OPTICON:

THE OPTICAL INFRARED CO-ORDINATION NETWORK FOR ASTRONOMY

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1. Introduction

For many years the European Commission (EC) has operated a series of 'Framework Programmes' aimed at improving European integration in science and technology. The most recent of these is the sixth framework programme, 'FP6', which runs for five years from 2004. Building from a smaller project, also called OPTICON, which was funded under the fifth framework programme, a large pan-European consortium proposed a much larger OPTICON project to FP6. Although a few elements of the proposal were not supported, the end result was very positive and a contract for €19.2 million, plus substantial matching funds, was signed in the spring of 2004.

The FP6 OPTICON project is what is known as an Integrated Infrastructure Initiative, (I3). The activities being undertaken are wide ranging and are described below, grouped by the three themes which define an I3 contract, Networks, Trans-national access and technology oriented Joint Research Activities. The OPTICON Project has 47 contractors spread right across Europe. These contractors comprise national funding agencies, research groups and small commercial enterprises. In several cases several laboratories or institutes are grouped together under the umbrella of a single contractor so in practice there are about 70 organisations involved in the programme. Many of these activities are interlinked as shown below in Figure 1:

1. University of Cambridge

2. Particle Physics and Astronomy Research Council

3. European Space Agency

4. European Southern Observatory

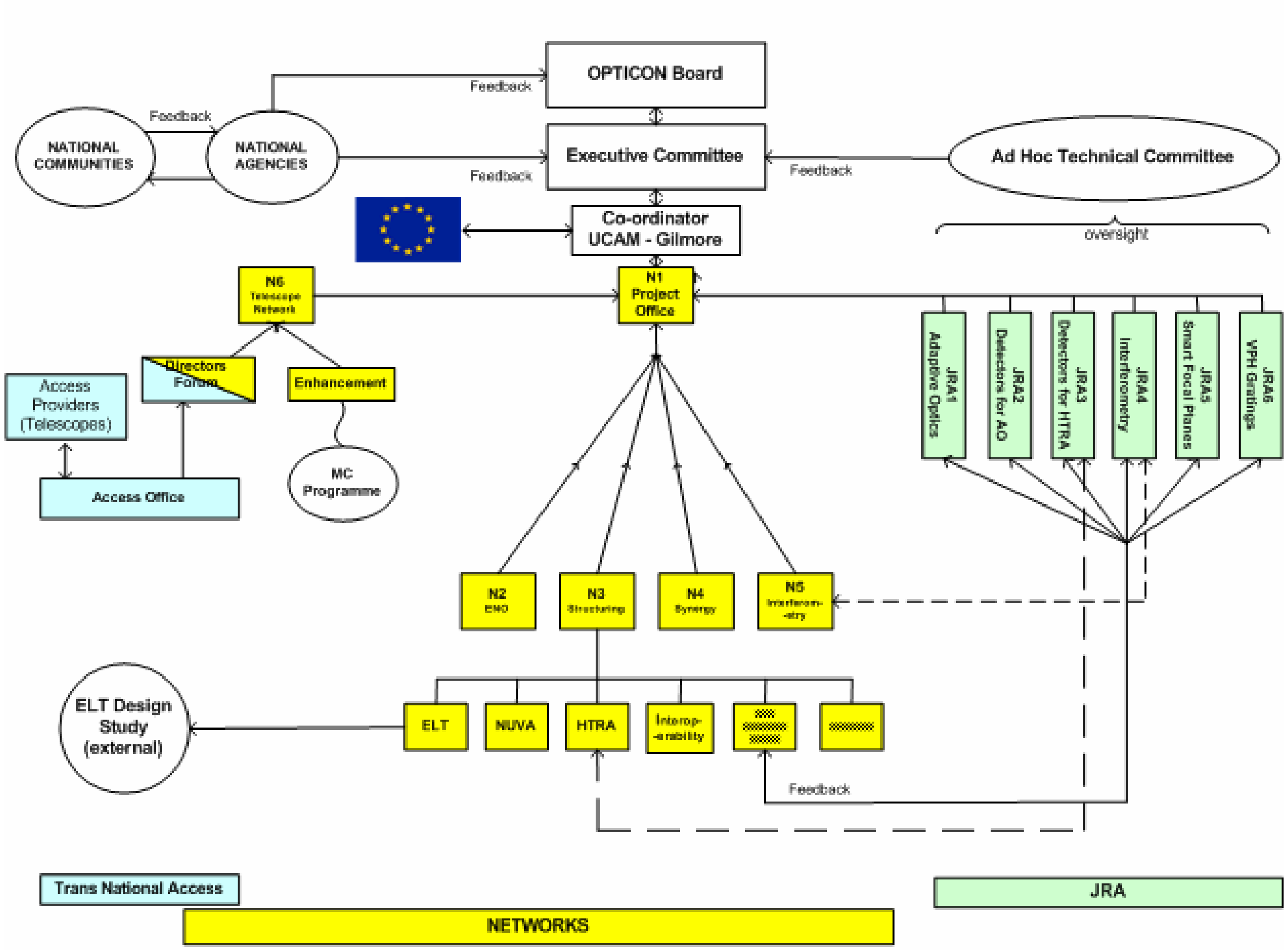

Figure 1 The OPTICON organisational structure

MISSION STATEMENT

The OPTICON Integrated Infrastructure Initiative brings together many of Europe's astronomical observatories, data centres and laboratories . Our goal is to identify opportunities where greater progress can be made by collaboration than by competition, and to take unified actions to achieve those agreed goals.

