz (µrad)	1.5
Repeatability Tx, Ty (µm)	± 0.5
Repeatability Tz (µm)	± 0.25
Repeatability Rx, Ry, Rz (µrad)	± 1
Mechanical properties	
Payload capacity (kg) (with orientation from 0° to 90°)	up to 500
Motor type	Brushless motor with absolute encoder
Miscellaneous	
Operating temperature range (°C)	-20 to + 40
Humidity level (%)	up to 100
Materials	Aluminum, steel, stainless steel
Size mobile platform (mm)	Ø 690
Height in middle position (mm)	360
Mass (kg)	~ 90
Cable length (m)	10 (longer on request)
Options	Customized platform design Modular external diameter
Controller	
Controller type	ALPHA custom
Interface	Ethernet, USB
Power supply	120-240 VAC / 50-60 Hz

The performances are specified for single axis motions, with all other axes at midrange and for a rotation center in the middle of the mobile platform.



Hexapod in middle position





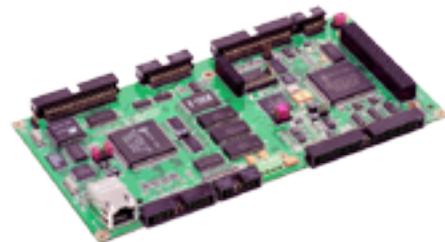
CAPELLA controller

KEY FEATURES

- Ethernet, USB or Serial (RS-232)
- General purpose inputs / outputs
- Complete control software
- Compatible with: NanoPos



Features	
Axis number	6 + 2 optional
Motion controller	DeltaTau Clipper programmed with SYMETRIE hexapod control software
Communication	Ethernet / USB / Serial (RS-232)
Drive type	Micronix piezo drivers
Encoder input	Incremental differential signals (RS-422)
Connectors	6x D-sub 15 pins
GPIO	2 outputs & 1 input optically isolated (D-sub 9 pins)
Safety	Emergency stop input
Miscellaneous	
Voltage	110-240 VAC / 50-60 Hz
Power	< 500 W (4A internal fuse)
Dimensions	Height (H) / Width (B) / Depth (T) (see figure below), 88.1 mm (2U) / 448.90 mm (84F) / 315.5 mm
Mass	~ 5 kg
Operating temperature	0 °C to + 45 °C
Storage temperature	- 25 °C to + 70 °C





ALPHA controller

KEY FEATURES

- Ethernet or USB
- General purpose inputs / outputs
- Complete control software
- Compatible with: BORA, BREVA, ZONDA, KUBAN, JORAN



Features	
Axis number	6 + 2 optional
Motion controller	DeltaTau Geobrick LV programmed with SYMETRIE hexapod control software
Communication	Ethernet / USB
Drive type	DC, Brushless or Stepper drivers
Encoder input	Incremental differential signals (RS-422) or high-speed serial protocol for absolute encoders (Endat or BiSS)
Connectors	6x D-sub 15 pins or M17 (6 additional connectors with absolute encoders)
GPIO	2 outputs & 1 input optically isolated (D-sub 9 pins) 8 optional inputs and handwheel (D-Sub 15 pins high density)
Safety	Emergency stop input / Safe Torque Off (STO) function
Miscellaneous	
Voltage	110-240 VAC / 50-60 Hz
Power	< 300 W for BORA and BREVA DC < 750 W for BREVA ST, BREVA BL < 1000 W for ZONDA, KUBAN, JORAN ST < 1500 W for JORAN BL
Dimensions	Height (H) / Width (B) / Depth (T) (see figure on CAPELLA controller) 132.55 mm (3U) / 448.90 mm (84F) / 435.5 mm for model with power < 1000 W 177 mm (4U) / 448.90 mm (84F) / 495.5 mm for model with power < 1500 W
Mass	~ 10 kg
Operating temperature	0 °C to + 45 °C
Storage temperature	- 25 °C to + 70 °C





VEGA controller



KEY FEATURES

- Ethernet or USB
- General purpose inputs/outputs
- Complete control software
- Compatible with: SIRIUS

Features	
Axis number	6 + 2 optional
Motion controller	DeltaTau Geobrick LV programmed with SYMETRIE hexapod control software
Communication	Ethernet / USB
Drive type	Brushless drivers
Encoder input	High-speed serial protocol for absolute encoders (Endat or BISS)
Connectors	2x Harting Han 72DD
GPIO	2 outputs & 1 input optically isolated (D-sub 9 pins) 8 optional inputs and handwheel (D-Sub 15 pins high density)
Safety	Emergency stop input / Safe Torque Off (STO) function
Miscellaneous	
Voltage	110-240 VAC or 400 VAC (three phases 3P + N + E) / 50-60 Hz
Power	< 1500 W on standard
Dimensions	Height (H) / Width (B) / Depth (T) 767 mm (16U) + 76 mm (castors) / 553 mm / 600 mm
Mass	< 75 kg with 110-240 VAC model < 100 kg with 400 VAC model
Operating temperature	0 °C to + 45 °C
Storage temperature	- 25 °C to + 70 °C



