OBSERVATORY SCIENCES LTD

DISCOVERY

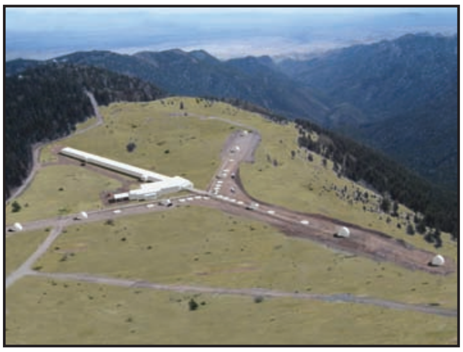
BIG SCIENCE SOLUTIONS SPRING 2010

Delivering EPICS training to ITER Observatory Sciences consultants have delivered EPICS training to the CODAC (COntrol, Data Access and Communication) Group at ITER international fusion project in Southern France. **Page 2**

Next generation telescopes race to first light The three largest telescopes ever to be built are racing to completion. These telescopes are many times larger than the previous generation, holding the potential to open up a new window on the universe. **Page 4**

CONTROL SOFTWARE TESTED FOR MULTI-TELESCOPE ARRAY

Observatory Sciences consultants have carried out factory tests using their control system software on the first of a series of telescopes for the Magdalena Ridge Observatory, New Mexico.



The telescopes will form an interferometry array (MROI) that will combine the light beams from several telescopes to produce ultra high resolution images. The initial phase of the project is the construction of the first of these telescopes. The contract for its manufacture was awarded to Belgian telescope manufacturer AMOS, working in partnership with Observatory Sciences to produce the control system.

The first telescope has now been constructed, and tests in the AMOS factory in Liege, Belgium were performed by Observatory Sciences consultants Alan Greer and Chris Mayer last November. The telescope's control system has been produced by Observatory Sciences using the LabVIEW graphical programming language from National Instruments, incorporating positional astronomy and telescope pointing software supplied under licence from Tpoint. The factory tests used this software to point, slew and track the telescope.

Fully automated

The final tests verified that the full sequence of powering the drives, homing and engaging the axes could be fully automated by the telescope control system. The drive system itself is controlled by a Delta Tau UMAC motion controller. The MROI array is planned to comprise up to ten 1.4m diameter telescopes in an equilateral "Y" shape array, operating in the optical and near-infrared, to provide imaging capabilities with sub-milliarcsecond resolution.

CONTROLLERS PUT PHYSICS IN MOTION

One of the most common requirements for our projects, whether it is for an astronomical or a high-energy physics application, is software for motion control. Optical telescopes have demanding requirements for precise and synchronised motion control of the telescope mount, whilst most high-energy physics facilities incorporate large numbers of motion axes that are used to position and move experimental equipment.

OSL offers EPICS software embedded in Delta Tau's GeoBrick LV-PC, to enable plug-and-play EPICS software integration

Software engineers from Observatory Sciences have been involved in motion control applications for many years, with a lot of experience gained with the Delta-Tau PMAC (Programmable Multi Axis Controller). Back in the 1990s, PMAC controllers were adopted by the Gemini telescope project to control the elevation and azimuth axes of the twin 8m telescopes. OSL consultant Andy Foster worked to integrate them with the EPICS software framework that was used throughout the Gemini control system.

Andy's work included enhancing the EPICS driver software to support Fast Data Logging on the PMAC itself, at the 2kHz servo rate. This proved extremely useful in commissioning where the data was fed into Matlab for 'on-the-spot' analysis of problems and help with servo tuning.

The Gemini systems used a VMEbus interface for their PMAC systems, with software running under the Wind River vxWorks real-time operating system. More recently, large experimental control systems have begun to use the Linux operating system and the Australian Synchrotron Project has adopted EPICS with Linux as their software platform. German beamline supplier Accel has supplied several beamlines to the Australian Synchrotron and Observatory Sciences worked with them to produce a Linux driver for the Delta Tau PMAC2 Ultralite motion controller card. This driver is **Continued on page 4**

OBSERVATORY SCIENCES DELIVERS EPICS TRAINING TO ITER

Summer 2009 saw Observatory Sciences consultants delivering EPICS training to the CODAC (COntrol, Data Access and Communication) Group at ITER in Southern France.

ITER is a major international research and engineering project intended to prove the viability of fusion as an energy source, and to collect the data necessary for the design and subsequent operation of the first electricity-producing fusion power plant.