2. Networks

N1. Management.

Network 1 is the management team. The Co-ordinator, the legal entity responsible for the OPTICON contract, is the University of Cambridge in the UK. The University is represented by Professor G. Gilmore who, in scientific terminology, can be thought of as the Principal Investigator of the project. The Project Scientist, Dr John Davies, supports the co-ordinator from a small project office located in the UK Astronomy Technology Centre at the Royal Observatory, Edinburgh. Strategic decisions of the OPTICON consortium are made by a 20 member board and are then implemented by a smaller executive committee chaired by Prof Gilmore. More details of the management team can be found at the OPTICON web site; www.astro-opticon.org.

Figure 2 OPTICON Board Meeting October 2004, Grenoble, France

N2. Co-ordination and Integration of ENO facilities.

This activity is intended to encourage telescope operators at the Teide (OT) and Roque de los Muchachos (ORM) Observatories in the Canary Islands to improve and develop their existing programme of co-operation between facilities on these sites. This is being accomplished by a number of working groups which will promote better co-ordination between similar infrastructures and provide a unified approach to common challenges. For example, the network will carry out the co-ordination and implementation of a laser traffic control system for the ORM to prevent the laser guide star beams from one telescope affecting observations underway at another telescope. This requires a close collaboration between the different facilities to develop a joint software system to orchestrate multiple laser operation.

3. European Space Agency	4. European Southern Observatory

Figure 3 Observatorio Roque de los Muchachos, La Palma, Canary Islands, Spain

Since the Canary Islands probably represent the best observatory site inside the physical boundaries of the EU and the islands are potential sites for future major facilities, this network will undertake a comprehensive characterization of both the OT and ORM. An automatic Differential Image Motion Monitor (DIMM) will be developed and installed at the ORM to make systematic measurements of the night-time seeing and meteorology of the site. Intensive campaigns using a Generalized Seeing Monitor, an instrument based on a technique developed by a team at Nice University, will be carried out to provide seeing measurements at the Teide Observatory. The co-operating observatories will co-ordinate all the existing data provided by the several automatic weather stations at ORM, studying the differences between particular locations. A new automatic weather station will be installed at the site set aside for any future Extremely Large Telescope (ELT) which might be built there. Additional information will be provided by an all-sky camera (CONCAM) which will be used to measure the sky background on dark nights, and a LIDAR which will give the water vapour content. Studies of the size and amount of dust particles and studies of the vertical profile of wind and turbulence will also be undertaken.

For the solar community, which has several major facilities at these observatories, the project will design and develop a dynamic, complete and user-friendly decentralised computing information tool (JIS) for the European Solar Physics community.

N3. Structuring European Astronomy.

The objective of this activity is to provide a European consensus on several important topics. Accordingly it is split into 6 quasi-independent working groups, each with its own leader but co-ordinated by the Project Scientist.

5. Centre Suisse d'Electronique et de L'Univers

6. Institut National des Sciences de

N3.1 *The Extremely Large Telescope Working Group* holds regular scientific meetings to develop the scientific goals and to set European technological needs for a future European Extremely Large Telescope. The activity is co-ordinated by an OPTICON sponsored project scientist, Dr Isobel Hook, at the University of Oxford. This activity is integrated with a separate project, also part funded by the EC, for a design study for a European Extremely Large Telescope. The OPTICON Working Group provides advice to the team conducting the design study to ensure that the outcome is focussed on the requirements of the likely user community. Meetings of this group were held in Marseilles in November 2003 and in Florence in November 2004. The project also maintains evolving ELT web pages including a regularly updated science case - http://www-astro.physics.ox.ac.uk/%7Eimh/ELT/.

Figure 4 ELT Science Meeting, Florence, November 2004

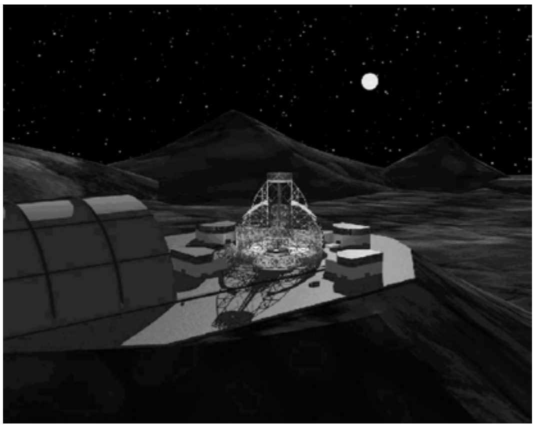

Figure 5 OWL Telescope

N3.2 *The Network for Ultraviolet Astronomy (NUVA)* plans to structure a diverse European community of UV astronomers and identify an agreed strategy for the future. This activity has become more important than ever with the failure of the STIS instrument on the HST and the strong likelihood that its planned successor, the COS, will not be installed on the HST as originally planned. The group intends to plan and execute a road mapping exercise for the future of UV astronomy and to organise large UV conference. The NUVA is chaired by Prof Ana-Ines Gomes de Castro from the University Complutense of Madrid (UCM). It held its first workshop in the summer of 2004 and a special book of the proceedings of this workshop is in preparation. www.ucm.es/info/nuva.