EnDat 2.2

BiSS
INTERFACE

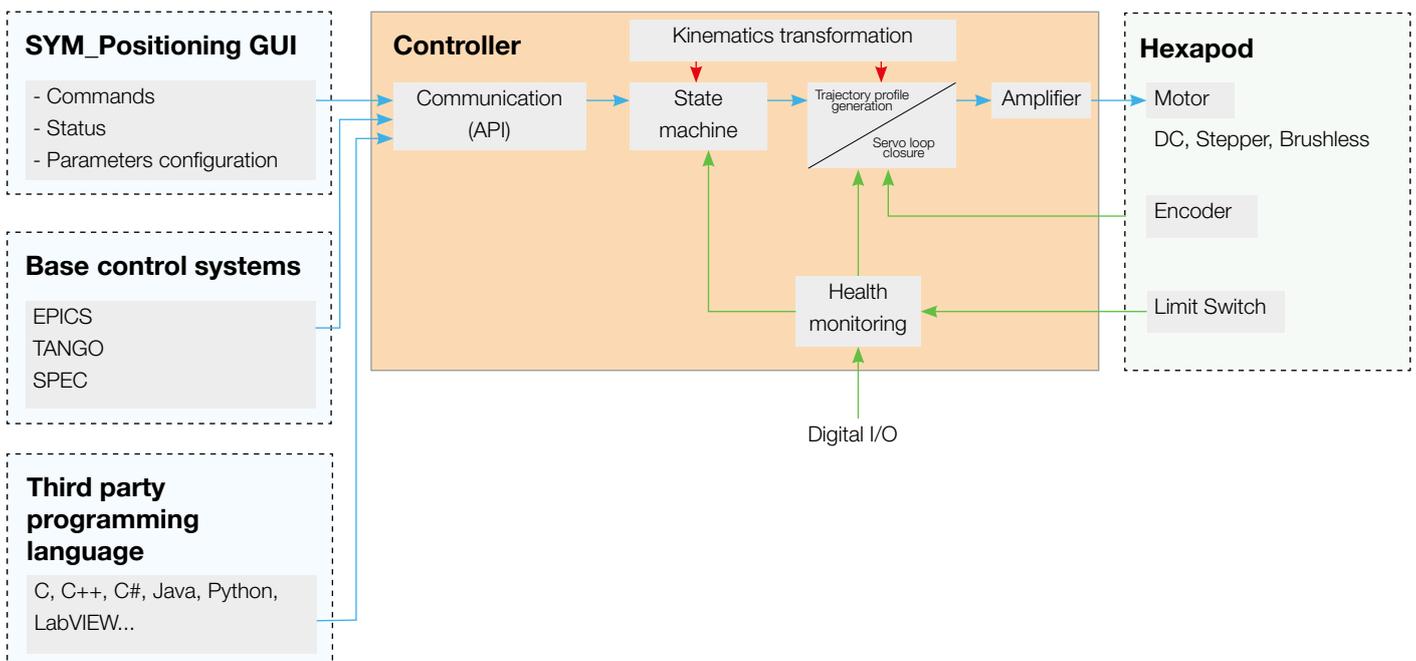


Controller technology

The motion controller is integrated with drive amplifiers and power supplies in an industrial control enclosure. It is the brain responsible for the hexapod control; it allows the following tasks especially:

- **Communication:** communicates with the graphical interface software or a base control system through the Application Programming Interface (API).
- **State machine:** executes a state machine, responsible for the control of the hexapod. The state machine uses the hardware inputs and data received from the Application Programming Interface (API) to determine what to do.
- **Kinematics transformations:** performs the conversion between position expressed in DOF (degrees of freedom) regarding the defined coordinate systems and actuators' lengths.
- **Coordinate systems:** transformations are calculated inside the motion controller at a low level.
- **Servo loop closure:** ensures that the position error between the target actuator position and the measured position is minimized.
- **Health monitoring:** the motion controller checks the state of hardware inputs and control loop deviations from normal operating conditions.
- **Trajectory profile generation:** the motion controller implements an interpolation algorithm to produce smooth motion with a trajectory control to guarantee low cross-coupling.
- **Validation process:** before each motion the controller checks if the requested motion is valid, considering the payload, the hexapod parameters and including safety limits.

From the user to motion:





Controller technology

The control software embedded on the motion controller is developed by SYMETRIE. All functionalities necessary to control the hexapod are included, even the most advanced and complicated features. Embedded software programming is easily customizable to integrate the more complex customer application requirements (examples: integrate additional axis control, customized digital outputs, add safety sensors...).

