5th Annual Report

OPTICON

Optical Infrared Co-ordination Network for Astronomy

Integrating Activity

implemented as

Integrated Infrastructure Initiative

Contract number:	*RII3-CT-2004-001566*
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Project website:	*www.astro-opticon.org*
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A. ACTIVITY REPORT

1. PROGRESS REPORT

Progress report

1.1 Summary of the activities and major achievements

OPTICON is a large I3, with many activities. All have proven highly successful during FP6, and have continued successful through this last year of funded FP6 activity. OPTICON has involved six major JRA projects, six complex and multi-component networking activities, and an access programme which includes every 2-4m telescope worldwide with even partial European ownership, as well as several more specialist facilities, with all these activities spread across 47 full OPTICON partners, and involving some 70 labs and organisations. Thanks to considerable good-will, hard work, and the enthusiasm of the participants for this ambitious project, all activities were carried out successfully.

Our programme includes a set of activities related to improving the quality, the multi-national nature, and the international competitiveness, of European ground-based optical-infrared astronomy. Our member/user community is extremely large indeed, including several whole communities each of which independently merits substantial EC support. The primary sub-communities include classical (night-time) optical and near infra-red astronomy from the ground, classical (day-time) solar astronomy from the ground, and the European Interferometry Initiative, the community making the promise of ultra-high spatial resolution astronomy a reality accessible to science users independent of a requirement for extreme technical specialist knowledge. In addition, networks support open and wide community involvement in science planning for the next generation European Extremely Large Telescope, for future data reduction software systems, for development of the Canarian Observatories, for ultra-violet (satellite) astronomy, and for planning future Key Technologies of potential relevance to enhancing astronomical facilities.

Underlying this future promise is access to today's telescopes, on the basis of merit, regardless of (European) country of origin. The OPTICON access programme includes every state of the art medium-sized telescope globally in which there is any European ownership. This applies to both solar (day-time) telescopes and to optical-infrared (night-time) telescopes. While the access programme remains severely cash-limited, it nonetheless is succeeding in introducing new users, and users from communities which do not fund their own premium facilities.

The initial ambition of OPTICON was:

- To increase the quality of European astronomical research, by ensuring that the best European scientists have access to world-class facilities;
- To increase the quantity of European astronomy, by ensuring that all of Europe's astronomers have access to excellent facilities purely on merit;
- To sponsor and develop training systems to train young and/or inexperienced astronomers in the use of state of the art facilities;
- To strengthen the community overall by encouraging and supporting collaboration across traditional boundaries, whether geographical or technical;
- To gain economies of scale, and efficiencies in operational costs, though shared experience ('best practice') and through co-ordination of resources and facility access to allow optimum use of these investments.

ACCESS

This OPTICON forum of directors of telescopes is the unique forum in which the directors of these facilities are brought together, so we take the opportunity to disseminate best practise. Specifically, we are using the directors' forum as the opportunity to plan future coordinated operation of multiple distributed facilities. This operational mode has the potential to reduce operations costs while at the same time enhancing scientific output. It is thus being promoted by the various telescope funding agencies, through AstroNet, another FP6-funded grouping. Defining and implementing this new operational paradigm will be a major challenge through FP7 and beyond.

This set of goals was delivered through the telescope Access program. It is worth emphasising that the OPTICON Access Program, and Telescope Director's Forum, brought together for the first time ever all the directors of all Europe's mid-sized telescopes. That process has led to considerable synergies, with real detailed proposals now under development to harmonise and merge operations between several facilities. All telescope operators have confirmed their enthusiasm for this activity, and intend it to continue.

The users are equally happy, with available funded access being substantially over-subscribed. Our ambitions to strengthen and extend the community are proceeding very well, and are purely resource-limited. During 2008, over 54% of those astronomers supported with T&S grants in 2008 were new users. This result is quite positive since the OPTICON Access programme has been run for five years and we still receive a high percentage of new users. In addition 34 % were young-early stage researchers. The gender ratio among users with T&S grants is 29% female and 71% male. This access programme was supplemented by dedicated training school activities, in all of telescope access and use, data acquisition and reduction, and specialist techniques, such as interferometry.