Figure 6 NUVA Meeting, UCM, Madrid, September 2004

N3.3 *The High Time Resolution Astrophysics (HTRA)* activity brings together the expertise of different teams which have so far developed HTRA equipment and techniques independently. The objective is to produce a consensus on several technological aspects of astrophysical techniques which require observations with high time resolution. Working groups are being formed to test existing detectors in different domains (e.g. temporal resolution and signal to noise ratio) and to determine figures of merit for detectors already existing or under development**.** The groups will review existing specialised software for HTRA data handling and compare them to the needs for common-user applications, standardised procedures, and the demands of new detectors and instruments. It is planned to develop concepts for HTRA instrumentation on medium-sized and large telescopes and compile a report of the state-of-the-art in HTRA astrophysics for different waveband regimes. The HTRA network maintains close links with the JRA-3 on detectors for HTRA.

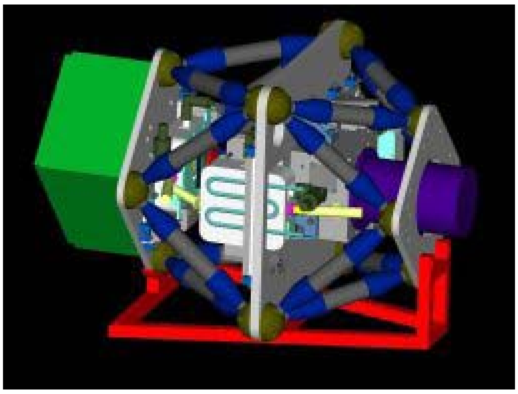

Figure 7 ULTRACAM: studying astrophysics on the fastest timescales

Universiteit Leiden 9. Universiteit Leiden	ASTRON 10. Stichting Astronomisch Onderzoek in Nederland (ASTRON)

N3.4 *The Interoperability Working Group* will exchange ideas and develop protocols for the integration of large databases into an Astrophysical Virtual Observatory (AVO). The members will develop a mechanism to link the operators of large data archives, (the Data Centre Alliance). This activity has already gained support from other EC contracts and will most likely become quite self sustaining.

Figure 8 Astrophysical Virtual Observatory logo

N3.5 *The Key Technologies Working Group.* New technology is the life blood of astronomy. The KTWG will identify future technology needs, look for opportunities which technology developments in other sectors provide for astronomy, encourage European collaborative technology development projects, and provide a forum for discussing potential routes for further technology development. Specialist teams will map astronomical science goals onto existing technologies and those requiring further development. They will look into particular technology areas and investigate how European cooperation can help make significant advances in these areas. The objective is to bring together teams to develop proposals for technology development relevant to astronomical telescopes and instrumentation. As part of the activity, special efforts will be made to develop European capabilities for technology development in IR and Optical astronomy using e-mail newsletters, web-pages and an interactive WIKI site. The participants in the network are also attempting to develop industrial collaborations using existing frameworks where possible.

Figure 9 Key Technologies Working Group Meeting, Grenoble, France

N3.6 *The Working Group on Future Astronomical Software Environments* will discuss how the analysis of astronomical data and the development of new algorithms can be made more efficient by the definition of a common software environment. High-level requirements will be formulated and on this basis the group will propose recommendations on architecture, design and interface specifications to guide possible implementations. This will be done in collaboration with AVO and GRID computing efforts to ensure compatibility.

N4. Mechanisms for Synergy in Space and Ground Co-ordination.

This small network will develop options for international agencies, especially the EC, to improve European scientific competitiveness in exploiting scientific data from space observatories. This is essential if European investment in space missions is not to be exploited by astronomers from other nations which did not lead the projects but who will have access to the data under open data archiving arrangements. In particular they will address the options to support a European Elite Fellowship Programme and attempt to identify possible mechanisms to provide scientific support for exploitation of European space projects.

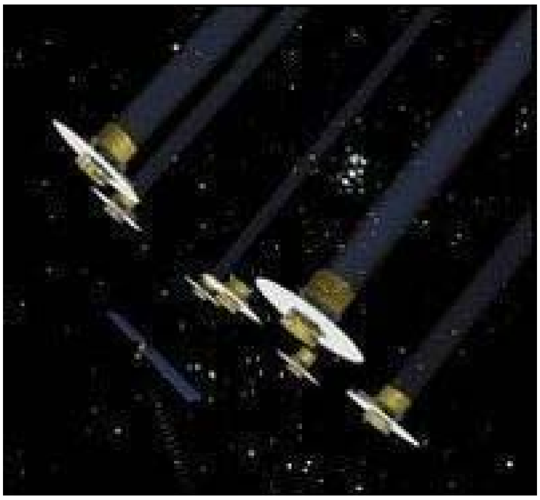

Figure 10 Artist's impression of Darwin flotilla of 6 space telescopes

13. Nordic Optical Telescope Scientific Association

14. Greek National Committee for Astronomy

N5. Interferometry Forum

The objective of the Interferometry Forum is to bring optical interferometry to mainstream astronomy and to enable all the countries of Europe to participate fully in future technical and scientific developments in optical interferometry. The specific aims are:

(1) to exploit the scientific opportunities of the new facilities;

(2) to integrate interferometry with more traditional astronomical techniques by making interferometry accessible to non-specialists;

(3) to develop a long-term scientific perspective for optical / infrared interferometry well into the next decade.

Several activities to achieve these goals are planned. One of these is to provide funding for visits of researchers to perform collaborative work on one of the topics of the European Interferometry Initiative. The visits will typically last for one month and will strengthen the network of astronomers engaged in technical and scientific work on optical / infrared interferometry. Approximately 6 exchange visits per year throughout the 5 year programme are anticipated and the first visits are already taking place. In addition to these visits, working groups will be established to consider topics crucial to the future of optical interferometry on a strategic level and will develop the science case and technology road-map for a future large interferometer.