The customers have the choice between several configurations to control the hexapod:

- **Windows Graphical User Interface (GUI): SYM_Positioning software**
- **Application Programming Interface (API):** to integrate the hexapod control into your environment
- **Base control system drivers: EPICS, TANGO, SPEC**
- **Specific programming library: C, C++, C#, Java, Python, LabVIEW...**

SYMETRIE controllers are based on Delta Tau motion controllers, which are the global reference for precision motion control. SYMETRIE has a strong experience in using Delta Tau products. Delta Tau controllers' main characteristics are :



- Providing structures that enable easy implementation and execution of complex kinematics calculation. This capability permits the motion for the hexapod to be programmed in the natural coordinates of the tool-tip.
- The power and flexibility of its trajectory generation algorithms.
- Performing highly sophisticated look ahead calculations on programmed trajectories. This feature will scan ahead in the programmed trajectories, looking for potential violations of its position, velocity, and acceleration limits. If it sees a violation, it will then work backward through the pre-computed buffered trajectories, slowing down the parts of these trajectories necessary to keep the moves within limits. These calculations are completed before these sections of the trajectory are actually executed.

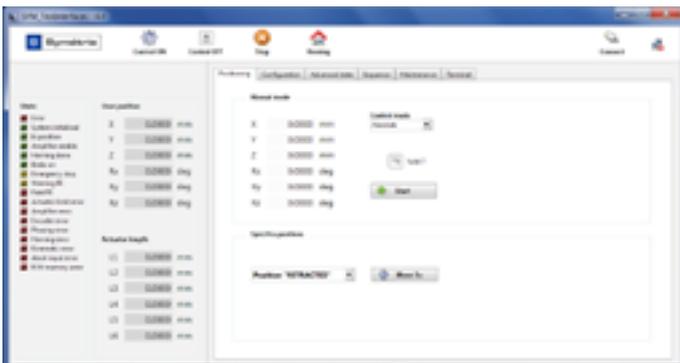


DELTA TAU Geo Brick LV controller

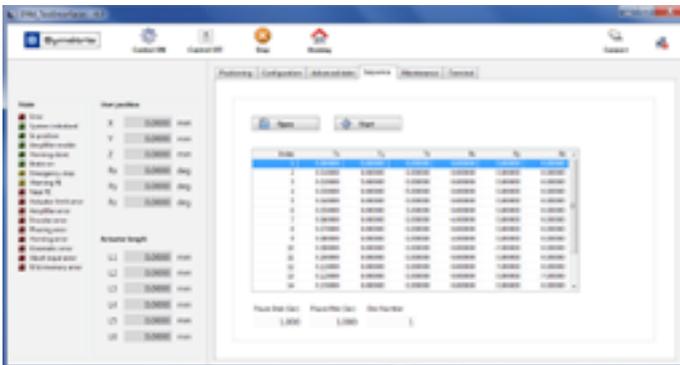


SYM_Positioning software

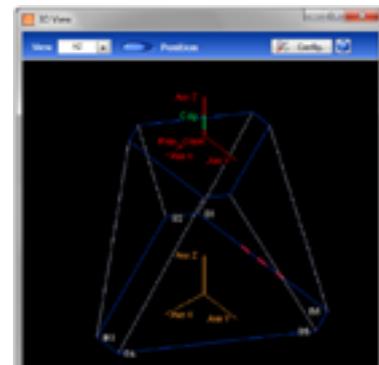
SYM_Positioning is an ergonomic GUI software, which is well suited for the customer who does not need to integrate the hexapod in a more complicated system. All functionalities necessary to control the hexapod are included, even the most advanced and complicated features.



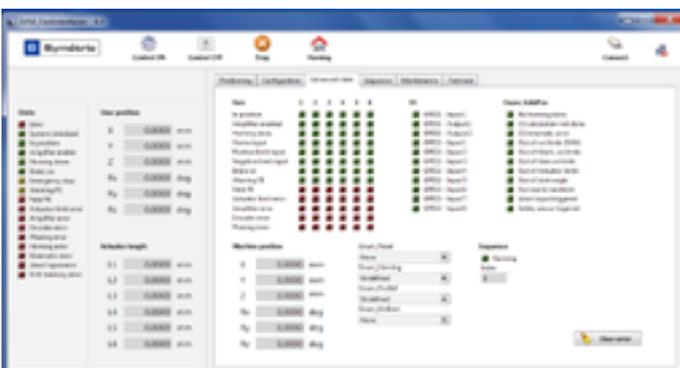
Main window allowing the user to set the target position of the hexapod.



Window allowing the user to create an automated list of points for the hexapod.



Window allowing to display the hexapod position in 3D.



Window allowing the user to get an overview of the hexapod current state.



Hand-held control unit



A manual control unit is provided optionally with the hexapod. This unit is useful to control fine adjustments, without necessarily using the software.

Features available on this manual control unit are similar to those found on a CNC machine:

- Axis selector: Tx, Ty, Tz, Rx, Ry, Rz
- Increment size selector: 0 (hand-held disabled), x1, x10, x100, +/- (continuous mode)
- J+ button: allow to realize a continuous motion in positive direction
- J- button: allow to realize a continuous motion in negative direction
- Pulse generator: wheel to control incremental motion



Application Programming Interface (API)

With the standalone configuration, in addition to the control enclosure, the system comes with a documentation about the commands necessary to communicate with the hexapod. All functionalities necessary to control the hexapod are available, even the most advanced and complicated features.