NETWORKS

OPTICON's networking activities are focussed on strengthening the astronomical community in Europe, integrating newer communities and young scientists into technologies and opportunities with considerable future development potential and developing the science and technical cases to justify those future technologies, infrastructures and research potential.
This facet of OPTICON's programme is to encourage the community to work together, and to plan for the future in a way which is both ambitious and coherent. Many OPTICON networks contribute to this approach, with positive developments on many fronts. Among the most ambitious goals was:

- To develop scientific cases and initiate technical investigations for next-generation world-class observational facilities, ensuring the continuing excellence and development of European astronomy on the world stage.

Very considerable progress was made in developing the European leadership of the next major optical-infrared infrastructure, the Extremely Large Telescope. Highlights include completion and delivery of the two printed books presenting the `Science Case for an Extremely Large Telescope'. Perhaps the most impressive network achievement has been developments supporting European intentions to build an Extremely Large Telescope. This plan is now agreed as the highest priority for ground-based astronomy in all the major European funding agencies and by the ESO Council. OPTICON delivered the community Science Case, following many major meetings and workshops involving a wide community, and is focussing technical developments, designed to enhance extant large telescopes, particularly towards those technologies of clear future relevance to the Extremely large

Telescope.

This aspect of OPTICON's and Europe's activities has been vastly successful. Thanks to many initiatives, of which the OPTICON activity in developing a common science case, and merging the various national and central technical planning work was a major part, Europe is now fully committed to developing a single European Extremely Large Telescope Project, an approved item on the ESFRI list. This is the first time in over 100 years that European astronomy planning for major new facilities has been competitive with planning and developments in the US. The importance of this activity will only increase.

Other OPTICON ambitions include:

- To identify those future technical developments which are most necessary to strengthen community scientific quality and productivity;
- To invest in those common technological developments which are critical for the development of the next generation facilities;
- To develop together those techniques, tools, instruments and enhancements which will add value across the whole community;
- To identify support tools, especially software, which can be developed to enhance scientific productivity, and to reduce technical restrictions on scientific use of specialised facilites.

A strong future for European astronomy needs not only a strong user community, and timely plans for excellent facilities, as noted above. Technology and creativity to support those developments is essential. This is the activity of our technology networks, and the JRA activities. These activities form a forward-looking and complementary set of approaches, focussed on developing the best technology in adaptive optics, fast detectors, gratings, interferometric controls, and instrument designs, interfaces, and data reduction requirements. Progress in this extremely ambitious goal is simply remarkable.

The Key Technologies network has played a major role here, identifying those technologies most likely to become mature, given reasonable investments.

More specialist facilities and projects, from future developments in interferometric imaging and technology, through space-born ultraviolet science, to future software requirements, have all been advanced through detailed analysis. A specific and important network is developing a detailed roadmap for future key technologies, establishing a planning basis for the future of astronomy, and identifying those activities which are likely to evolve into future technology solutions.

TECHNICAL DEVELOPMENTS – JRA activities

Delivering world-class science requires world-class technology. The remaining aspect of OPTICON work is to provide identification of new technologies of potential interest (through technology road mapping), proof of principle of these technologies through prototype development, and for those special cases of clear high impact, further development through detailed design and/or `critical technology subsystem implementation.

OPTICON JRA activities are grouped into six projects. These range from the very large, multi-faceted and extremely ambitious JRA1, which addresses all aspects of the future development of the real-time adaptive optics wavefront control systems which are the critical requirement for the next stages of development in astronomy, to the highly specialised JRAs which focus on a specific yet critical requirement.

JRA1 included a variety of developments of key technologies for adaptive optics systems, for both telescopes and instruments, of direct relevance to enhancing the performance of Europe's premier facilities.

