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DISCOVERY

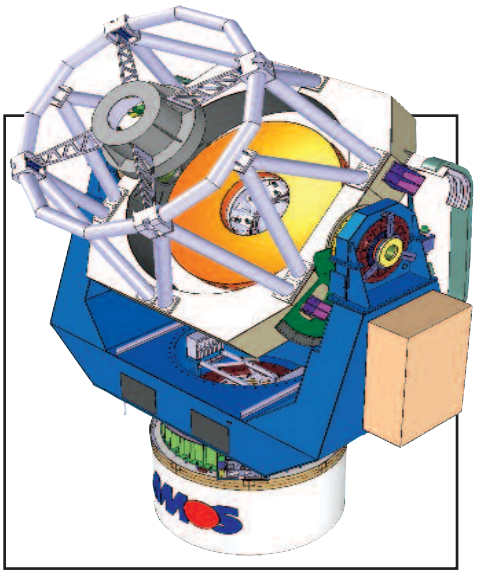
BIG SCIENCE SOLUTIONS SPRING 2012

Gemini's adaptive optics The Gemini Multi-conjugate adaptive optics system (GeMS) was developed to provide wide field imaging at extremely high resolution over an area of sky ten times larger than that covered by any comparable adaptive optics system. **Page 2**

ATST enclosure control system At SPIE 2012, Alastair Borrowman will present a paper discussing the benefits of using commercial-off-the-shelf (COTS) software for control of the Advanced Technology Solar Telescope (ATST) enclosure. **Page 3**

WIDE-SKY TELESCOPE GETS MULTI-FUNCTION CONTROLS

Observatory Sciences has been contracted to provide the control system for a 2.5m wide-field survey telescope based in Spain



The construction of the T250 telescope called for an innovative design that would address the technical challenge of a large aperture of 2.5m combined with a wide field of view of 3 degrees.

The T250 telescope is being built by AMOS in Belgium for the OAJ (Observatorio Astrofisico de Javalambre). Together with its smaller sister T80 telescope, the T250 will provide Spain with state of the art facilities for wide area astrophysical surveys.

The facility will be used by the Javalambre Physics of the Accelerating Universe Astrophysical Survey (J-PAS) to map the observable universe in 56 colours. This multi-purpose astronomical survey will observe more than 8000 square degrees, about a fifth of the whole sky, mapping stars, galaxies, supernovas, quasars and solar system objects with extreme accuracy.

The construction of the T250 telescope called for an innovative design that would address the technical challenge of a large aperture of 2.5m combined with a wide field of view of 3 degrees. To meet these requirements, the telescope is built around a Ritchey-Chretien-like design, equipped with a field corrector and de-rotator. The focal plan corresponds to a Cassegrain layout, and the M1 and M2 mirrors have hyperbolic aspheric surfaces.

The telescope is equipped with a field corrector which is located beyond the central hole of M1. It consists of three lenses of fused silica with four aspheric surfaces and diameters in the range 500 – 600mm. The two mirrors and the three lenses are designed to optimise the polychromatic image quality and maintain a low distortion over the entire field of view.

Because of its fast optics, the T250 is a very compact telescope, with a height of about 6.5m and an outer diameter of 5m. It will weigh around 40 tonnes. The telescope will use a large 1 gigapixel camera, being built by E2V, Chelmsford. E2V is a leader in telescope imaging devices, with the likes of the Hubble Space Telescope and Gaia, an ESA mission to record over one billion stars, among its projects.

The gigapixel camera for the T250 will use 14 newly developed E2V CCD290-99 high performance imaging sensors. The 85 megapixel devices will be back-thinned and given a multi-layer, anti-reflection coating for maximum sensitivity. They are a 9k x 9k pixel format, with multiple outputs for rapid readout times, and are mounted in a precision package to allow them to be assembled into a mosaic, providing an image area that is nearly 0.5m in

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COMMISSIONING OF THE DCT TO BEGIN THIS YEAR

This year will see the commissioning of the Discovery Channel Telescope, with first light scheduled for May. February saw the testing of the performance of the primary mirror and active optics system, while the secondary mirror – the last major component to be delivered – was installed in January. The Discovery Channel Telescope (DCT) is among the most technically sophisticated ground-based telescopes of its size, with many advanced features which will optimise its performance. Observatory Sciences produced the telescope control software, built on National Instruments LabVIEW and incorporating state-of-the-art pointing software, supplied by OSL under a licencing agreement with Tpoint.