Launched as an idea for international collaboration in 1985, the ITER Agreement includes China, the European Union, India, Japan, Korea, Russia and the United States, representing over half of the world's population. It will be the world's biggest research project, with a budget of more than 10 billion Euros that will see the construction of a working Tokamak – the best design for producing fusion power. The complex ITER Tokamak system will be nearly 30m tall and weigh 23,000 tonnes. In choosing EPICS for the software environment used to build the ITER control system, the CODAC team made what it describes as "a safe, conservative choice."

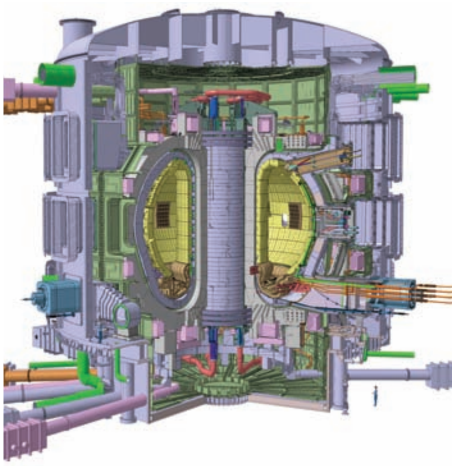
OSL consultants delivering EPICS training course at ITER

Observatory Sciences Director Philip Taylor comments: "The EPICS community is delighted by the ITER decision. EPICS is an established software architecture that is well-proven and reliable, and where they could be assured of input and feedback from a large community of existing users, and which could be readily tailored to their own requirements."

Important milestone

The ITER project is situated on 180 hectares of land in St. Paul-lez-Durance, a commune in the Provence region of Southern France, adjacent to the existing French nuclear research centre at CEA Caderache. Site preparation began in January 2007, representing the first important milestone in the ten year-long construction process.

Assembly of the Tokamak is due to start in 2013 for completion four years later, with first plasma scheduled for 2018. The operational phase is expected to last for 20 years. First a several-year "shakedown" period of operation with pure Hydrogen will be run during which the machine will remain accessible for repairs, in order to test the most promising physics regimes. This will be followed by operation in Deuterium with a small amount of Tritium to test shielding provisions. Finally, scientists will launch a third phase with increasingly frequent full operation with an equal mixture of Deuterium and Tritium, at full fusion power.



With a height of 29m and a diameter of 28m, ITER will be the world's largest tokamak. © ITER Organization

But ITER is not an end in itself: it is the bridge toward a first plant that will demonstrate the large-scale production of electrical power and Tritium fuel self-sufficiency. This is the next step after ITER: the Demonstration Power Plant, or DEMO for short. A conceptual design for such a machine could be complete by 2017. If all goes well, DEMO will lead fusion into its industrial era, beginning operations in the early 2030s, and putting fusion power into the grid as early as 2040.

EPICS PIONEERS REWARDED AT ICALEPCS

Andy Foster and Aya Yoshimura from Observatory Sciences both attended the International Conference on Accelerator and Large Experimental Physics Control Systems (ICALEPCS) in Japan in October 2009.

A highlight of the conference was the presentation of the ICALEPCS Lifetime Achievement Award to Marty Kraimer, Bob Dalesio and Jeff Hill, who pioneered the development of the EPICS control system that now underpins virtually every major physics project. In addition to their technical achievement, these three have worked tirelessly to foster the spirit of collaboration that has been vital to the success of EPICS. "This was a just reward for these individuals who have been so critical in the success of EPICS, which has now become the de-facto standard for accelerators and large experimental physics control systems," comments Foster.

Global recognition

Since its beginning as a two-project collaboration in 1989, EPICS has become globally recognised as a capable, robust, and extensible control system infrastructure for a wide range of projects. It is used on hundreds of projects, including accelerators, tokomaks, telescopes and others, in over seventeen countries. Observatory Sciences is a leading supplier of EPICS expertise, creating bespoke control systems and delivering EPICS training to help users make the best use of its features.

The next conference on the Observatory Sciences agenda is SPIE Astronomical Telescopes and Instrumentation, running from 27 June to 2 July 2010 in San Diego, California, USA. Observatory Sciences is contributing to a number of the papers at this conference, including ones on the VISTA and Discovery Channel Telescopes. We are looking forward to meeting new clients as well as old friends.

Observatory Sciences provides full project management and support services for public and private sector clients. This can reduce the learning curve at project implementation and achieve crucial savings in time and manpower.

- Design and development of instrument and equipment control software
- Technical reviews and studies of software solutions
- Training and skills transfer
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- Procurement and integration
- Facilities management and operation
- Software commissioning and support
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VISTA TELESCOPE NOW OPERATIONAL IN CHILE

December 2009 saw the acceptance by ESO of the completed VISTA telescope situated at Cerro Paranal in Chile's Atacama Desert.

