

## *Speakers and lectures*

# **Academy Symposium The European Extremely Large Telescope**

(22 November 2016)

### **The European Extremely Large Telescope (E-ELT) project – History and Construction Status**

*Roberto Tamai, E-ELT Programme Manager, European Southern Observatory (ESO), Germany*

The E-ELT was formally approved by the ESO Council back in 2012, but the required funding level to start construction was actually only reached in 2014, greenlighting the start of major construction contracts in December of that year. Since then, the programme has entered a very busy phase, leading to the recent signing of the first major industrial contracts and agreements with scientific institutes in ESO Member States to design and build the first suite of scientific instruments.

This presentation will summarise the current status of the E-ELT Programme and discuss its scientific objectives, managerial organisation, programmatic aspects and system engineering approach. It will also outline the procurement strategies put in place to achieve the goal of the Programme: to build the 'world's biggest eye on the sky' within the next decade.

**Roberto Tamai** comes from Naples and was educated in Italy and in Berkeley, California. He started his career working as Project Engineer on the ESA Hypersonic Plasma Wind Tunnel Project, Scirocco, at the Italian Aerospace Research Center (CIRA). He has had a distinguished career at ESO, both in Chile and in Garching+, Germany. In 1999 he moved to Paranal, Chile, as a mechanical engineer and became the Head of Engineering and then the Deputy Director of the ESO's La Silla-Paranal Observatory. In 2008 he returned to Garching to work on the E-ELT, and in 2009 he was made Head of the Technology Division and then Deputy Director of Engineering at ESO.

Roberto was appointed Programme Manager for the European Extremely Large Telescope (E-ELT) effective 1 February 2014.

### **Telescopic images through earth's atmosphere**

*Joseph Braat, Delft University of Technology, Academy member*

This lecture will discuss a number of tests that illustrate the image quality of a telescope and show the limits of resolution. It will also demonstrate the dramatic deterioration in telescopic images through the earth's atmosphere. Fortunately, as the other speakers at the mini-symposium will show, we may be able to compensate almost entirely for the disastrous influence of atmospheric turbulence on astronomical imaging.

**Joseph Braat** studied physics at Delft University of Technology and did his PhD research at the Institut d'Optique in Orsay, France. In 1973 he joined Philips Research Laboratories, where he worked on optical data storage and optical lithography. He moved to Delft University of Technology in 1988, first as part-time Professor and then as Full Professor of Optics at the Department of Applied Physics. As Professor Emeritus, he remains active in the field of optics.

### **Intelligent Number Crunching for the ELT**

*Michel Verhaegen, Delft Center for Systems and Control – CSI team*

A key element in establishing the performance of the E-ELT is the Adaptive Optics system. Such a system consists of active optical elements – such as deformable mirrors and wavefront sensors – to correct for the

wavefront aberrations induced by wind turbulence, for example. The real-time control is challenging due to a combination of factors, such as the large number of sensor and actuator elements and the high spatial-temporal bandwidth of the control system. This lecture will briefly explain these challenges. It will also briefly present novel developments in designing dedicated algorithmic solutions that enable super-efficient 'number crunching' and compare them to the classical MVM (Matrix Vector Multiplication) solution.

**Michel Verhaegen** received his engineering degree in Aeronautics from Delft University of Technology in 1982 and his PhD in Applied Sciences from the University of Leuven in 1985. From 1985 to 1994, he was a Research Fellow at the US National Research Council (NRC) and the Royal Netherlands Academy of Arts and Sciences. From 1994 to 1999, he was an Associate Professor with the Control Laboratory at Delft University of Technology and became a Full Professor at the Faculty of Applied Physics, University of Twente in 1999. Since 2001, he has been with the Delft Center for Systems and Control, Delft University of Technology. He was an Associate Editor of *Automatica* and is currently an Associate Editor of *IEEE Transactions on Automatic Control*. He is a member of the Technical Committee on System Identification and Adaptive Control (SIAC). He currently holds an ERC research fellowship and is heading research in the area of integrating systems and control for smart optics systems. His main research focus is system identification, distributed and fault-tolerant control, and data-driven controller design methodologies.

## **The challenge of making an affordable, 50 mm thick mirror with a 39 m diameter**

*Jan Nijenhuis, TNO Technical Sciences*

The E-ELT will be the biggest optical telescope in the world. Its primary mirror will be no less than 39 metres in diameter and only 50 millimetres thick. Until recently such dimensions were unimaginable, as any mirror of that size would be too vulnerable and could never achieve the necessary optical quality. In addition, it also had to be affordable. That is why the ESO divided the mirror into 798 hexagonal segments of virtually the same size. Each segment has the same support unit. All segments are also furnished with passive and active auxiliary equipment to achieve the best possible mirror shape and positioning.

In 2015, the ESO asked TNO and VDL Enabling Technologies Group to develop the mirror support structure. The structure has to meet countless demands in terms of performance, maintenance, robustness, cost, and so on. The engineering model was ready in March of this year and production could begin. TNO hopes to deliver the first four support units to ESO in mid-2017.

TNO and VDL are not the only tenderers, unfortunately. ESO has awarded a Spanish firm a parallel contract. The best design will win, after which a public procurement procedure will commence to choose who will build the remaining 794 support units. It will be obvious that TNO and VDL will do their best to win this contract for the Netherlands. This is the exciting story of an almost impossible assignment that was completed with success.

**Jan Nijenhuis** is a Systems Engineer/Architect at TNO Technical Sciences in Delft, the Netherlands. He is responsible for the technical design of optomechanical instruments that often perform in the nanometre range and do not exceed 1 metre in size. In the past 20 years of his career, much of his work has been for the ESO. That work always involves designing entirely new instruments for which there are no comparable examples but that must, nevertheless, always be delivered.

Jan Nijenhuis is also active in space exploration. He designs optical instruments that orbit Earth and observe either our planet or space. Some of these instruments measure the Earth's atmosphere (e.g. ozone) and atmospheric pollution, while others make astronomical observations of the Universe (e.g. GAIA, HIFI).

## **What will the future bring? Scientific discoveries expected from the E-ELT**

*Eline Tolstoy, Kapteyn Astronomical Institute, University of Groningen*

This talk will give an overview of anticipated scientific breakthroughs resulting from the advanced instrumentation and gigantic leap in telescope size of the E-ELT in the Atacama desert in Chile. I will also speculate as to where unexpected breakthroughs might occur. Every new facility that significantly enlarges the discovery space has produced dramatic advances in our understanding of the Universe, often in unexpected directions.

**Eline Tolstoy** studied in Leiden, where she obtained a degree in Astronomy in 1990. She did her PhD research at the University of Groningen, finishing in 1995. Her research project on resolved stellar populations in nearby galaxies was carried out at the Space Telescope Science Institute in Baltimore, USA. From 1996 to 1998 she was an ESA postdoctoral fellow at the Space Telescope – European Coordinating Facility in Garching, Germany, and in 1998 became an ESO postdoctoral fellow there, where she was involved in the commissioning of the VLT until 2000. From 2000 to 2001 she was a Gemini support scientist at the University of Oxford, supporting UK users of the then new Gemini telescope on Mauna Kea in Hawaii. In 2001 she returned to the Kapteyn Astronomical Institute as an Academy fellow (2001-2006). In 2006 she was appointed Associate Professor, and in 2011 Full Professor. She obtained an NWO-VICI grant in 2007 to prepare for the scientific exploitation of the E-ELT. Since 2013 she has worked as a project scientist for MICADO, one of the first light instruments under construction for the ESO-ELT, and as the Dutch PI of the project.