For more details of the European Interferometry Initiative see the paper by E.J Bakker et al in the proceedings of the 2004 Jenam conference:
(http://www.strw.leidenuniv.nl/~eurinterf/mission.html)

Figure 11 European Interferometry Initiative logo

RUHR-UNIVERSITÄT BOCHUM 15. RDS at R-U Bochum	16. Schweizerische Akademie der Naturwissenschaften

N6. OPTICON Telescopes network

The objectives of this network are to exploit the common pool of experience and consolidate the basis for the future productivity of existing European observatories. The network has three main strands.

A Director's Forum meets regularly to review all aspects of the management, exploitation and development of the European observing facilities included in the OPTICON programme.

Figure 12 Telescope Directors Meeting, Observatoire de Haute Provence, France

A trans-national Access Office located at the IAC in Tenerife supports the trans-national Access programme described below.

Looking to the future, a Research Enhancement working group will bring together representatives of major European observatories, databases, and research institutes to identify the best methods to develop skills across the emerging generation of European astronomers. This group will identify areas where additional experience is required and organise practical activities to satisfy these needs. They will also investigate various activities such as those needed for the development of new instrumentation or those related to the use of virtual observatories.

KIS	ULL
17. Kiepenheuer-Institut fur Sonnephysik	18. RA3 at University of La Laguna

Network Contacts

For more information on these activities please contact the appropriate activity leader, as given in the table below:

Networking Activity	Chair	Institute	Email
N2: Co-ordination and Integration of ENO Facilities	J Burgos	IAC	jburgos@ll.iac.es
N3: Structuring European Astronomy	J Davies	UKATC	jkd@roe.ac.uk
ELT	I Hook	ASTRON	imh@astro.ox.ac.uk
NUVA	A Gomez de Castro		aig@mat.ucm.es
Interoperability	P Quinn	ESO	pjq@eso.org
HTRA	H Spruit	MPA	henk@mpa-garching.mpg.de
Key Technologies	C Cunningham	UKATC	crc@roe.ac.uk
Software	P Grosbol	ESO	pgrosbol@eso.org
N4: Synergy	J-L Puget/M Kessler	IAS/ESA-RSSD	jean-loup.puget@ ias.fr/ martin.kessler@esa.int
N5: Interferometry	A Quirrenbach/E Bakker	Leiden Observatory	quirrenb@strw.leidenuniv.nl/ bakker@strw.leidenuniv.nl
N6: Telescope Directors Forum	J Davies	UKATC	jkd@roe.ac.uk
Enhancement	M Dennefeld	IAP	dennefel@iap.fr

3. Trans-National Access programme

The trans-national access programme provides access to 17 world class observatories comprising 18 optical-infrared telescopes of between 1.5 and 4m aperture and 4 solar telescopes. EC funds allow astronomers from user communities across Europe to travel to more telescopes and use instruments not available at their national facilities. Qualifying European users receive travel grants to visit telescopes operated by other nations and the telescope operators receive a contribution to their operational costs.
Special emphasis is given to new users and those astronomers without similar infrastructures in their own countries.

19. Gran Telescopio de Canarias, S.A.

20. The Royal Swedish Academy of Sciences

LIST OF TELESCOPES IN THE OPTICON ACCESS PROGRAMME:

Anglo Australian Observatory	3.5m Telescope	Telescopio Nazionale Galileo	3.5m Telescope
Anglo Australian Observatory	Schmidt Telescope	Nordic Optical Telescope	2.5m Telescope
Centro Astronomico Hispano Aleman	3.5m Telescope	Aristarchos	2.5m Telescope
Centro Astronomico Hispano Aleman	2.2m Telescope	Observatoire de Haute Provence	1.9m Telescope
Canada France Hawaii Telescope	3.6m Telescope	Telescope Bernard Lyot	2m Telescope
ESO La Silla	3.6m Telescope	Telescopio Carlos Sanchez	1.5m Telescope
ESO La Silla	3.5m Telescope	THEMIS	Solar Telescope
ESO La Silla	2.2m Telescope	Swedish Solar Telescope	Solar Telescope
Isaac Newton Group	4.2m Telescope	Vacuum Tower Telescope	Solar Telescope
Isaac Newton Group	2.5m Telescope	Liverpool Telescope	2m Telescope
UK Infrared Telescope	3.8m Telescope	Dutch Open Telescope	Solar Telescope

For more details of access programme and its rules visit www.otri.iac.es/opticon/ or see the material presented in these proceedings or the 2004 JENAM conference by J. Burgos et al.

Figure 13 OPTICON Trans-national Access Programme Telescope Map

4. Joint Research Activities.

The OPTICON I3 has 6 Joint Research Activities (JRA). Many of these activities are designed to provide basic research and development required for future advance in European ground based telescopes, both in terms of possible upgrades to existing facilities and looking towards future extremely large telescopes. Unlike the other OPTICON activities, these are not fully funded by the EC, and have all attracted considerable matching and extra funds from the national organisation within the OPTICON consortium.

JRA1: Adaptive Optics

The primary goal of this JRA is to develop the concepts, designs and technologies required for the next generation of Adaptive Optics (AO) which will equip large telescopes over the next decade and beyond. Several possible AO systems will be investigated in parallel, Natural Guide Star (NGS) Extreme AO (XAO); Multi-Conjugate Adaptive Optics (MCAO) with multiple Fields of View; and multi Laser Guide Star (LGS) systems. In each of these areas feasibility studies will be performed, prototypes developed and supporting R&D for the enabling technologies will be carried out.

