

Stuart Clark

The discovery machine

ESO's Very Large Telescope is a vast discovery machine in the Chilean desert. Stuart Clark visited the Very Large Telescope and came back Very Impressed.

There is nothing ordinary about the VLT. Sitting on Cerro Paranal in Chile, 2,635 kilometres above sea level, it is located in one of the driest places on the Earth: the Atacama desert, in the foothills of the Andes. It is about a thirty-hour journey from England involving multiple flights and a final, gut-wrenching drive through the deep desert.

When you are at the VLT, there is nothing close by. The staff work an eight-days-on, six-days-off rota. When they are on shift, they live at the summit because they are over a hundred kilometres from the nearest city, Antofagasta, with very little in between. No water pipes, no electricity lines, no drainage run to or from the VLT. As a result, everything has to be transported in and out of the site. Every day, two tankers full of water trundle in to supply the 100 or so people that live and work on the mountain. Once a week, a tanker of diesel arrives to feed the electricity generator. That makes electricity at the VLT five times more expensive than anywhere in the rest of Chile. In total, the observatory costs two million Euros to run every month. At that price, the science has to be good.

Despite or perhaps partly because of the isolation, the VLT is the most successful observatory in the world. At least once every day, somewhere in the world, an astronomer hears that his or her research with the VLT has been reviewed by an independent astronomer and accepted for publication in one of the world's scientific journals; thus sharing that new knowledge with the astronomical community.

This phenomenal success rate – the highest of any observatory in the world – is achieved because everything at the VLT runs to strict timetables. It is a slick, impressive discovery machine. So slick, in fact, that watching the astronomers at work is something of an anticlimax. There is no time wasted at the telescopes on analysis; that is all done by

astronomers at universities and research establishments throughout the world. At the VLT, the emphasis is on collecting the best possible astronomical data.

“People often come to the observatory expecting that astronomers will be throwing their hands up in triumph at the things they see on the computer screens. That hardly ever happens. We must stay calm in order to deliver the very best observations that we can to the astronomers waiting at home. All the people who work here are calm people; we choose them partly because of that. It is very important to us,” says Andres Kaufer, the director of the Paranal Observatory.

Indeed, in the first few hours of the night that I was at the VLT, the scheduled observations were interrupted twice, once for a supernova and once for a gamma-ray burst. However, you would never know it. All is calm and quiet. This is business as usual for the discovery machine.

One time when this calm demeanour probably did break was when an ESO astronomer took the first actual image of a planet outside our Solar System. Now, the astronomer Gaël Chauvin only admits to being surprised, but his eyes light up when he tells the story.

He was running a programme on UT4 (although each telescope has a name, the astronomers and engineers still refer to them as UT for unit telescope, followed by a number) to test the capability of the VLT to the limit. He knew it was a long shot; nevertheless Chauvin was looking for planets. To stand any hope of success, the telescope and camera system had to de-twinkle the stars by analysing the atmosphere and deforming a small mirror to compensate for the soupy turbulence in the air's upper layers; a process known as adaptive optics.

The survey had been going well from a technological point of view but scientifically, it was less than thrilling. Chauvin had observed 150 stars but had yet to see a planet. When the telescope centred on star 2M1207, Chauvin hit the button to switch the adaptive optics on. “It was amazing. When we closed the adaptive optics loop, this small bump of light just appeared,” he says with a smile.

Since then, his success rate has grown. He has seen planets around the stars AB Pictoris and GQ Lupi. These are almost certainly gas giant planets similar to Jupiter in

our own Solar System. “We are just at the beginning. These were a surprise because people did not really believe we would see planets with the VLT,” says Chauvin.

The search will continue and Chauvin looks forward to the day when they can analyse the atmospheres of these distant giant worlds.

Day teams

During the daytime, the telescopes are the responsibility of the engineers. This is the time when maintenance and repairs are carried out. During the visit, one of the mirror supports on UT2 had been found leaking oil and needed replacing. Engineers were hanging in the framework underneath the mirror, carefully extracting the faulty part and fitting the replacement. The mirrors are held by sixty-four of these supports, which hold the flexible mirror in a precise shape, no matter where in the sky the telescope is pointing.

By 5:30pm, the repair was done and it was time for the engineers to complete their last task of the day. They open the telescopes before handing them over to the astronomers. First the telescope is tilted over, coming to rest just twenty degrees from the horizon. This minimizes the possibility of something falling from the opening roof and hitting the mirror.

“If one of the primary mirrors were to break, I don’t know what we would do,” says Kaufer, shaking his head. There is no spare primary mirror and the purpose-built facility outside Paris to make the four VLT mirrors has long since been disassembled.

As the enclosure doors part, the eastern twilight seeps into the dome. Bathed in the violet light, the telescope begins to twist upright. It moves almost silently, making the whole operation seem graceful. But it is when the engineers open the wind vents that the true spectacle begins. Dozens of louvred shutters slowly open all around. The red light of the setting Sun in the west fills the cracks, as the louvres open more, everything turns golden orange.