A major effort was devoted to enhancement of new instruments allowing direct imaging of extrasolar planets. The main goal of this collaboration was to enhance the performance of the proposed new instrument Planet Finder's scientific capabilities by the inclusion of enhanced science instruments (integral field spectrograph and differential polarimeter). The renamed VLT SPHERE project (standing for Spectro-Polarimetric High-Contrast Exoplanet Research) has successfully accreted several new European Institutes outside the original JRA1 partners. This interest is due to the potential high scientific return of this future facility: the direct detection of Extrasolar Planets. In June 2006, ESO Council decided to proceed with and fund the full development of SPHERE as part of the 2nd Generation instrument programme of the Very Large Telescope.

JRA1 also supports work on European new facilities outside ESO. An original work proposal of the Spanish GranteCan large telescope GTC Project Office consisted of the conceptual study, design and fabrication of a multi-object wavefront sensor based on the concept of curvature wavefront sensing. Substantial advances have been made here, and continue, as this system becomes close to implementation.

Another part-European new facility is the Large Binocular Telescope, LBT. OPTICON supported part development of a Multiple Field of View AO wavefront sensor prototype to be tested on the AO system of LINC-NIRVANA: a Fizeau Interferometer for the Large Binocular Telescope (LBT). The prototype system consists of a Ground Layer Wavefront Sensor, a High Layer Wavefront sensor, de-rotation units for the sensors, one deformable mirror, collimation and imaging optics for the High Layer wavefront sensor (HWS) and a patrol camera for monitoring the acquisition field of the HWS.

In more generally-applicable technical developments of adaptive optics systems, SPARTA (Standard Platform for Adaptive optics Real Time Applications) went through different phases of evolution in which ESO and Durham tried different solutions of various complexity. ESO and Durham developed a concept for SPARTA based on a hybrid architecture that uses three different technologies for different purposes. FPGAs are used to pre-process the large incoming data stream to more manageable sizes (i.e.: from pixels to gradients, developed by Durham) and to implement the high-speed communication infrastructure that runs serial FPDP. Digital Signal Processors are in charge of the main mathematical operations and general-purpose Central Processing Units perform more complex tasks or high level operations developed by ESO. A full end to end SPARTA prototype was built and this demonstrated that the architecture could meet the 2nd generation AO system requirements. Following review, serial production of SPARTA systems for VLT SPHERE and the VLT AO Facility has started.

Following the VLT Planet Finder studies noted above, a top level specification for the development of the 1370 actuator piezo deformable mirror prototype was produced by the SPHERE Consortium in 2004. These top level requirements were integrated into a Technical specifications and Statement of Work by ESO. In 2005 a Call for Tender was issued by ESO, and two proposals were received and evaluated. After difficult negotiations the contract was granted and signed, and has proven highly successful. The successful development of this 1377 actuator deformable mirror was a world first from the view point of the number of actuators. This success has already led CILAS to negotiate with the US Thirty Meter Telescope project for the manufacturing of two 60x60 actuator deformable mirrors and with the US New Solar Telescope project for a 40x40 actuator cooled deformable mirror. This is a good demonstration of European Research funding impact helping industry to capture new contracts outside Europe.

In a related success, we note particularly the successful development of the OCam fast camera system. OPTICON JRA2 is developing the next generation of CCD-based fast wavefront sensors, which are critical for all adaptive optics, interferometry and high time resolution astrophysics. One of the most successful of OPTICON's prototype implementations is construction and integration of the OPTICON ultra-fast CCD wavefront sensor camera OCam.

This was developed by a team under Philippe Feautrier, funded by OPTICON.
For the first time in the world, they demonstrated at the end of FP6 a CCD camera system (using the CCD220 and OCam developed within OPTICON/JRA2) running at 1200 frames/s with 240x240 pixels images and having a read noise lower than 0.5 electrons. This has never been done before anywhere in the world and was a major achievement of OPTICON FP6. OCam is being patented, will be used as the new standard at Europe's major astronomical observatories, and will be sold commercially.

Since low-noise detection of photons is one of the two limiting factors in astronomy, OPTICON also supported complementary development of a different technology for fast imaging, in JRA3. This developed an AA-pn-sensor , which was also completed successfully. The results are 256x512 pixel CCDs designed for high time resolution (>1kHz frame rate) astronomy and adaptive optics applications. Preliminary tests have shown that the device lives up to the expectations based on the single-element test devices produced in previous years. This is to be confirmed with full tests and characterisation. If the preliminary results hold up, the device will have spectacular performance, making it probably the best CCD with on-chip electron amplification ever made.