Research will be also be pursued for high accuracy and high dynamic range wavefront sensing, high computing power real time computer (RTC) hardware and software, MCAO control theory, large deformable mirrors, high-density piezo stack deformable mirrors, high-density large stroke micro-mirrors and associated control electronics. This is the largest JRA and its objectives are summarised below.

- Conduct system studies and designs for new AO-MCAO facilities for current European infrastructures such as the ESO Very Large Telescope (VLT)
- Study an Extreme Adaptive Optics system dedicated to searching for extra solar planets.
- Consideration of a L/NGS MCAO system for the VLT dedicated to large (1’) Field of View (FOV) correction at short wavelengths.
- Design and prototype development of a multi-object WFS for the Gran Telescopio Canarias MCAO system.
- Design and prototype development of a multiple field of view WFS for the Large Binocular Telescope.

21. Universite de Liege | 22. Utrecht University

- Investigate the feasibility, conceptual and preliminary design of a VLT adaptive secondary.
- Perform a theoretical study and experimental demonstration of an optimal MCAO control on the ESO MCAO demonstrator.
- Develop and test a prototype of a piezo stack Deformable Mirror with more than 1200 actuators.
- Design, manufacture and test a large (~1m) convex glass shell for large deformable mirrors.
- Carry out a full design of a 2k actuator and low order MDM and develop prototypes. Corresponding control electronics will be designed and prototyped.
- Develop Pyramid and Shack Hartmann wave front sensors and compare their performance on a dedicated test bench.

JRA2: Fast Optical Detectors for AO

The next generation of Adaptive Optics systems for 8 to 10-m class telescopes will require an increased number of degrees of freedom, which will in turn increase the number of actuators required by a factor of 5 to 10. Existing CCD's are often not matched to the requirements of the corresponding wavefront sensors, for example they have frame rates which are too slow and they are too noisy for the next generation of AO systems The success of such new AO concepts will therefore strongly depend on new developments in the field of visible detectors, both in terms of usable number of pixels and increased sensitivity. This JRA will attempt to define, fabricate and fully characterize a detector working at visible wavelengths which would be suitable for use in the wavefront sensors of future AO systems..

The participants foresee producing a 256x256 pixel detector working at visible wavelengths which will allow fast frame rates (1 kHz) with very low read noise (3e- or less). Two types of detectors are well suited for this application. The first type are EMCCDs (Electron Multiplying CCDs) which have zero read noise with a degraded quantum efficiency (QE). A good detector alternative would be the PN sensors produced by the Max Planck Institute. These sensors can be operated with multiple outputs (256), a multiplexer using an ASIC (see below) and have an excellent QE up to 1 μm wavelength with relatively low noise figures (3-4 e-). AO simulations and experiments will be made in order to decide which technology is best suited to the requirements. Detailed design of the detector and final fabrication of the device will be subcontracted as it requires specialist skills and equipment.

23. Politecnico di Milano	24. Universitat Graz

Current CCD controllers cannot be used for these new types of detectors so a dedicated controller will be built for the chosen detector. At the same time, the project will study the feasibility of Application Specific Integrated Circuits (ASIC) Controllers for use with the chosen detector.

Finally, a prototype AO wavefront sensor will be built and evaluated using an AO test bench and/or tests on the sky.

Figure 14 The NAOS visible wavefront sensor (ESO).

JRA3: Fast Readout High Performance Optical Detectors

Astrophysical detectors usually operate at low light levels, and thus have very stringent demands on quantum efficiency and low noise. This is particularly important if fast readout and short integration times are needed to explore astrophysical phenomena that involve very rapid temporal evolution. The JRA3 team aim to develop common techniques for the wide range of field sizes and temporal resolution required for different areas of astrophysics. A related application utilising rapid readout techniques is to obtain observations for brief periods of time when seeing-induced wavefront errors are negligible and diffraction limited images with large isoplanatic fields result. This so called "lucky astronomy" can be used to generate high angular resolution images on relatively bright sources.

There are several common lines of research covered by this activity:

- The evaluation, optimization, integration and tests of state-of-the-art detectors
- The development of front-end-electronics and controllers which maximise read out speed and minimise noise
- The development of data handling software to exploit the data products to their fullest extent
- The development of breadboard instrumentation test beds into integrated systems

25. THEMIS S.L.	26. University of Bremen

The JRA3 team will combine these different lines of research and development of sensor systems for studies at very high time resolution with special emphasis on the three most promising detector concepts: L3-CCDs, PN sensors, and Avalance PhotoDiode (APD) arrays. The team will co-operate closely with its supporting network, N3.3.

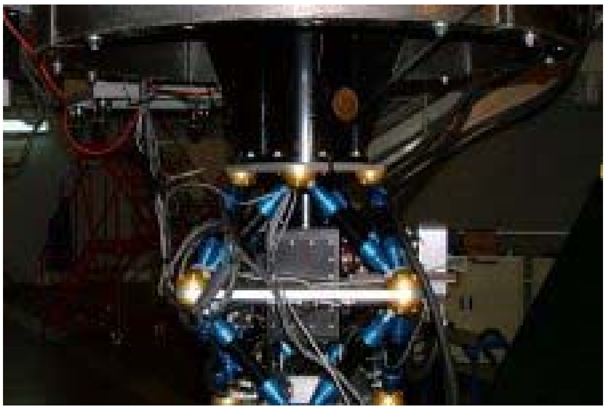

Figure 15 ULTRACAM: an ultra-fast, triple-beam CCD camera

Low Light Level (L3) CCDs are the most promising development for extending current technologies towards faster operation. Different optimization strategies are required to extend the L3 concept into different parts of parameter space (shorter read-out time, higher dynamic range, larger arrays, reduced noise etc). This activity will, in particular, pay special attention to studies of improvements in packaging and greater multiplicity of readout ports.