The Application Programming Interface and the controller Ethernet protocol (TCP/IP) are highly documented. This open architecture permits to integrate the hexapod control under any third party programming language (LabVIEW, C, C++, C#, Java, Python...).

Thanks to our recent developments, it is now possible to easily integrate the hexapod into EPICS, SPEC, or TANGO.

TANGO

EPICS

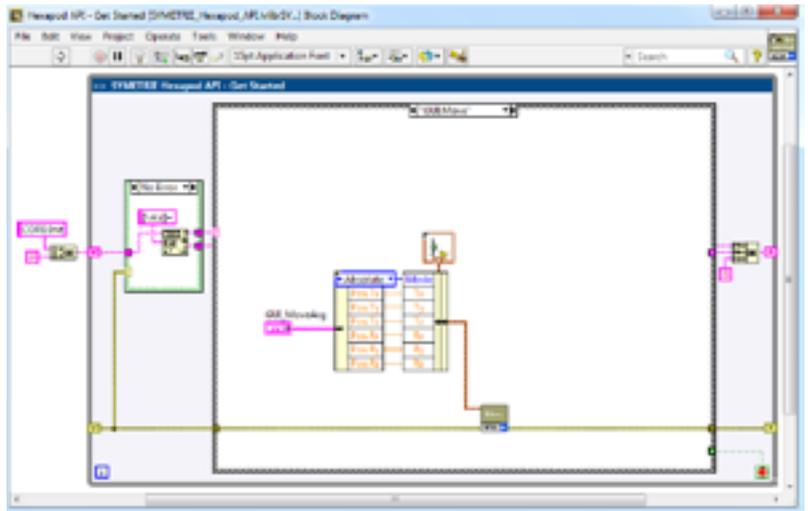
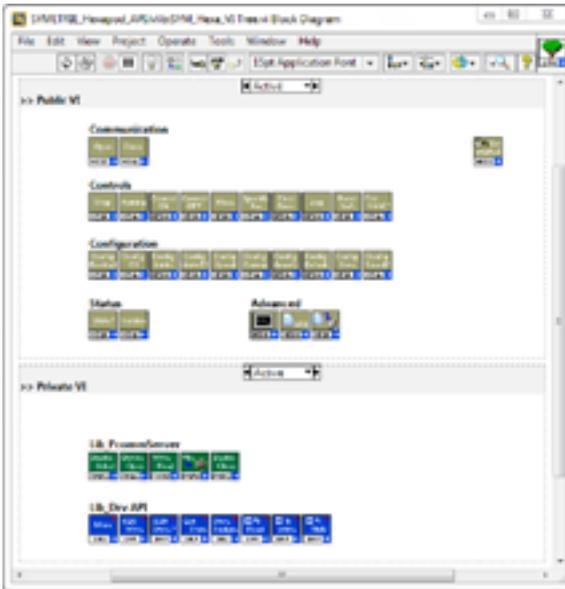


spec

LabVIEW library for hexapod controller

The library features easy-to-use native LabVIEW VIs (Virtual Instruments) to control and command SYMETRIE hexapod directly from your favorite graphical development environment. With this library, you can easily and quickly integrate full hexapod control into your application and eliminate complex programming expertise. Using this approach, you do not need to learn specialized software programming skills, which means you can achieve higher performance and better results in less time.

VIs are provided to simplify the programming of the hexapod control into your application. To start using them, we assume a prior knowledge of proper LabVIEW programming techniques. Nevertheless it is not necessary to be a LabVIEW expert to use our library.



C library for hexapod controller

The C library allows the application programmers to control the hexapod with a minimum of programming effort. With this library, the programmer has access to all hexapod controller features to create her/his own software or integrate it into a more application environment.

```
int sym_api_vs_getresponse(socket sock, char *pCmd) {
    ST_API_TPNAC_ETH_L_pCMD = (0);
    int i_irc = 0;

    // Build control string
    L_pCMD eRequestType = VS_DOWNLOAD;
    L_pCMD eRequest = VS_TPNAC_GETRESPONSE;
    L_pCMD iValue = 0;
    L_pCMD iIndex = 0;
    L_pCMD iLength = htons(strlen(pCmd));

    // Write
    strcpy(L_pCMD, eData, pCmd, strlen(pCmd));
    i_irc = write(tpnac(sock, (char*)L_pCMD, DEF_API_TPNAC_ETH_CMD_SIZE + strlen(pCmd));
    if (i_irc < 0) {return DEF_API_TPNAC_ERR_WRITE;}

    // Read
    memset(pCmd, 0, DEF_API_TPNAC_STRING_SIZE);
    if ((i_irc = read(tpnac(sock, pCmd, DEF_API_TPNAC_STRING_SIZE)) < 0) {
        return DEF_API_TPNAC_ERR_READ;
    }

    // If acknowledge character is received, return the string and return success
    if (pCmd[i_irc-1] == '\004' ||
        pCmd[i_irc-2] == '\0')
    }

    return i_irc;
}
```



Applications: Astronomy

Ground-based telescopes are more and more powerful in order to help astronomers to see further and more accurately. As a consequence, telescopes manufacturers are looking after improved mirror positioning performances. Hexapods are used to realign the secondary mirror relatively to the primary mirror to compensate the mechanical deformations of the telescope structure due to temperature and gravity changes during the night.



