Laser-based metrology for Hexapods

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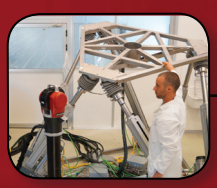

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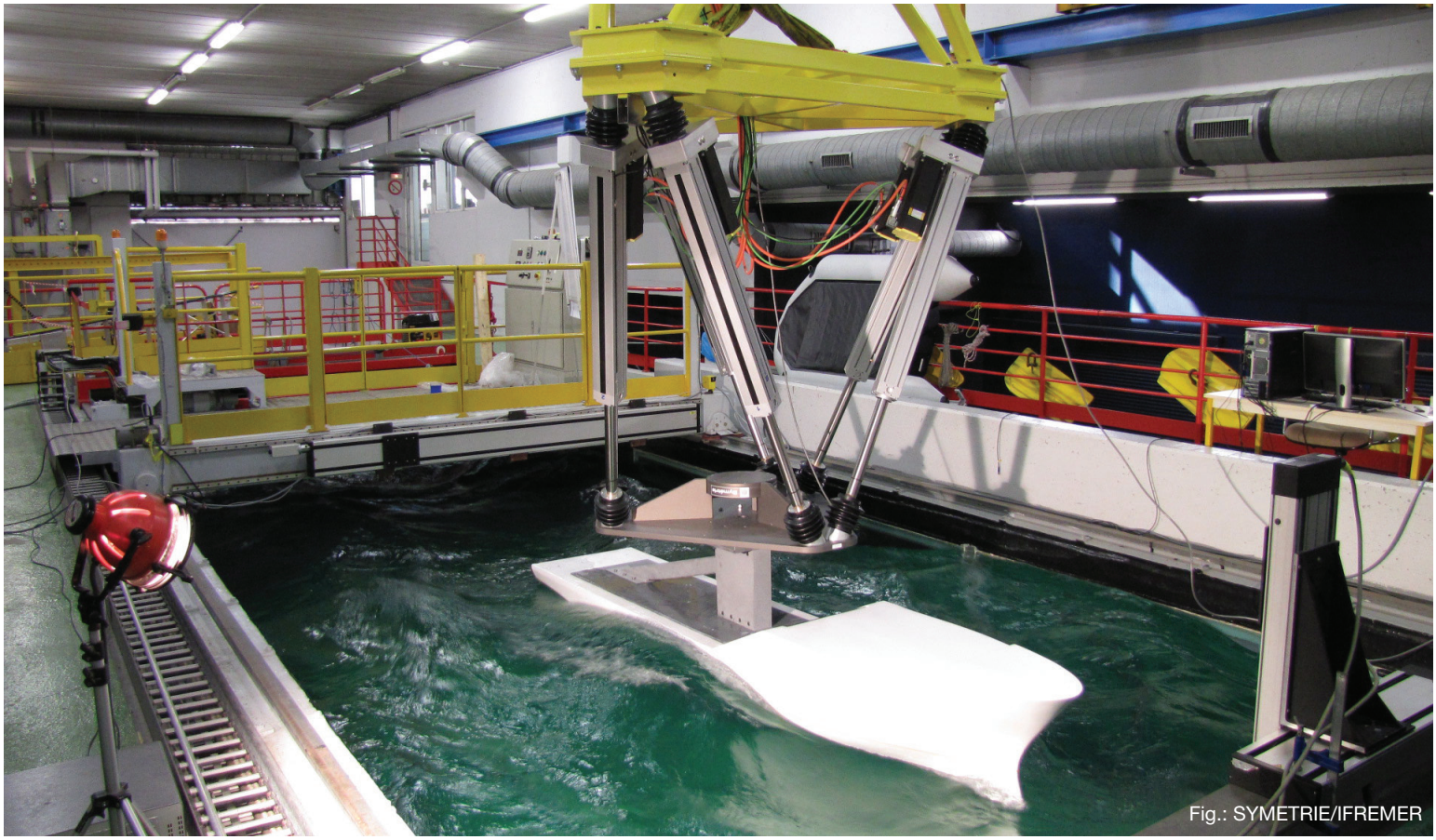
Fig.: SYMETRIE/IFREMER

HEXAPODS

The six feet for special applications

Hexapod: The word sounds alien, but we see them every day. A Hexapod (Hexa is the Greek word for Six; pod is Greek for foot) is simply a spatial motion machine with six driving elements. They can be seen at fairgrounds, as the motor for carnival rides, or on flight simulators for pilot training. In both cases, the cabin is mounted on 6 stilts, whose length can be changed and rotated against each other. This design allows the platform to move in all six degrees of freedom. At Symétrie in Nimes (France), one of the leading manufacturers of high precision positioning and motion hexapods, laser trackers are used in production and assembly to ensure the precision of movement through every angle and position.