An optical sensor system based on PN-chips and suitable for very high time resolution studies at low light levels will be developed. This is a new detector concept at optical/NIR wavelengths and it bridges the gap in performance of current detector technology at wavelengths around 1 micron.

Attempts will be made to develop a multi-pixel array of Avalanche PhotoDiode (APD) detectors. APDs are a promising way of extending the sampling rate of low-light level applications to a few microseconds, without involving cryogenic cooling. New developments will hopefully overcome the strongest limitations of APDs which have so far only been used as single channel devices, by optimizing multiplicity, dynamic range, and shaping times.

Each of the different detector concepts are likely to be best suited for different parts of parameter space, which is much broader than the fraction served by classical CCDs. Most applications involving studies with high temporal resolution will require a combination of the advantages of the different detector concepts so the project aims to develop a specialised controller for very high time resolution studies with frame-transfer L3CCDs, PN-, and APD cameras. Such a controller will be optimized for increased dynamic range, low noise and will support multiple port systems.

An essential element in testing and operating the detectors and the electronics for these detectors will be new software for operations control, image analysis, pipeline operation, and storage in fast imaging applications. Development of this software is required to compare performance with other systems and to enable actual operations of any of the new detector schemes.

JRA4: Interferometry

Interferometry is the combination of multiple telescopes in a single coherent array to produce very high spatial resolution. Long used by radio astronomers it is now becoming practical at much shorter wavelengths. The objective of this programme is to ensure that Europe will play a leading role in the development of optical interferometry over the next decade and to enable European astronomers to fully exploit the scientific potential of existing and planned large facilities. The near-term scientific productivity of interferometers is limited mainly by:

(1) the inherent limitations of the existing focal-plane instrumentation and the difficulties of phasing and co-phasing the elements of interferometric arrays.

(2) the lack of adequate algorithms and tools for the analysis and interpretation of the data.

(3) limitations of component technologies and modelling tools.

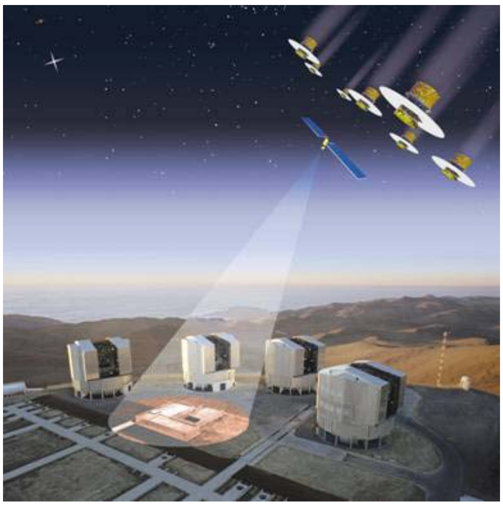

Figure 16 The Darwin and VLT arrays

29. Universite de Paris-Sud

30. Konkoly Observatory of the Hungarian Academy of Sciences

The Interferometry JRA will address areas (1) and (2) through the coordinated development of advanced analysis software and targeted initiatives to further the design of next-generation focal-plane instrumentation and fringe tracking devices. The group will perform studies of possible advanced instruments to replace present-day interferometers which are equipped with first-generation focal-plane instruments consciously designed to be relatively simple and limited in their capabilities. The team will support up to eight initial studies for advanced instruments which will cover a wide range of concepts. These studies will then be examined to identify the most promising of these concepts, and to assess their technical and financial viability. The highest-priority concepts will then be studied in more detail through feasibility and pre-design studies.

The sensitivity of fringe trackers is one of the most important characteristics of an interferometer. Improvements over the current state of the art can be achieved mainly in two areas: fringe tracking algorithms and detectors. Fringe tracking algorithms optimized for the particular operating conditions of large facilities will improve the co-phasing ability beyond those of the current adaptations from small-aperture interferometers.

In parallel to studies of hardware, the Interferometry JRA will develop a dedicated software package for the analysis of data from optical / infrared interferometers. This package will be developed according to quality standards used in comparable industrial efforts and is referred to as the European Optical Long-Baseline Interferometry (OLBI) software system. A user support group will be established throughout the lifetime of the project. The JRA will also develop an '*Off-lineToobox'* a data analysis package which will contain utilities for input/output, general data manipulation such as sort/merge, data display and editing routines. It will also provide software for fitting simple geometrical models to sparse data sets, and to estimate best-fit parameters of physical source models to interferometric data. The toolbox will provide facilities for astrometric data reduction, which includes routines to determine the interferometer and source geometry from the data, to determine stellar proper motions and parallaxes and to fit orbits of binary stars and planetary companions. A variety of image reconstruction algorithms will be offered, based on adaptations of familiar existing methods and on new techniques optimized for use with optical interferometer data.