VISTA, the Visible and Infrared Survey Telescope for Astronomy, is the largest and most powerful telescope yet built for surveying the sky using infrared light, able to survey large regions of the southern sky to levels 10-100 times fainter than previous surveys. VISTA was developed and built by a consortium of 18 British universities at a cost of some £37 million, with a primary mirror control system designed and implemented by Observatory Sciences.

Earlier in the year, Observatory Sciences consultants Alastair Borrowman and Alan Greer helped with final commissioning of VISTA's secondary mirror. The results from wavefront sensors near the telescope's focal plane are used to adjust the position, tip and tilt of the secondary mirror by sending signals to the hexapod secondary mirror support system.

Primary mirror control system

Back in 2004, Observatory Sciences produced the software for VISTA's primary mirror control system, which was produced using ESO's VLT Common Software. It is used to adjust the position and shape of VISTA's 4.1m diameter primary mirror. The primary mirror control system consists of a set of 84 supports which apply varying forces during changing conditions. These include different telescope positions and wind gusts as well as gravity. As the telescope changes position, so the loads on the primary mirror alter.

This first image to be released publicly from VISTA shows the spectacular star-forming region known as the Flame Nebula, or NGC 2024, in the constellation of Orion

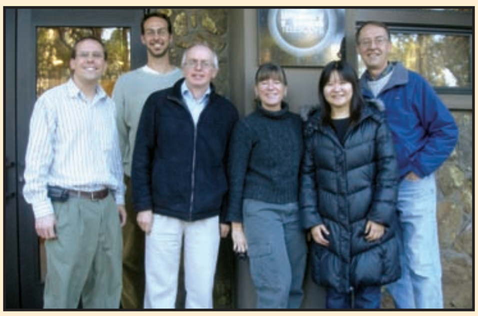
The software calculates the forces to be applied by the active supports at a rate of up to 50 times a second, to compensate for the ongoing changes and ensure that the mirror maintains optimal shape for best possible image quality at all times.

The formal acceptance of the telescope by ESO also saw the release of the first pictures from the telescope, revealing spectacular views of the Milky Way and distant galaxies. Scientists and researchers will now be looking forward to getting down to the serious work of understanding the nature, distribution and origin of known types of stars and galaxies, and unravelling the mysteries of 'dark energy' and 'dark matter'.

DCT SOFTWARE FINAL ACCEPTANCE TESTING

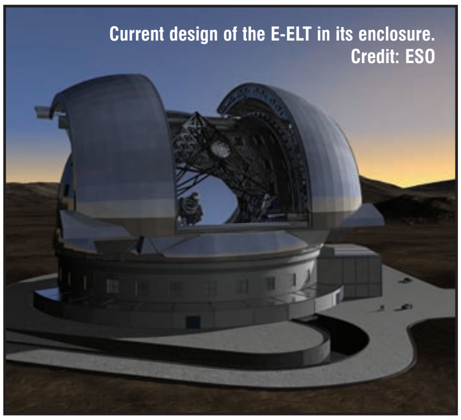
December 2009 saw Observatory Sciences consultants Philip Taylor, Aya Yoshimura and Alastair Borrowman at the Discovery Channel Telescope headquarters in Flagstaff, Arizona for final acceptance testing of the telescope control system. The tests were completed successfully and the team involved in the tests is pictured outside the DCT building.

The key requirements for the telescope control system were that it should build on existing platforms to ensure a cost-effective design with the most readily available support. This led to the adoption of National Instruments LabVIEW software throughout the DCT control system, as well as for the telescope control system itself. "LabVIEW is becoming widely adopted for telescope control systems," says Taylor. "The strength of the graphical front end provides a means for rapid production at the user interface level, and the readily available support, simple incorporation of existing algorithms in almost any language, and the ease of interfacing hardware from different vendors mean that it is becoming increasingly popular for control systems."



The software delivered by OSL also incorporated astrometric, pointing test and pointing kernel software supplied by Pat Wallace (Tpoint Software). This state-of-the-art telescope pointing software is supplied by OSL under a licensing agreement with Tpoint.