The DCT's Telescope Control System (TCS) generates position and velocity demands for the mount and rotator axes to position the target accurately at a point in the

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GEMINI SOUTH'S ADAPTIVE OPTICS TAKE IMAGING TO NEW HEIGHTS

December saw the Gemini South telescope in Chile produce its first ultra-sharp, wide-field image, the highest angular resolution and widest field of view ever captured from the ground

The crispness of the image of a dense globular cluster of stars called NGC 288 highlights the potential of the revolutionary adaptive optics system in the Gemini South telescope in Chile, which will now provide astronomers with a powerful tool for the study of astronomical phenomena from black holes at the centres of galaxies to the life histories of stars.

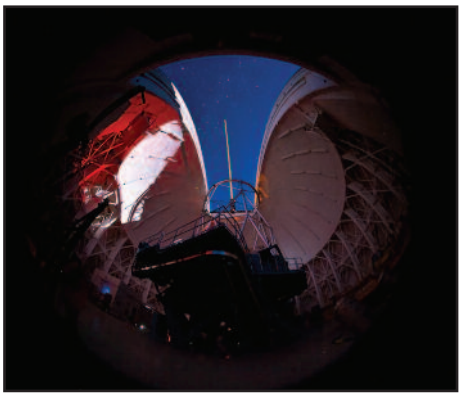
The Gemini Multi-conjugate adaptive optics System (GeMS) was developed to provide wide field imaging at extremely high resolution over an area of sky ten times larger than that covered by any other comparable adaptive optics system. GeMS compensates for the effects of rapidly changing distortions due to atmospheric turbulence by sampling the turbulence and constructing a model of how the atmosphere is distorting the starlight. Laser guide stars produce an artificial reference star high in the atmosphere. By using several laser guide stars and several deformable mirrors, the system can provide uniform image compensation.

GeMS provides a way forward for adaptive optics on the very large telescopes of the future now being planned. The goals of these giant telescopes will be achieved only if they are coupled with efficient adaptive optics systems allowing them to actually achieve their unprecedented angular resolution.

Observatory Sciences staff have been involved with the Gemini adaptive optics project from the earliest stages of its development, producing the control software for four of the subsystems that make up the GeMS system. These include: the beam transfer optics (BTO) system, which launches the laser beam; the beam transfer optics diagnostics sensor system, which provides BTO mirror corrections; the GeMS slow focus wavefront sensor which computes the slowly varying focus corrections from a natural guide star that the laser guide star (LGS) cannot provide; and the adaptive optics module (Canopus), which contains all the optics and sensors to compensate the input beam and relay it to the instrument.

Observatory Sciences also provided on-site effort in Australia to complete and commission the control software for the Gemini South Adaptive Optics Imager (GSAOI) which captured the first GeMS images.

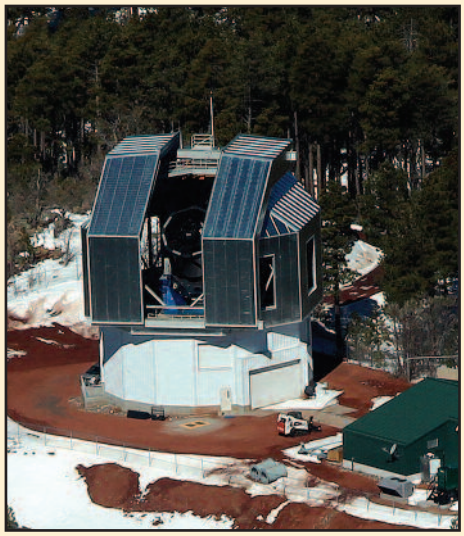
In February 2011 OSL consultant Philip Taylor visited Chile to work on a further development of GeMS: the laser bench beam stabilisation (LBBS) system. The LBBS is a fast tip-tilt mirror control system which runs a closed loop servo at 100Hz. Feedback information to stabilise the laser beam is provided by a spot position detector. The control software was written by Observatory Sciences. In addition,



Fish eye view of the Gemini South laser propagating into the zenith during the first night of on-sky laser operations

Observatory Sciences consultants Chris Mayer and Andy Foster can trace their involvement with the Gemini project back to the 1990s, when they worked on the commissioning of the telescopes and on through a succession of new projects, upgrades and redevelopments.

Gemini is an international project centred around twin 8.1m reflecting telescopes – Gemini North in Hawaii and Gemini South in Chile, which together provide complete sky coverage. Software development work on these two telescopes was performed at Observatory Sciences' UK base, using computer simulation of the telescopes' facilities where necessary. As part of its responsibilities, Observatory Sciences developed the software to control both telescopes. This involved the integration and testing of several subsystems to meet the original design requirements.