31. Office National d'Etudes et de Recherches Aerospatiales	32. Centro de Astrofisica da Universidade do Porto

Activity JRA5: Smart Focal Planes

Smart focal planes will be an essential component of future instrumentation for VLTs and eventually for a European ELT. Of particular interest are three technologies: Integral field spectroscopy using image slicers, beam manipulators and multi-slit units including Micro Opto Electro-Mechanical Systems (MOEMS). Integral Field Units (IFUs) based on image slicers and fibre bundles are required to build spectrometers having relatively large fields of view (1 arcmin square) for current and future generations of telescopes. The team will also explore and prototype technologies to direct light from small fields within the telescope focal plane to multiple IFUs. These technologies will include deployable pick-off arms operating at cryogenic temperatures, robotic fibre positioners, tiltable mirrors, and piezo actuated robotic devices. Finally the project will investigate techniques for manufacturing reconfigurable focal plane masks in cryogenic near infrared spectrometers. Options include inserting a slit mask into the focal plane via an intermediate cryostat and air lock or developing 'programmable' slit masks that can be reconfigured remotely whilst in place in the cryostat. The participants will explore the feasibility of MOEMS as a reliable solution for the next generation of optical and near infrared multi-object spectrographs.

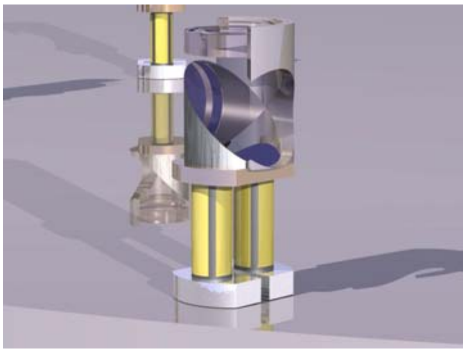

Figure 17 A biped Starbug (Anglo-Australian Observatory), based on Smart Focal Plane technologies, carrying the optical relay optic, consisting of the lens and fold mirror. The Starbug can "walk" around a focal plane to quickly reposition the optics different target fields.

In collaboration with the Key Technology Working Group (Network N3.4) the JRA will develop and revise existing technology roadmaps then use the roadmaps to aid decision making on which technologies to pursue. The team will fix requirements and specifications to provide realistic and measurable goals for technology studies. They will then develop and evaluate concepts for future instruments using Smart Focal Planes with particular emphasis on technology requirements and challenges which are common to many of the Smart Focal Plane devices, such as metrology, cryogenic mechanism reliability, tribology, position sensing and actuation.

33. Technion - Israel Institute of Technology	34. Uniwersytet Mikolaja Kopernika w Toruniu

The technology development activity will develop areas which offer key performance enhancements for multi-object and integral field spectroscopy, and are feasible for prototyping in the near-term. For example:

- Develop smooth image slicer optics for the visible and develop transmissive devices, replacing linear arrays of mirrors with customised arrays of small lenses.

- Study cryogenic pick-off arms with particular emphasis on high angular resolution, possible alternatives for positioning and methods to improve thermal performance.

- Investigate the technology required for the miniaturisation of beam steering devices.

- Develop concepts for robotic mirror positioners and optical layouts to act as multi-object spectrometer feeds.

- Study new ways to manufacture high quality fibre-based IFUs for the wavelength range 0.35 - 2.5 microns and consider how fibre IFUs can be miniaturised for multi-object applications.

- Investigate concepts and predicted performance of cryo-mechanisms for actuators and linear slides and identify where future work is needed.

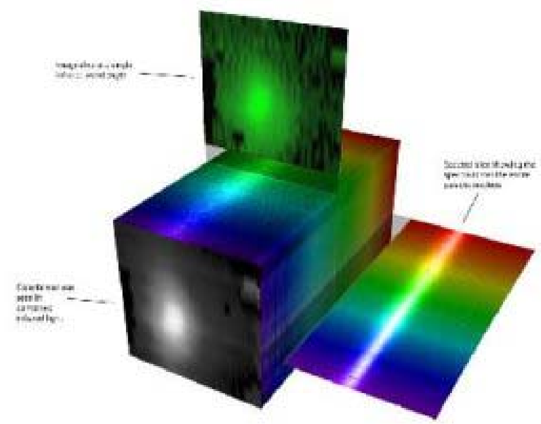

Figure 18 Pictorial Representation of a data cube produced by the UIST Imaging Spectrometer on the UKIRT telescope (http://www.jach.hawaii.edu/UKIRT/instruments/uist/uist.html)

35. University of Durham	36. Universite de Geneve

In a second phase of the project, and after an evaluation of risks and challenges in the provision of enabling technologies, the JRA will attempt to build and test prototype devices and subsystems using the chosen Smart Focal Plane technology.

JRA6: Volume Phase Holographic Gratings (VPHG)

Most of Europe's large telescopes are equipped with low-to-mid resolution imaging spectrographs operating in the optical and near infrared (1-5 microns). The major source of light loss in these instruments is the dispersing elements, generally grisms. Developments here can produce dramatic effects on overall throughput and efficiency. In principle, VPHGs can be designed to provide much improved performance but their behaviour needs to be fully tested so their properties can be optimised for the next generation of astronomical instruments. This JRA will evaluate, develop and prototype VPHGs for astronomical instrumentation.

For the near IR regime the JRA will attempt to fabricate fully-functional VPHGs working at cryogenic (77 K) temperature and optimised for infrared (1-2.5 micron) wavelengths. There will also be a study to investigate the possibility of extending the visible wavelength range to 5 microns. A programme of characterisation of the VPHGs will then be carried out. This will include a study of the behaviour of the VPHGs at low temperature and evaluation of the degradation of their performance under controlled irradiation.

Figure 19 High Diffraction Efficiency Transmission Grating

In the optical regime attempts will be made to produce VPHG-based spectroscopic assemblies with improved performance with special attention to, cross dispersion, tunability of the resolution and focal plane filling.