After photon detection, spatial resolution if the key limiting factor in astronomy. OPTICON supports development of improved systems here largely in real-time wavefront control (adaptive optics), but also in interferometry (which also uses adaptive optics). JRA4 was another ambitious project, developing, in partnership with an associated network activity, the European skill base in interferometric astronomy. Europe is currently developing the largest and most sophisticated interferometric optical/infrared facility on Earth, the VLT Interferometer, at ESO's Paranal observatory. Interferometry is an extremely powerful technique, yet remains in the domain of specialist users. This JRA (and network) worked to develop new generations of instruments and software to ensure the considerable scientific potential of this methodology is available as a common and widely-used research tool. In interferometry, work focussed on supporting development of concepts and prototypes for next-generation instruments, of wide applicability and easier user access. In June 2008, the 3 projects Gravity, Matisse and VSI were approved by ESO for the 2nd generation of VLTI instruments. Gravity and Matisse have begun their phase B: their preliminary design review (PDR) will be held on March and June 2009, respectively. Their first light is scheduled around 2012-2013. VSI will begin its phase B mid 2009, for a PDR in 2010. OPTICON supported development of two of these instruments, helping ensure Europe's future astronomers have access to world-leading facilities, open for use by the best scientists.

JRA5 concentrated on the interface between the telescope, collecting photons, and the detector, recording them. In between vast sophistication is required to ensure the right photons are delivered in the right format to the correct detector. These `smart focal plane' systems are being developed to ensure that future large telescopes can indeed deliver their scientific potential: they will also be invaluable to improve the scientific productivity of the present generation of major infrastructures. This involves some especially interesting work at an SME in the Czech Republic. In other work, OPTICON supports the development of technologies to gain maximum scientific benefit from the full large-area focal planes of current telescopes (and future Extremely Large Telescopes) by targeting the objects observed in the most effective manner. Among promising new technologies identified and prototyped, MOEMS slit mirror devices have been taken forward into manufacture of a prototype 20,000 element array by LAM/Marseille and Institut de Micro-Technologies of University of Neuchatel (Switzerland).

Optimising the instruments which focus and/or disperse light before detection is a continuing challenge. One specific effort of note here, given its exceptional promise, is use of new materials. Rather than steel and glass, new organic film (photo-chromic) material show particular promise, eg n Volume Phase Holographic Gratings (VPHGs).
JRA6 is developing a new class of optical/infrared dispersive devices, Volume Phase Holographic Gratings. These VPHGs are significantly more efficient than standard gratings currently in use. They are a development in which Europe is establishing a clear global lead: this JRA involves both research groups in Italy and an SME in Belgium. Progress is spectacular, and has led already to patented results. Significant achievements and their impact resulting from this JRA6 activity included:

1. Full cryogenic characterization of J,H and K VPHGs
2. First operational non-traditional instrument configuration based on VPHGs
3. First working holographic grating obtained on a film of photocromic polymer.

1.2 NA1: Management Activity

Participant number[1]	1a	2b	**Total**
Participant short name[2]	UCAM - IoA	STFC - UKATC	
Person-months[3]	13	13.88	**26.88**

OPTICON operates a distributed management structure. The Co-ordinator (G. Gilmore) is based at the Institute for Astronomy, Cambridge where he is supported by administrative and financial staff. The Project Scientist (J. Davies) and his assistant are based at the UKATC, Edinburgh and the Trans-National Access Office operates from the IAC in La Laguna, Tenerife. In addition the larger JRA and networks have their own local activity leaders with responsibility to ensure progress according to the defined work plan and deliverables. Tasks are clearly divided between these various elements and regular e-mail and telephone communications, supplemented by face to face meetings as needed, have ensured the smooth running of the project.

