

VALUABLE OPTICS TRANSPORTED WITH AIR-CUSHIONS

The 41-ton heavy mirror cell of the biggest telescope in the world, located in ESO Observatory, on Cerro Paranal, Chile, has to be regularly maintained. A tape-guided air-cushion system was developed for vibrationless transportation and a positioning accuracy within the telescope building as well as in the maintenance shop.

Air cushions for transportation tasks at the observatory

A telescope technology for the future

The biggest telescope in the world, the "Very Large Telescope" (VLT), is the most important technology in the new astronomical station of the European Southern Observatory (ESO), on the 2,632-meter high Cerro Paranal in Chile. The ESO was founded in 1962 to explore the skies over the south hemisphere and it is currently led by eight European countries. Astronomers are moving away to remote mountains

because light sources and increasing pollution make difficult to explore the firmament. In the eighties, the Cerro Paranal, in the middle of the Atacama desert, 600 Km to the north of Santiago (Chile) was chosen as the most suitable location for the telescope (the cost amounted to one billion DM). This is an extremely dry desert where the year has 350 clear nights and the wind is very mild.

The VLT, based on state-of-the art technology, consists of several optically linked telescopes. Its main elements consists of four altazimuth-mounted reflecting telescopes, having a primary mirror with a diameter of 8.2 m. The telescopes arrangement is trapezoidal. There are also three 1.8 m mobile telescopes. The light from the seven telescopes meet in the VLT interferometer (VLTI), this forming, a 220-m² tank for the light. This enables an optical resolution (picture quality) of 0.0005 angular seconds, which was impossible to obtain up to now.

The four telescopes, which can also be used separately, are identical. The 8,2 m mirror sets a new world record in telescope building. Mass

problems led to the development of active optics. The mirror is only 18 cm thick, which make it very flexible and it is supported by 150 hydraulic jacks so that it can keep the accuracy at 1/10000 mm of its paraboloidal surface in all positions. Each deviation of the mirror surface from the nominal shape is corrected computer-controlled through the hydraulic jack.



View of the VLT on Cerro Paranal in Chile

The metal coat of the primary mirrors has a working life of two years, which means that every six months a primary mirror has to be disassembled, re-coated and assembled again. The maintenance shop containing the metal coating bay is approximately 2 km away, at the foot of Cerro Paranal.

Inside the building, the main structure of the telescope carries and operates the telescope and the mirrors. The primary mirror, embedded in a cell made of steel, is assembled in the underside of the telescope tube. This mirror cell has a total mass of approximately 41 tons. A door at a height of 5.2 m enables to move the mirror and the mirror cell to or away from the telescope building.

The mirror cell is easily assembled and dis-assembled by using the air-cushion technology

The Delu company from Nuremberg conducted a feasibility study in 1992 in which a tape-guided transport system based on air-cushions was

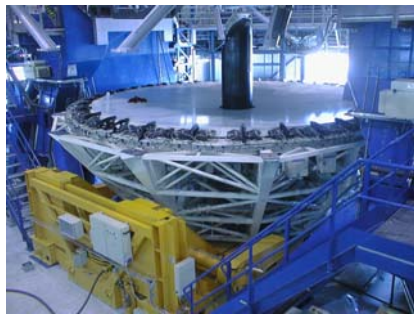
designed to carry out the assembly tasks of the mirror cell and enable transportation in the building, where the telescope is kept as well as in the metal coating bay. A mobile lifting device with a U-shaped platform overcomes the difference in height between the azimuth level in the telescope and the floor level. This device lowers and lifts the tape-guided transport system loaded with the mirror cell.

Assembling and operating the transport system

The operation of this tape-guided and remote-controlled transport system, which has maximum load capacity of 60 tons and a positioning accuracy of $\pm 1\text{mm}$, is based on the air-cushion principle. Loads are suspended on an air cushion and they can be moved in all directions and exactly positioned with very little power. There are no shakes and vibrations during transport and therefore it is possible to move securely heavy and fragile loads, like the primary mirror of the telescope. The demands on the load capacity of the floor in the telescope are lower than with conventional transport systems as the pressure is distributed over a relatively large area. The air pressure in the air cushions of the tape-guided transport system is 2 bar with the maximum load and the friction coefficient is $\mu = 0.001$. With this technique, the small overall height of this system provides a cost-effective solution, to carry out transportation.

For reasons of safety, the tape-guided transport system is automatically orientated along an optical guiding tape unit. This guiding tape unit is fixed to the floor of the telescope, the maintenance shop and the lifting device. The movements are carried out by four pneumatic friction wheel drives, which are synchronously guided by computer-controlled steering units. The friction wheel drives allow to overcome slopes up to maximum 2%. If the transport system glides off the passive guiding tape, an emergency brake is released by the on-board computer. Once the transport system has left the guiding tape it becomes omnimobile, that is, the transport system can be moved in all directions. A precision stop mechanism under the telescope tube

enables a high positioning accuracy of the tape-guided transport system and an easy assembly and disassembly of the mirror cell. A single operator controls from a portable pendant control, connected

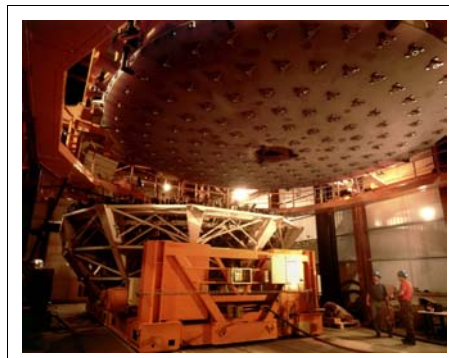


Tape-guided, remote-controlled air-cushion transport system during the positioning of the mirror cell in the telescope.

to the control unit of the tape-guided transport system by means of a cable.

The tape-guided transport system is equipped with a lifting gear to assembly and disassembly the mirror cell. A useful lifting of 1,800 mm is required. To ensure a safe assembly and disassembly of the mirror cell, the lifting system is equipped with a force-sensing device and an automatic creep gear in the upper lifting area. The tape-guided transport system is also equipped with two air-cushion running gears per each set of eight air cushions in order to avoid any steps or gaps that the transport system may find in its way from the turning and fixed parts of the telescope to the telescope building and the lifting platform. The two running gears are changed over automatically to overcome these difficulties.

A transporter was developed to carry the tape-guided transport system together with the load (total mass: vehicle and mirror cell approx. 75 tons) to the maintenance shop. A self-loading and unloading mechanism of the tape-guided transport system loads and unloads the transporter. After the transporter has carried the transport system with the load to the maintenance shop, the transport system unloads itself and glides to the room where the metal coating bay is located and there it carries out new transport and positioning tasks.



Air-cushion transport system in the maintenance shop.

Three advantages were decisive for the introduction of air-cushion technology:

-Firstly, using this transport system based on air cushions these fragile loads can be moved without any vibrations.

-Secondly, with an air-cushion running gear, the load is broadly distributed over the floor. This fact has played an important role in the static position of the main structure of the telescope.

-Thirdly, an exact positioning is possible with very little power. Because this transport system glides during assembly work, the mirror cell virtually snaps into its exact position.



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