37. Landessternwarte Heidelberg (LSW)	38. Astronomical Institute of the Academy of Sciences of the Czech Republic

An attempt to develop re-writable VPHGs based on photochromic polymers will be made. This will require analysis of the modulation of the refractive index between the two isomeric forms of available photochromic materials and a study of suitable chemical modifications in order to increase the change of the refractive index of the candidate materials. Ab-initio and DFT computations of molecular polarisabilities of the model photochromic compounds will be made, after which small quantities of the chosen materials will be prepared for use in laboratory tests. These materials will be characterised using NMR, UV-visible, Infrared and Raman spectroscopy to provide preliminary efficiency measurements at room temperature.

Based on all the results thus obtained, the team will study the relationship between the variation of the refractive index with the chemical structure and optimise the experimental procedure for the synthesis of the best photochromic materials. Then they will attempt to develop optimised photochromic VPHGs for the near infrared which fulfil the requirements for actual observations in realistic observatory environments.

JRA contacts

For more information on these activities please contact the appropriate activity leader, as given in the table below:

JRA	**PI**	**Institute**	**Email**
JRA1: Adaptive Optics	N Hubin	ESO	nhubin @ eso.org
JRA2: Fast Optical Detectors for AO	P Feautrier	LAOG	Philippe.Feautrier @ obs.ujf-grenoble.fr
JRA3: Fast Readout High Performance Optical Detectors	S Wagner	LSW	s.wagner @ lsw.uni-heidelberg
JRA4: Interferometry	A Chelli	LAOG	chelli @ laog.obs.ujf-grenoble.fr
JRA5: Smart Focal Planes	C Cunningham	UKATC	crc @ roe.ac.uk
JRA6: Volume Phase Holographic Gratings	F Zerbi	Politecnico di Milano	zerbi @ merate.mi.astro.it

39. The University of Sheffield

40. The University of Warwick

5. Conclusions

Following its formation in 2000 under the auspices of the EU Fifth Framework programme, OPTICON has grown naturally as one of the means by which an increasingly integrated European astronomical community can develop an integrated programme. By coordinating existing European medium sized facilities in optical and infrared astronomy and bringing together the broad range of skills, resources and expertise that exist within the astronomical community, it will have an important impact on astronomical progress. OPTICON will ensure that a broad range of the traditional astronomical facilities will be running in a coordinated homogeneous way for the benefit of the whole European community in its broadest sense.

Looking to the future, a coordinated and balanced set of technical developments which are already identified as key technologies for the next generation of major technological advances in detectors, spectrographs and atmospheric image distortion control are being supported. All these developments are critical for substantial improvement in scientific exploitation of Europe's astronomical facilities.

This balanced approach positions the wider European community for design and development of the next generation of infrastructures, vital to ensure continuing European astronomical leadership in the world community. OPTICON will assist Europe's astronomers to play a leading role in an internationally competitive European Research Area.

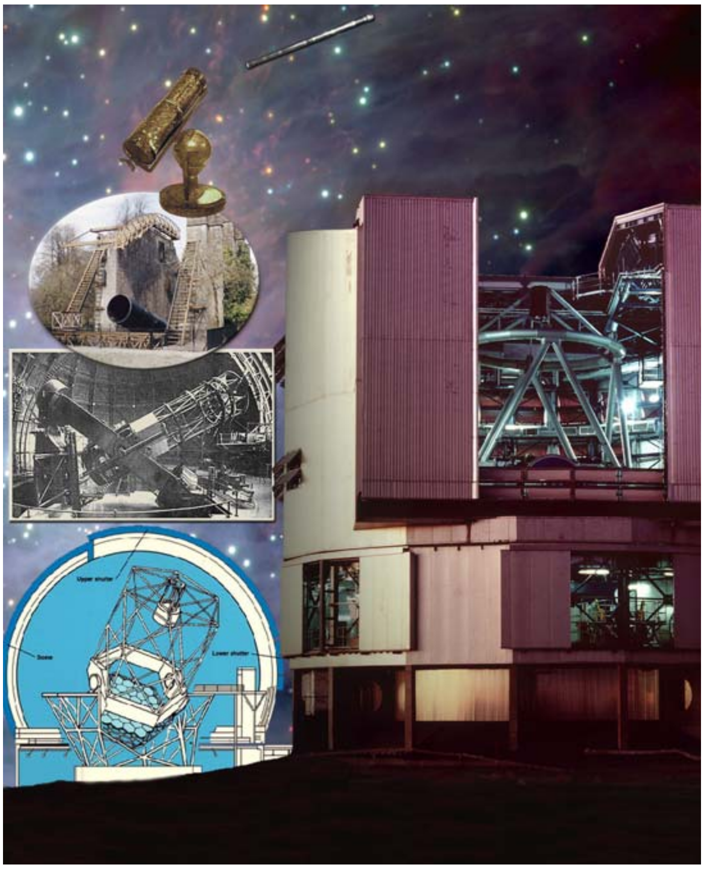

Figure 20 Telescopes and their infrastructures

6. Summary

The OPTICON FP6 contract came into force on January 1st, 2004 and runs for 5 years. Many of the activities described above are already underway and in particular the trans-national access programme has already attracted considerable interest. For more information on this multi-faceted programme please visit the OPTICON website at www.astro-opticon.org for more details, downloadable material and additional contact information.

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41. The University of Vienna

42. National Observatory of Athens

43. Institut de Fisica d'Altes Energies

44. Reflex s r o

45. TNO TPD

46. Liverpool John Moores University

47. Anglo-Australian Telescope Board