DISCOVERY CHANNEL TELESCOPE

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image plane. The TCS also outputs expected guide and wavefront sensor target positions, as well as atmospheric dispersion correction demands. The TCS incorporates feedback including measured guide target corrections, secondary mirror position and weather data as inputs to its pointing model.

The TCS comprises four main components: a communication interface, a graphical user interface, the astrometric kernel (comprising the pointing model and transformation algorithms) and a hardware interface which outputs demands in the form required by the axis controllers.

Projects for the Discovery Channel Telescope include a survey of the composition of Kuiper Belt objects and surveys of the little-explored distant Solar System

Early results at the DCT suggest the full Ritchey-Chretien system is working extremely well. Image quality of 1 arc second has been achieved in testing of the mount pointing model and telescope control system. Except for some minor problems, star acquisition has been reliable and tracking steady.

The Discovery TV Channel plans to air its first major feature on the DCT in June this year.

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.

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COST-EFFECTIVE SOLUTION FOR TELESCOPE CONTROL

Reduced costs and accelerated development are key benefits of using commercial-off-the-shelf software for telescope control

The SPIE Astronomical Telescopes and Instrumentation conference is coming to Amsterdam in July 2012. Alastair Borrowman of Observatory Sciences will be presenting a paper discussing the benefits of using commercial-off-the-shelf (COTS) software for control of the Advanced Technology Solar Telescope (ATST) enclosure, to be constructed at Haleakala on the island of Maui, Hawaii.

As Programmable Logic Controllers (PLCs) evolve from simple logical controllers into more capable Programmable Automation Controllers (PACs), scientific facilities are making increasing use of such devices to control complex mechanisms. Observatory Sciences has incorporated COTS software into the ATST's Common Services Framework (CSF) software infrastructure to enable high-level control of hardware through a PAC. The paper presented at SPIE will describe the Enclosure Control System (ECS) currently under development by OSL in the UK and by IDOM in Spain, detailing the selection and use of the PLCIO communication library from Commercial Timesharing Inc.

The library is implemented in C and delivered with source code. It separates the programmer from the controller's communication details through a simple Applications Programming Interface (API). Capable of communicating with many types of PACs/PLCs (including Allen-Bradley and Siemens) the API remains the same irrespective of the controller in use. The ECS is implemented in Java

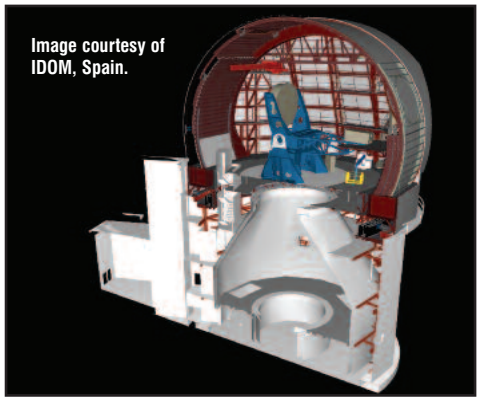

Image courtesy of IDOM, Spain.

using the observatory's framework running on Linux. The link between Java and the PLCIO C library is provided by a thin Java Native Interface (JNI) layer.

To provide enhanced software testing capabilities prior to hardware becoming available, a software PAC simulator has been developed based upon the PLCIO's Virtual PLC. This creates a simulator operating inside PLCIO and therefore below the level of the library's API. In this way the ECS uses the same software and operates in the same manner irrespective of whether it is connected to the real or simulated PAC, ensuring software using during testing is always the software used in operations.

Communication timing test data illustrates that the use of CSF, JNI and PLCIO provides a control system capable of controlling enclosure tracking mechanisms, and that would be equally valid for telescope mount control.

SEE YOU AT SPIE IN AMSTERDAM

SPIE Astronomical Telescopes and Instrumentation is the world's largest astronomical telescopes and instrumentation conference, with an associated exhibition program. Held every two years, it is a must-visit event, attracting over 1500 delegates. The exhibition will be open from July 2-4th and Observatory Sciences will have a stand (number 226), as will our colleagues from AMOS, Delta Tau UK, General Dynamics SATCOM Technologies (GDST) and IDOM. We'd be delighted to welcome you on to our stand to discuss any project requirements.

SPANISH TELESCOPE CONTROL

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diameter. The focal plane assembly will also include the telescope guide and wavefront sensors. The whole focal plane will then be contained in a custom cryogenic camera, with vacuum and cooling components and integrated electronics which will provide state-of-the-art low noise for maximum sensitivity.

Observatory Sciences will provide the telescope control system which will co-ordinate several subsystems including the secondary mirror hexapod motion control, the telescope dome, the guiding system and a wavefront sensor system used to monitor and improve the image quality. The guiding system will incorporate four CCDs at the corners of the telescope field of view which will be used to monitor the position of guide stars. This technique will allow automatic correction of the elevation, azimuth and rotation axes positions.