The primary management activity remains the co-ordination of the six JRA projects, the five complex and multi-activity networking activities, and the trans-national access programme which includes every modern 2-4m telescope worldwide with even partial European ownership, as well as several more specialist facilities. These activities are spread across 47 full OPTICON partners, and involving some 70 laboratories and organisations.

Three management meetings were held, one of the OPTICON board, the overarching management body, and two of the smaller executive committee. These meetings are detailed in the table below, with links to the minutes. Notable achievements included financial fine tuning as the final stages of the project began and the development of a detailed plan for FP7 implementation. The project office, distributed between contractors nos. 1 and 2, provided support for these meetings, produced and circulated minutes etc.

The technical sections of the 4th annual report were collated at Edinburgh and delivered in a timely manner to the Co-ordinator. The Co-ordinator and his support team was then responsible for the integration of the financial information and the final delivery of the report. As in the previous year, this time consuming process included resolving open questions, correcting errors and misunderstandings, obtaining adequate audit certificates and resubmission of the report. Once the final issues were resolved, the management team calculated the correct payments to be made to each contractor, including supplying them with detailed information on how the amounts were calculated and how the delivered funds were to be allocated between work packages within each contractor. The funds were then distributed once they had been received from the EC.

[1] Lead participant first

[2] Use the same contractor short names and numbers indicated in the table "list of participants" in Annex I of your contract.

[3] AC contractors must include both the total estimated human effort (including permanent staff) and, in brackets, additional staff only.

The Project Scientist participated in meetings related to N3.1 (Elba) and JRA-4 (Porto) He was in regular telephone and e-mail contact with the leaders of all the other activities as required.

The project office continued to maintain the OPTICON web site

The Project Scientist and Scientific Coordinator were in frequent contact with their counterparts in RadioNet, and Astronet. The project scientist participated in a meeting of the I3NET forum on September 1st in Amsterdam to share information and discuss common issues. The project Scientist and the Co-ordinator attended the Astronet symposium in Liverpool in June 2008.

Milestones and Deliverables

Deliverable/ Milestone No	Name of deliverable/milestone	Work-package /Task No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
M19	Executive meeting. Garching	WP1	UCAM, STFC	49	49
M20	Complete Annual report to EU	WP1	UCAM, STFC	50	50
M16	Executive meeting	WP1	UCAM, STFC	54	55
M18	OPTICON Board meeting	WP1	UCAM, STFC	54	59

Meetings and Workshops

Date	Title/subject of meeting	Location	Number of attendees	Website address
9 January 2008	9th Executive Committee meeting	Munich, DE	16 +1 videocon	http://www.astro-opticon.org/agendas_minutes/Final-mins-exec9.pdf
9 July 2008	10th Executive Committee meeting	Paris, FR	13 +1 by telecon	http://www.astro-opticon.org/agendas_minutes/Final-OPTICONexec10mins.pdf
10-11 November 2008	6th Board meeting	Porto. PT	26	http://www.astro-opticon.org/board_mtg6_november08.html

There has been no general meeting of the entire consortium. It is too large, and its activities too diverse, to make such a meeting productive.

No specific consortium management problems have been encountered.

1.3 NETWORKING ACTIVITIES (other than Management)

1.3.1 NA2: Coordination and Integration of ENO facilities

Contractors:

Participant number[4]	7	2	27	8	25	43	17	20
Participant short name[5]	IAC	STFC	IOA-KUL	INAF	THEMIS	IFAE	KIS	RSAS
Person-months[6]	60 (9)	4	1	4	4	4	4	4
Participant number[7]	22	13	24	1				**Total**
Participant short name[8]	Utrecht	NOTSA	Uni-Graz	UCAM				
Person-months[9]	4	4	5 (4)	4				

Other participants[10]:

- ✓ Laboratoire Universitaire d'Astrophysique de Nice (LUAN), France
- ✓ Jodrell Bank Observatory, United Kingdom

Summary of Objectives and progress made:

WP1.: Co-ordination of scientific communities at ENO:

WP1.1.: Dissemination of good practices:
One general NA2 meeting was organized in 2008, after the last OPTICON Board meeting held in Oporto. Assessment was focussed in main achievements of this networking activity highlighting the success of the LTCS and JIS as well as the excellent results achieved for the coordination actions on Site Characterization. Likewise, it was pointed out the key role of the public outreach group for the integration of the institutions at both Canary Islands' Astronomical Observatories.