Large ground-based optical telescopes

Two SURES hexapods position secondary mirrors with a resolution of 0.5 arcsec on two large ground-based optical telescopes being manufactured by AMOS in Belgium. The payloads weigh 350 kg each and have a diameter of approximately 900 mm.



Ground-based optical telescopes

The hexapod is installed on Pan-STARRS-2 optical telescope at an altitude of 4267 m on Maui, Hawaii. Pan-STARRS-2 is operated by the Institute for Astronomy of the University of Hawaii. A small version of the SURES hexapod has been adapted as the secondary mirror is 600 mm diameter and weighs less than 110 kg.



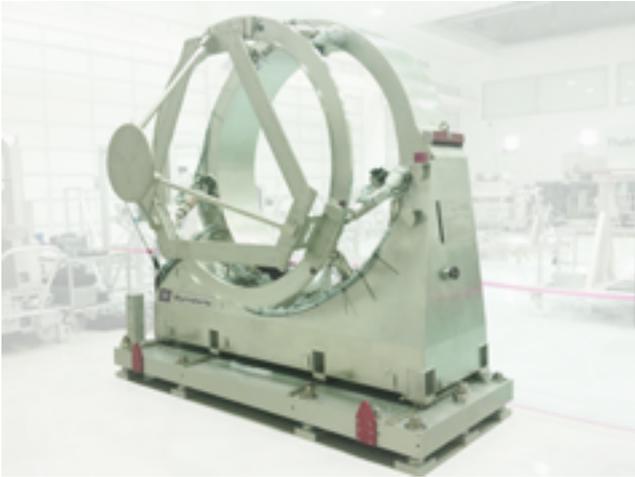
Ground-based radio telescopes

NOEMA is the most powerful millimeter radiotelescope of the Northern Hemisphere. Located in the French Alps, it is operated by the IRAM research institute for radio astronomy. Customized hexapods with light carbon platforms are positioning the 900 mm diameter subreflectors with high precision.



Applications: Optical benches

Hexapods are particularly adequate to precisely align mirrors on satellites or to calibrate and test space optical components during mounting and testing phases.

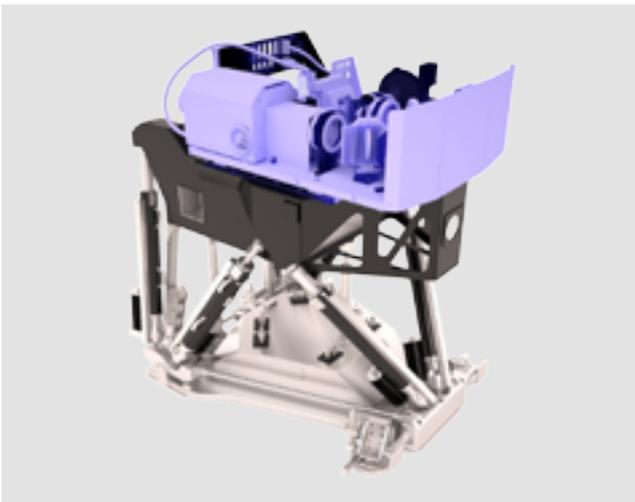


Mirror adjustment on a satellite

- Environment: high vacuum (10^{-6} mbar)
- Payload capacity: 250 kg / Hexapod height: 2.5 m
- Resolution: less than $1 \mu\text{m}$ (linear) and $2 \mu\text{rad}$ (angular)

Thales Alenia Space has to adjust a mirror during its integration on an optical satellite using five degrees of freedom (TX, TY, TZ, RX, RY) with high accuracy.

Bertin Technologies is responsible for the adjustment bench of this mirror and selected SYMETRIE's hexapod proposal. This solution based on a 3-meter-height hexapod is a technological breakthrough compared to the mounting and test equipment previously used in the space industry.