Designed, manufactured, assembled and tested in AMOS premises in Belgium, the T250 is scheduled for delivery to CEFCA (Center for the Study of Physics of the Cosmos of Aragon) in Teruel Aragon later this year. The 2.55m mirror will be completely manufactured in-house, and will represent the largest mirror ever polished at AMOS.

LSST NOW 'NUMBER ONE PRIORITY' IN USA FOR GROUND-BASED ASTRONOMY

Google has joined a group of 36 universities and national labs that are building the Large Synoptic Survey Telescope, now officially the priority project for ground-based astronomy in the USA

Scheduled to begin operations toward the end of this decade, the 8.4m Large Synoptic Survey Telescope LSST will be able to survey the entire visible sky deeply in multiple colours every week with its three-billion pixel digital camera.

The computational challenges addressed by LSST are of interest to a number of technology and software companies including Google, who have been members of the LSST for over five years. Google's involvement in the collaboration includes providing advice on the massive ingestion of information from the LSST, on the processing and analysing the continuous data streams in a 24/7 fault tolerant manner, and on managing large parallel data systems. Google is expected to play a significant role in making the LSST data and new discoveries coming out of LSST available to the public rapidly and broadly. Multiple teams of professional scientists will be able to make new discoveries in parallel, while amateur astronomers and the public will be free to view LSST images to follow developments or even make their own contributions.

During 2011, initial site leveling of the telescope site on Cerro Pachón in Chile was completed, shortening the summit by nine vertical metres and removing approximately 19,000 cubic metres of rock and earth.

In 2006, Observatory Sciences produced a design study of the observatory control system software for the LSST. Headquartered in Arizona, USA, the LSST is a revolutionary new


Image courtesy of LSST Corporation

design of telescope that has a field of view 1000 times larger than that of existing large telescopes and a world-class light gathering capability. The LSST will image an area of the sky roughly 50 times that of the full moon every 15 seconds, opening a movie-like window on objects that change or move on rapid time scales. Using the light-bending gravity of dark matter, the LSST will chart the history of the expansion of the universe and probe the mysterious nature of dark energy.

NEW BEAMLINE AT DIAMOND

The control equipment integration and commissioning work by Observatory Sciences consultant Andy Foster at the Diamond Light Source synchrotron saw the First branch line of the new I13 beamline available to first users late in 2011 for coherence related experiments. I13 is one of the final Phase II beamlines to go into operation at Diamond. Work is well underway to complete Phase III by 2018 – a further 10 beamlines bringing the total to 32.

Andy has been onsite at Diamond for much of the last five years working on many different areas, including commissioning of various pieces of beamline equipment on I13. This beamline incorporates an imaging branch and a coherence branch. These have included Huber sample stages, filters, the QCM (Quad-Bounce Monochromator) on the coherence branch and the PCO Dimax camera on the imaging branch. "It was an especially busy time," he says, "leading up to first users on the coherence branch, which occurred on Thursday 3rd November 2011."

As well as I13, Andy is responsible for helping out on I12 and B16. "On I12 – the JEEP beamline – users bring in various pieces of equipment, such as Eurotherm temperature controllers, which need to be integrated into the EPICS beamline control system at short notice," he explains. "B16 is a test beamline, where users can try out their equipment before applying for experimental time on a dedicated beamline." Examples of work done on this beamline include the commissioning of a high-voltage power supply, the commissioning of a Montel Mirror system with parasitic motion correction between yaw, pitch and roll, and the addition of temperature monitors throughout the hutch which are read back into EPICS and archived, to learn how thermal fluctuations affect experiments.

With the work at Diamond now continuing into Phase III, OSL plans to have a permanent presence in Oxford later this year.

BLUEPRINT FOR ESS OPERATION

Scientists from across Europe met in February to discuss and exchange ideas on the development of the instrumentation for the European Spallation Source (ESS) project – a partnership of 17 European nations committed to the goal of collaboratively building and operating the world's largest facility for researching neutrons.

Located in Lund, Sweden, and co-hosted by both Sweden and Denmark, this €1.4bn construction aims to be generating long pulses of neutrons by the end of the decade. These will be used in parallel experiments that it is hoped will foster major advances from aging and health, materials technology for sustainable and renewable energy, to experiments in quantum physics, biomaterials and nano-science.

The ESS has adopted the EPICS framework for their controls software, which is one of Observatory Sciences' specialities. Scientists are engaged in a technical design review that will act as the blueprint for the construction of the ESS to start in 2013 and become operational in 2019.