WP1.2.: Laser Traffic Control System (LTCS) for ORM:
All the deliverables expected under this work package have been already accomplished. The LTCS system is installed on the WHT telescope and is fully operational.

WP2.: Site Characterisation of the Canary Islands' Observatories:
The ORM is one of the four short listed sites for hosting the E-ELT (the other ones are Ventarrones, Chile; Macon, Argentina, and Aklim, Morocco). Both optical and meteorological conditions analysis at all sites are crucial for final selection. With this aim, a

[4] Lead participant first
[5] Use the same contractor short names and numbers indicated in the table "list of participants" in Annex I of your contract.
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[7] Lead participant first
[8] Use the same contractor short names and numbers indicated in the table "list of participants" in Annex I of your contract.
[9] AC contractors must include both the total estimated human effort (including permanent staff) and, in brackets, additional staff only.
[10] No resources have been made available on the basis of prior agreements. Their participation is related to the attendance of meetings. No costs or resources are identified in Annex I of the contract for their participation

continuous site-testing campaign at the Degollada del Hoyo Verde at the ORM has been carried out using a MASS-DIMM on a 5m tower for turbulence parameters measurements and an Automatic Weather Station to measure meteorological parameters.

Automatic software to obtain the atmospheric turbulence profiles in quasi real time from G-SCIDAR observations has been developed. This software has been successfully tested and it will be installed at the Cute-SCIDAR instrument installed in the Roque de los Muchachos observatory (ORM).

DIMMA installation has been completed at both observatories (ORM & OT) and efforts are being focussed in their daily operation and calibration.

The working group has participated in the main forums related to ELT Design Study and the organization of SUCOSIP in November 2008.

WP3.: Joint Information System and Transfer of Knowledge:

WP3.1.: Development of a Joint Information System for Solar Physics (JIS):
Main efforts have been focussed in the promotion of this tool among the international solar physics community at appropriate forums/meetings. As a consequence, the Joint Information System has registered a considerable number of solar physicists along Europe.

WP3.2.: Co-ordinated actions on transfer of knowledge and public outreach:
One meeting was organized in 2008. Among the main results achieved during this last year we emphasize the following ones: Organization of the initiative "The Universe within reach" including several talks and a touring exhibition, compilation of audiovisual contents for the joint Public Outreach Website (http://www.eno.iac.es) in order to improve the exchange and distribution of information related to the ENO facilities, Open Days at ORM & OT during the summer and the edition of the digital publication (astroNewsletter) available in English and Spanish.

WP1: Co-ordination of scientific communities at ENO

WP 1.1 Dissemination of good practices:
After the last NA2-ENO meeting organized in La Palma, December 2007, a progress report was circulated on May 14th with the assessment of the different work packages, and particular attention to the ongoing activities on Public Outreach and Site Characterization. Likewise, the main outcomes of the Laser Traffic Control System (LTCS) as well as the Joint information System (JIS) for Solar Physics, which were properly accomplished during last year, were summarised.

With regard to the plans beyond NA2, only a network on the topic of Site Characterization was proposed and included in the OPTICON–FP7 proposal. Although this network, together with the other OPTICON activities, was positively evaluated by the EC, the financial cut applied to the proposal forced its withdrawal.