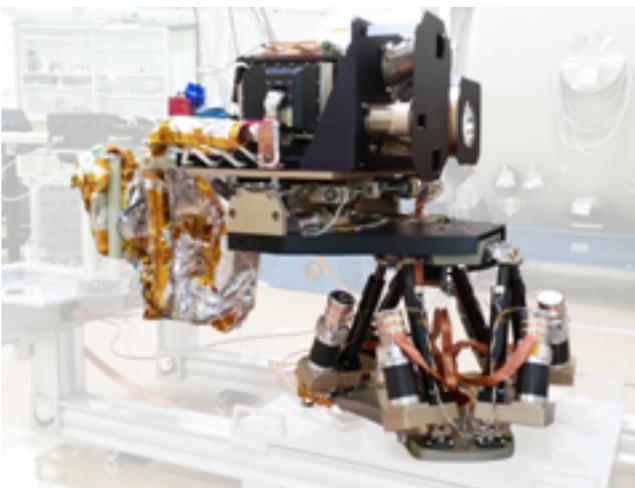


Optical integration and calibration

- High stability thanks to its conception and the use of Invar material with a low coefficient of thermal expansion
- High accuracy
- Customized platform to integrate the payload

Meteosat Third Generation (MTG) is the next fleet of meteorological satellites, which are managed by the European Space Agency (ESA) and Eumetsat.

This high rigidity and high stability hexapod has been made for integration and calibration of a space optical sensor of one of these satellites.



Space optical instrument calibration

- Resolution: less than $0.5 \mu\text{m}$ (linear) and $2.5 \mu\text{rad}$ (angular)
- Rigidity
- Environment: high vacuum (10^{-6} mbar)

A customized BREVA hexapod helps IAS Space Astrophysics Institute to calibrate Simbio-Sys space optical instrument, one of the major elements of the BepiColombo ESA mission dedicated to the study of Mercury.

This hexapod integrates an additional translation and a goniometer to pre-align one of the four instruments of Simbio-Sys in front of the optical source. Then the fine and precise positioning for the qualification is achieved thanks to the hexapod.



Applications: Synchrotrons

The precision positioning hexapods of SYMETRIE are particularly adapted for the specific precision positioning needs of particle accelerators and other research institutes.



JORAN hexapod

- High angular resolution: 0.5 μrad
- High stability
- Ultra heavy load > 3 tons

→ Mirror support, sample positioning, qRIXS experiments

JORAN hexapod has been developed thanks to a successful collaboration with ESRF (Grenoble, FRANCE).



ZONDA hexapod

- High resolution
- High stability
- Heavy load: 400 kg

→ Sample positioning, GI-SAXS experiments



BORA hexapod

- High resolution: 0.1 μm
- Compact size: 145 mm height

→ KB mirrors support, sample positioning



Applications: Special projects

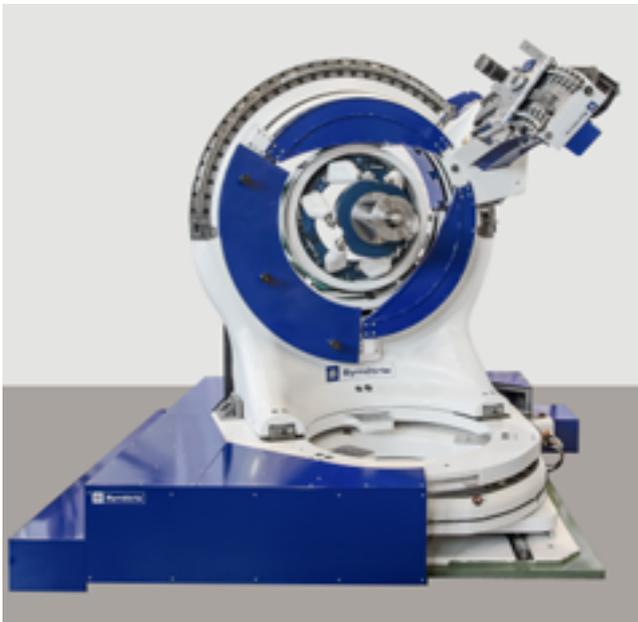
Our engineers are experienced to design made-to-measure hexapods with a high level of customization for very specific projects.



Laser MegaJoule

Laser MegaJoule (LMJ) is a large laser-based inertial confinement fusion (ICF) research device being built near Bordeaux, in France by the French nuclear science directorate, CEA.

- High precision positioning of the target in the convergence centre of 240 laser beams
- Harsh environment: high vacuum and radiations



Diffractometer

A joint CEA-CNRS (French National Center for Scientific Research) team uses this large size diffractometer to study nano structures on surfaces during their growth at ESRF synchrotron in Grenoble.

- Arm detector angular speed: 20 °/sec
- Sphere of confusion sample: 50 μm
- Sphere of confusion detector: 100 μm
- Integration of a BREVA hexapod to position the sample



JWST optical test bench

The James Webb Space Telescope (JWST) is the successor to Hubble. This telescope is an international collaboration between NASA, ESA and CSA.

This optical test bench was made by CEA to qualify the MIRIM (Mid Infra Red IMager) instrument of JWST.