The somewhat different robot

Essentially, hexapods are robots. They are used in many manufacturing sectors, including automotive. Hexapods have a parallel kinematic structure. Machines with a different kind of structure - serial kinematics - are far more popular in industry. Serial kinematics, particularly those that make up an articulated arm, have become well established in industrial production. Hexapods, meanwhile, are only used in special cases, but their accuracy in these areas are unmatched.

Their parallel kinematics offer higher positioning accuracy, as the position errors of the axes are not cumulative, as in serial kinematics, but are only proportional to the overall movement. This increased accuracy allows hexapods to handle particularly demanding applications that involve dynamics and low moving mass with the same high payload. These include studies into the wave movements of water, which are needed in shipbuilding research, or in the positioning of satellite antennas in anechoic chambers. In all cases, it's a case of the exact positioning of structures and components in space. The largest hexapods reach an average height of about 3 meters (9 feet).

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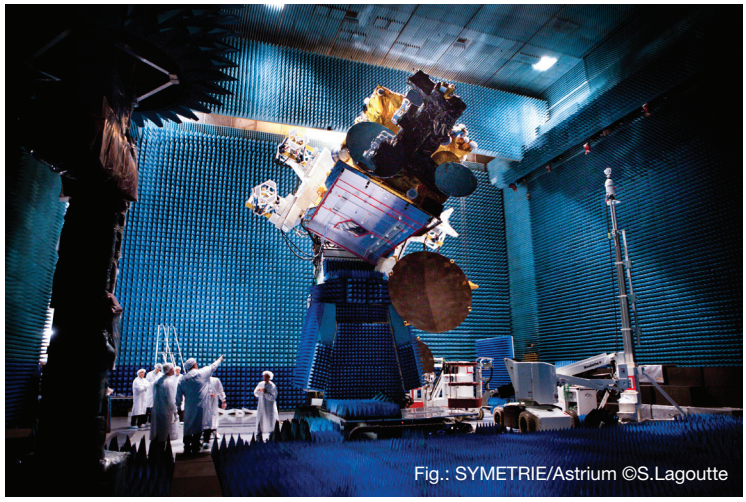
The AQUILON Hexapod can thereby accelerate a payload of 6 tons with 1 g. As was found at Symétrie, laser trackers are the ideal measurement systems for measuring the positions of the robot or its payload in space. And even while setting up the systems, and during the installation and calibration, portable measuring systems that can be used on the customer site play a crucial role.

Simulator for submarine crews that is moved by a hexapod.

In its element with special applications

The larger hexapods are traditionally used for movement simulation (these are motion hexapods). For example, submarine crews train for emergencies while the simulator, which is based on a robot with parallel kinematics, simulates the movements of the boat. The French are well experienced simulating the motion of waves swelling, while other customers use hexapods to prepare satellite antennas that are installed on ships and must be stabilized via positioning systems. Loading cranes are tested for simulations at sea. The realistic simulation of the waves by a robot is also important for companies that manufacture insulation for tankers that transport liquefied natural gas (LNG). In liquid form, cooled to -162 degrees, natural gas takes up only 1/600 of its original volume, which makes the transportation of large quantities of this fuel economical; more of a quarter of the natural gas transported worldwide is liquefied. But binding international standards on the construction and equipment of liquefied gas tankers requires extensive – and expensive - testing. Thanks to their ability to withstand certain types of damage from collisions or strandings these tankers are standardized worldwide. The Motion Hexapod of the specialists from France makes it possible to investigate the influence of surge or sloshing effects of the liquid load on the transport ship.



Testing of satellite systems with the help of a hexapod.

The influence of waves on a ship's hull is also studied in the wave pool at IFREMER in Boulogne-sur-Mer (see cover picture). The Deep Wave Basin is Europe's deepest wave pool for hydrodynamic investigations with a depth of depth of 20 meters (60 feet). These and other underwater acoustical measurements are carried out here, with the hexapod robot installed upside down for the applications.

Symétrie is also responsible for another customized solution with hexapods: one that can be operated under vacuum-like conditions (see next picture) has been constructed for the Maritime Research Institute Netherlands (MARIN). In a 240-meter long basin, tests can thereby be carried out on the underwater stability of ships' hulls, as well as on the influence of cavities and other fissures caused by steam bubbles on propellers. The tests are taken in the basin on models that are built at a smaller scale, but the results correspond with the full-size ships. These measurements are taken in almost vacuum-like conditions, with pressure as low as 2,500 Pasqual (the average air pressure of the atmosphere is 100,000 Pascal).

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Measurements with the laser tracker
A laser tracker is the ideal measuring system for the measurement of robot positions in space. Its unlimited portability allows it to be set up in the immediate vicinity of the object to be measured, without the latter having to be transported. This represents an unbeatable advantage over stationary measuring machines. Its compact design enables it to be transported in a car, so that measurements can even be carried out at the customer's premises. A measurement target, known as a Spherically Mounted Retroreflector (SMR) is the only equipment that is needed to measure structures or geometries. Laser trackers from API can dynamically track targets, taking continuous fluid measurements as the SMR moves across a surface – hence the name "trackers.".