NEXT GENERATION TELESCOPES RACE TO FIRST LIGHT



Current design of the E-ELT in its enclosure. Credit: ESO

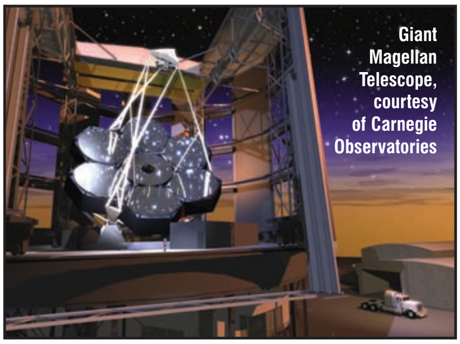
The three largest telescopes ever to be built are racing each other to completion. The heat is on not only to be first to pull back the curtain on some of the universe's most closely guarded secrets, but also to prove which of the designs is the best.

These new telescopes are many times larger than the previous generation, and so hold the potential to open up a whole new window on the universe. The smallest of the three is the Giant Magellan Telescope (GMT). With a cost estimated at US$650 million, it's scheduled to be built at Las Campanas Observatory in Chile.

The GMT design requires seven, 8.4m honeycomb mirrors to be mounted together to form the primary. The mirrors will be mechanically very stiff, and because of their largely hollow structure they'll be relatively light. The first mirror was cast in a rotating furnace at the Steward Observatory, Arizona, in November 2005, with the long process of figuring and polishing due to be completed during 2010.

Next in size, with a 30m diameter primary mirror, comes the Thirty Metre Telescope (TMT). In July 2009, the TMT Observatory Corporation selected Mauna Kea on the Big Island of Hawaii as its preferred construction site. The anticipated build cost is estimated at US$760 million in 2006 dollars, and the TMT project has now entered the early construction phase thanks to a $200 million pledge from the Gordon and Betty Moore Foundation.

Largest of them all, though, is the European Extremely Large Telescope (E-ELT) with a



Giant Magellan Telescope, courtesy of Carnegie Observatories

massive 42m diameter primary mirror. E-ELT, projected to cost 950 million Euros, or about US$1.3 billion, will be built by the European Southern Observatory. A report to ESO Council in March 2010 concluded that Cerro Armazones in Chile stands out as the preferred site. The telescope project is currently reaching the end of design Phase B, having received 57 million Euros in funding for detailed design and prototyping. The decision to build is expected by late 2010.

Segmented mirrors

Both E-ELT and TMT are being designed similarly with thin, segmented mirrors arrayed as a contiguous primary mirror. The 42m primary mirror of the E-ELT will be composed of 984 segments, whereas the 30m primary for TMT will comprise 492 segments. The optical design of the E-ELT also calls for an immense secondary mirror 6m in diameter, almost as large as the biggest primary telescope mirrors in operation today. Adaptive mirrors are incorporated into the optics of the telescope to compensate for the fuzziness in the stellar images introduced by atmospheric turbulence. A special correcting mirror in the telescope is supported by more than 5000 actuators that can distort its shape a thousand times per second.

OSL has been involved with the design studies for the telescope control system for the E-ELT since 2007 and has recently completed a third study which was to design a software framework that will be used to build the telescope's control systems. A set of software services is proposed that would be implemented using the standard Data Distribution Service (DDS) software which is ideally suited for the rapid transfer of large amounts of control data to the distributed systems that will control the E-ELT.

While size isn't everything, there is no doubt that a larger mirror can collect more light and resolve more detailed images. There is good reason, then, to build a mirror as large as is technically and economically possible. But the mirror diameter also impacts on the size and complexity of almost every related system. Further, with a larger mirror size come bigger problems in compensating for the effects of wind, atmospheric turbulence and any ground-based tremors.

All three telescopes are variously scheduled for completion between 2016 and 2018, but there is undoubtedly competition between them to be up and running first. Many technical, political and financial hurdles remain, not least of which is that none of the projects is yet fully funded.

PUTTING PHYSICS IN MOTION

Continued from page 1

available as open-source software and can be downloaded from the OSL website.

At the Diamond Light Source in the UK, 800 motion axes will be installed using Delta Tau controllers to control components in the second phase of synchrotron beamlines. These complement 700 already installed in Phase I. OSL has worked with Delta Tau PMAC systems throughout the Diamond control system, with beamline commissioning and enhancement work being performed by OSL consultants based at DLS. OSL also worked with the UK companies Delta Tau and Micromech in the successful bid to supply Diamond with Delta Tau's next generation of PMAC motion controller. The Delta Tau GeoBrick LV was designed especially for Diamond and can control up to eight axes of mixed servo and stepping motor types. The latest development of this system has seen OSL produce EPICS software embedded in the GeoBrick LV-PC, to enable plug-and-play EPICS software integration.