- Two positioning hexapods: a manual one for the cryostat, a customized BREVA for the light source
- High resolution positioning: 1 μm
- SONORA and BREVA hexapods have been adapted

A worldwide presence



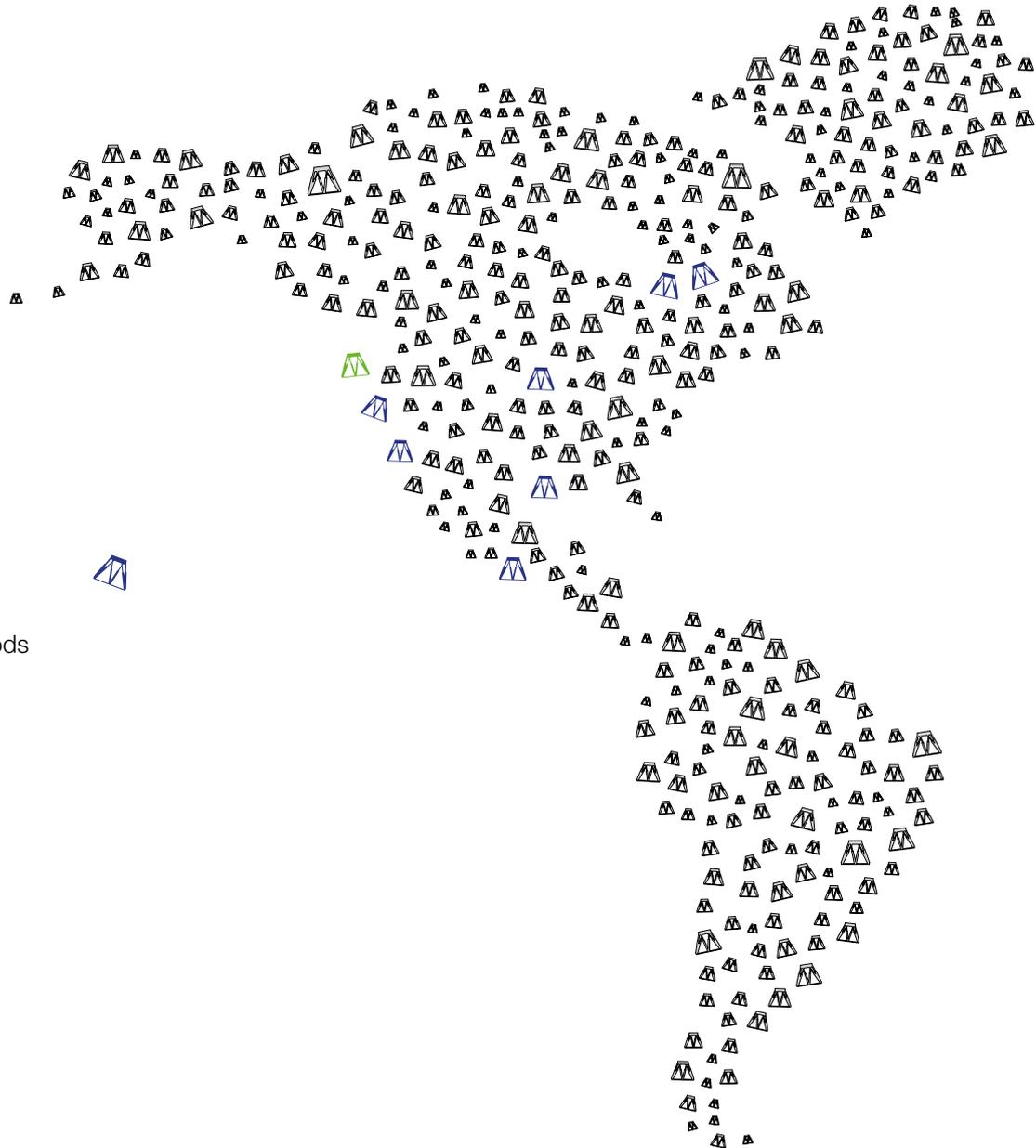
SYMETRIE hexapods locations

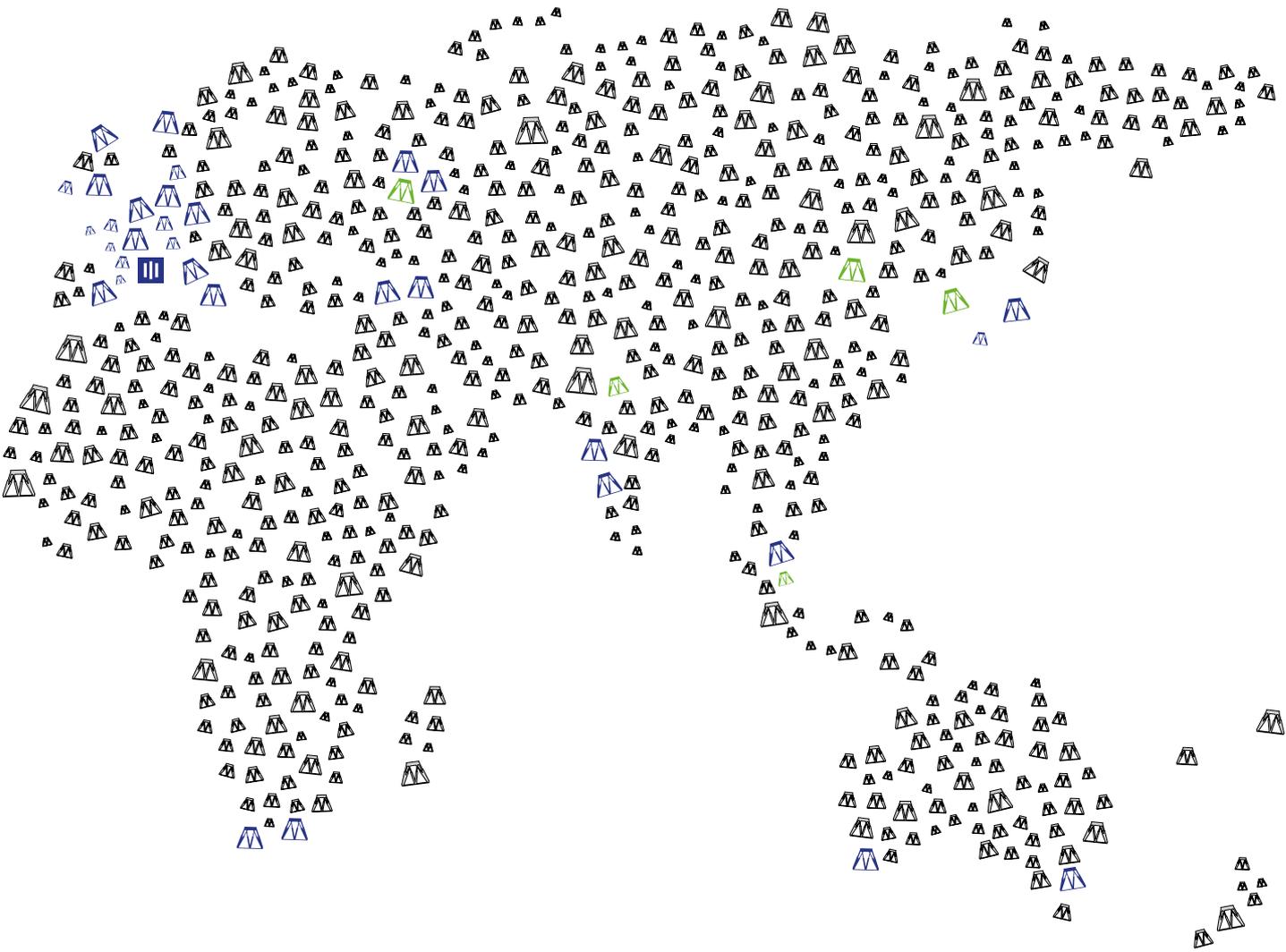


Distributors of SYMETRIE hexapods



SYMETRIE headquarters





Our hexapods all over the world

HOW TO CONTACT US



SYMETRIE headquarters

10, Allee Charles Babbage
30035 Nimes Cedex 1
FRANCE
Phone: +33 (4) 66 29 43 88
Fax: + 33 (4) 66 29 54 47
Email: info@symetrie.fr
www.symetrie.fr www.hexapod-system.com



Symétrie

Representatives



China

Beijing Reloh International Trade Co., Ltd

Room 1109 YuanYangDeYi Tower,
Zhongshili Nan Jie, Guangqumwai Dajie
Dongcheng District. 100022 Beijing
China
Phone: +86 10-87757858
Fax: +86 10-87757857
Email: info@reloh.com
www.lim-tec.com



Singapore

Zugo Photonics Private Limited

Blk 514 Chai Chee Lane
#03-07 Bedok Industrial Estate
Singapore 469029
Contact: Anthony Tan
Phone: +65 68440055 ext 119
Email: anthony.tan@zugophotonics.com
www.zugophotonics.com



India

SM Creative Electronics Limited

10, Electronic City, Sector
18 Gurgaon
122015 Haryana
India
Contact: Parveen Garg
Cell: +91 98161 89749
Phone: +91 124 4909850
Email: parveengarg@smcel.com; smcel@smcel.com
www.smcelindia.com



South Korea

INNOTICS

562-3, Dae-Lim B / D, 207-2
Seoul
South Korea
Phone: +82 (0) 2 2276 1013
Email: inno_jhchang@naver.com
www.innotics.com



Russia, Ukraine, Belarus, Armenia and Kazakhstan

CDP Systems Corp.

53 Leninsky Prospect
119991 Moscow
Russian Federation
Phone: +7 (499) 132 6912
Email: mfirdus@sci.lebedev.ru
www.cdpsystems.com



USA and Canada

MICRONIX USA

15375 Barranca Parkway, Suite E-106
Irvine, CA 92618, USA
Phone: +1 (949) 480-0538
Email: info@micronixusa.com
www.micronixusa.com