Beneath the platform I was standing on, whole panels of what looked like solid walls slide away, revealing the enclosure’s skeleton and the gentlest of breezes begins to waft through the dome. “We must keep the air flowing across the telescope at all times,” says Kaufer. This is because in totally still air, even the slightest movement can set up turbulence, which distorts the image quality. So the louvres are controlled according to

the wind conditions on the summit, to let a steady breeze of air through the telescope, enough to sweep away any turbulence and protect the image quality. As soon as the Sun has gone from the sky, it is time to set the telescopes to work for real.

The cloud deck sits well below the VLT's dynamite-blasted plateau. It stretches unmoving into the distance and gives the illusion of a frozen ocean, its breakers stilled in mid-roll. As the last rays of the Sun slip below this horizon, the behemoth Keuyen comes to life. The dome rotates with quiet force and a mechanical breathing noise permeates the cooler air.

"It is the cryogenics system," said Gonzalo Argandona, ESO's press officer in Chile. Water is pumped through the hollow metal framework of the telescope to keep it at a degree or two below the air temperature. Again, this protects the image quality. "The engineers and telescope controllers listen for that sound to tell them that everything is alright with the telescope," he added.

One by one the stars come out. The telescope is now ready to perform science. In the control room, the astronomers are arriving. Tonight the four telescopes will work independently although there are efforts to combine the telescopes into a single instrument that simulates a 100-metre-diameter mirror. Most of the observations on the VLT are performed in what's called service mode. This means that the astronomer who requests the observations does not actually visit the telescope to make them. Instead, two dedicated staff members control each telescope: the telescope and instrument scientist (TIO) and the night astronomer. As the name suggests, the TIO controls the telescope and the instruments. There are three instruments on each telescope, all permanently mounted. One sits on the back of the telescope, behind the primary mirror. The other two sit on the platforms, either side of where the telescope pivots. Each telescope has a different set of instruments, giving each their unique areas of capability.

The Night Astronomer is responsible for which observations are performed and in which order, from the set of approved programmes. They must have the knowledge to understand the purpose of the observation and how best to achieve it. It is not uncommon for the Night Astronomer to abandon a planned sequence of observations if the weather conditions change throughout the night. For example, nights of extreme stability in the atmosphere are best suited to taking finely detailed images of celestial objects.

Spectroscopy, on the other hand, where you are simply interested in collecting the encoded information within the light, does not need such stable conditions. As conditions change throughout the night, the Night Astronomers for each telescope unit decide which observations they can best achieve. They then take charge of quality controlling them afterwards so they know whether that target can be ticked off the list or if the observations need repeating.

Sometimes the decision is taken out of the Night Astronomer's hands, for instance when a supernova or gamma-ray burst explodes. Then the telescope with the correct instrument must stop what it is doing at once and move to observe the fleeting explosion before it fades from view. There is also a rapid response mode, in which control of the telescope is temporarily handed to authorised astronomers throughout the world, so that they can quickly acquire strongly variable targets.

Because the astronomers who apply for VLT time have to rely on the TIOs and Night Astronomers to take their data for them, there is a strict confidentiality maintained in the control room. So I can ask nothing about the science behind the observations being made. Even this close – in the actual control room – I'm still like a child with my nose pressed against the sweetshop window.

Next month, in part two of this series, Stuart Clark charts the future for the ESO optical telescopes, including a look at the proposals for a 42-metre telescope.

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Visting the VLT

It is now possible for anyone to visit Cerro Paranal and even walk on the platform where the domes are located. The tours take place on Saturdays when groups typically reach 80 people and sometimes more. Places must be booked in advance via the web site (www.eso.org/paranal/site/visitors/tourist/html). Tourists are responsible for getting themselves to the site, which does require a two-hour drive from Antofagasta through the desert with nothing en route, so make sure you have enough petrol and water. You will be taken to the visitors' centre, where the history, construction and science of the VLT are

explained. Then you will tour the control room and finally be taken onto the platform, to stand between the domes and soak up the atmosphere. Access inside the domes, however, is not yet possible for tourist visits.

Home away from home

There is nothing more welcoming than the atrium of the Paranal residencia. After a gruelling two-hour ride across the desert, climbing all the time into the more rarefied air, the residencia itself is at first conspicuous by its absence. I am led down a slope towards a wide doorway in the ground. As I step inside, I feel I have crossed into a sci-fi film or a misplaced Center Parcs. Tropical planets rise from a central pit as a wide curving path leads around them to the reception desk. I can hear water. The very last thing I expected in this arid land. I follow the sound and find myself peering over the tree-lined balcony into a swimming pool.

“I chose water to be the central theme of the residencia because it is the one thing the desert doesn’t have,” says Massimo Tarenghi, who oversaw the construction of the VLT and its 12 million Euro residencia.

In the seating area near the main desk are specially made rugs, each depicting one of the first images taken by the VLT. Yet this astonishing oasis is not profligate; the walls are concrete without cladding. A pigment in the mix gives them the same Mars-red colour as the surrounding desert, so that they do not require painting.

The residencia is built into the hillside, looking out over the Andean foothills and provides a home for all the workers when they are on shift at the mountaintop. I stayed there just one night but, with the internet access, good food and good company the location affords, it was hard to believe that we were surrounded by nothing but desert.