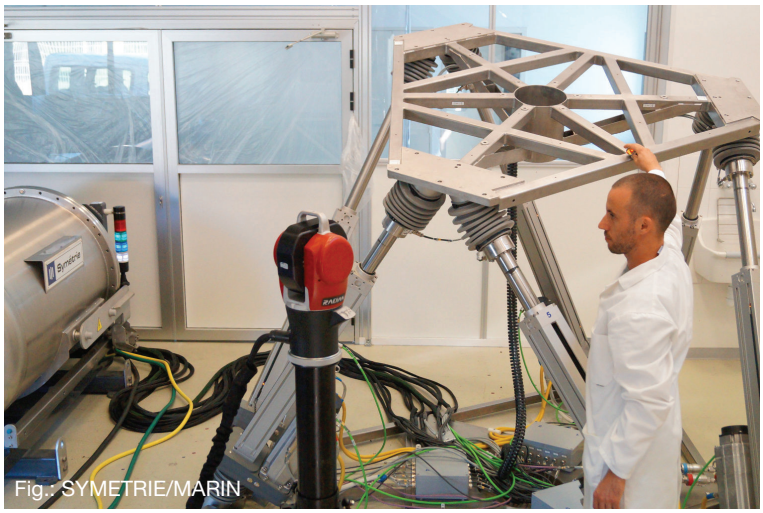
Fig.: SYMETRIE/MARIN

Measurements with a laser tracker on a hexapod suitable for negative pressure. The tracker thereby follows the target ball (in the right hand of the measurement technician); the control electronics is on the left, in the pressure cylinder.

Another tracking method is to fix the SMRs position, using a magnet, to an object that can then move freely while being tracked by the laser beam. A tripod is usually needed for the set-up, although laser trackers can be mounted directly on, or in the immediate vicinity of the object to be measured (for example, using a magnetic base). API trackers can even be mounted at a right angle or upside down from the ceiling. Standard software packages from established manufacturers are used. Customers particularly appreciate the high accuracy of laser-based measurement systems, which cannot be reached even approximately by any other mobile measurement method. The measurement volume is impressive, and, for this model, has a diameter of 160 meters. The tracker also offers a quick and efficient operation: Set-up and adjustment require only a few minutes, and only one person is needed for the operation.

Moving , testing, simulating
Less motion simulation, but lots of position accuracy: hexapods are also in demand for the testing of satellite antennas. The antennas and receiving devices are installed together in anechoic chambers for electromagnetic waves. The position of the antenna or the receiver can be changed by the hexapod robot in the open space, and the "far field" of the antenna can be calculated from the measured "near field" part using mathematical models. Similar tasks are performed by a parallel kinematic robot in the control of telescopes; more applications can also be found in the nuclear and synchrotron research, as well as in defense activities.

Radian: API Laser tracker
Radian is one of the latest generation of laser trackers. Its measurement range is 80 meters. In combination with the I-360 sensors, it is the most compact system for scanning and probing.

6DOF-Sensor I-360
Hand-held wireless sensor advantageous for tactile measuring hard to reach points and hidden structures. Also available in combination with a built-in scanner.

Fig.: API

Laser tracker and accessories: With the wireless 6D sensor can also measure points which can only be achieved by changing the position of the laser tracker.

In summary, hexapods represent an ideal solution for 6D motion simulations, thanks to their high dynamics and a simple statics. Moreover, through the parallel arrangement of their drives, they have a better ratio of payload to weight than serial robots. It can therefore be seen that hexapods are almost exclusively used in demanding test environments that require a movement simulation of this kind. Symétrie is the market leader in the field of wave simulators.

Speciality: Special solutions
For many unique applications, Symétrie needs to do more than just build the hexapod. The company, which won the Expert Group's 2007 the French Metrology Award, has its own software development department. Here, developers write programs for motion simulation and hexapod control that are not available on the market.

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Additionally, Symétrie created a cleanroom that meets ISO 7 standards for production. The testing center features several laser trackers and laser interferometers that operate on a stationary 3D coordinate measuring machine and a vacuum chamber.

These innovations allow Symétrie to introduce hexapods to a growing number of industries and applications. Ultimately, hexapods will be even more visible – even people still are not familiar with the word.

Fig.: SYMETRIE/GTT

Wave simulator for investigating the surge or slopping effects of liquid cargo.

About Symétrie

Symétrie is one of the leading companies in the market for hexapod-based solutions for precision applications and motion simulation. Founded in 2001 and based in Nimes (France), the company offers custom engineering solutions for position and attitude measurements in many industrial sectors. Geometry measurements are carried out by the company on behalf of customers, using laser trackers, laser interferometers and specialized software solutions.

The hexapod product range includes systems for various applications, from compact precision robots with submicron resolution up to motion hexapods for up to 6 tons payload. Its customers include many well-known companies in the areas of shipbuilding, aerospace, optics, automotive, medical and nuclear technology, as well as research institutes and universities. Symétrie is ISO 9001 qualified, and is authorized to perform calibrations in accordance with international standards.

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