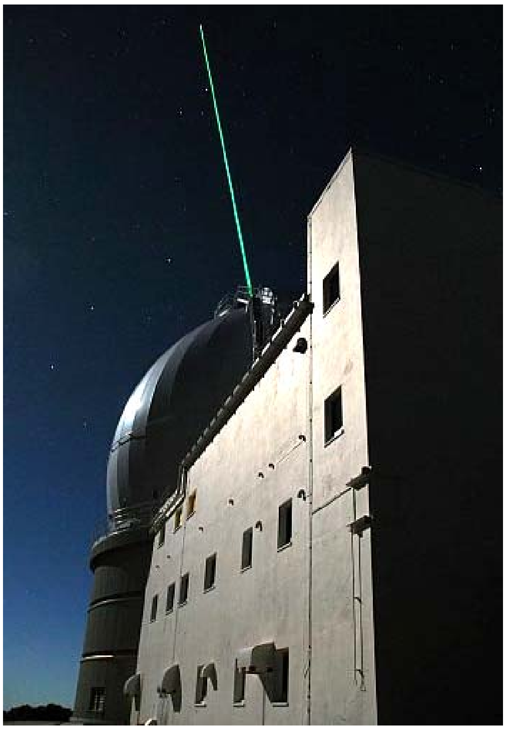
Finally, A. Sosa, as representative of the NA2 activity in the last OPTICON Board meeting held in Portugal (Porto. November 10-11th 2008) summarised the main activities carried out by the several working groups during this five-year contract.

WP1.2: Laser Traffic Control System (LTCS) for ORM

From the results of the tests done with INT and MAGIC telescopes, it became clear that the WHT laser can interfere with observations of other telescopes and affect their results. This stressed the importance of the Laser Traffic Control System.

The EU funding available during last years made possible the implementation of the LTCS system at WHT, which will protect the observations of the other telescopes. The system has already been tested successfully during the GLAS commissioning nights.

Finally the LTCS is designed to support a site with more than one laser operating simultaneously, and if in the future another telescope is equipped with a laser, it will be easy to integrate it in the already existing system.



Laser beacon at the WHT

Thus, all deliverables expected under this work package were accomplished in 2007. The LTCS system is installed on the WHT telescope and is fully operative.

The complete final report can be downloaded as paper 06/07 at the following Web address: http://www.otri.iac.es/na2/ver_meeting.php?id=27&id_proyecto=1 (see **Section 3: Use and dissemination of knowledge)**

WP2: Site Characterisation of the Canary Islands' Observatories.

Draft about the Sky transparency Parameter

During 2008 main efforts have been focussed in the operation and comparison of the different seeing monitors (DIMM, MASS DIMM, DIMMAs, RoboDIMM, etc.) as well as the dissemination of results achieved. As part of this promotional action several handouts are being developed about the following parameters: Photometric nights, Seeing statistical results, Vertical Turbulence Profiles, Atmospheric Extinction, Meteorology at the ORM, Wind speed and wind gusts, Inversion Layer at the Canary Islands, Visible sky brightness, Infrared Sky Background, Emission spectrum, Laser guide stars, Na layer, ING (CONCAM), Climatic trends, Seismicity, Surface Ozone, Extreme weather conditions.

Site Characterization Website at the IAC. http://www.iac.es/site-testing/.

To the section 'Recent Summaries-Annual Seeing Summary' of the website, has been added the seeing measurements at the ORM since 1994. Also available is the Canaries observatories' contribution to the '2008 ESO-SSAC' outstanding information about Climate history, Clear nights, Weather statistics, Water Vapour, Equipment deployed and Soil properties.

The bibliography has been improved with 'Referred Papers' and 'Conference-Proceedings' which deal about the history of the sky characterization of the Canary Islands' Astronomical observatories. See **Section 3: Use and dissemination of knowledge.**

Real-time data access has been added to the weather stations, with information from the Meteosat9 satellite including clouds and water vapour. Moreover, a series of web-tools to provide information on the scheduling, data acquisition and to visualise the data have been developed.

WP2.1 Co-ordination of night-time seeing measurements with DIMMs:

In January 2008 the MASS-DIMM was installed at the Degollada del Hoyo Verde. In order to guarantee its operation, it was necessary to deploy a WIFI connection in the area as well as the tower. The MASS-DIMM will work for the E-ELT site selection (FP6 project) and provide atmospheric turbulence parameters including integrated seeing.

Picture showing the situation of the two systems: IAC-DIMM and MASS-DIMM. The place that can be seen is not the one where the observations were carried out, but the relative distances between the systems are very similar. Note the differences in height due to tripods.

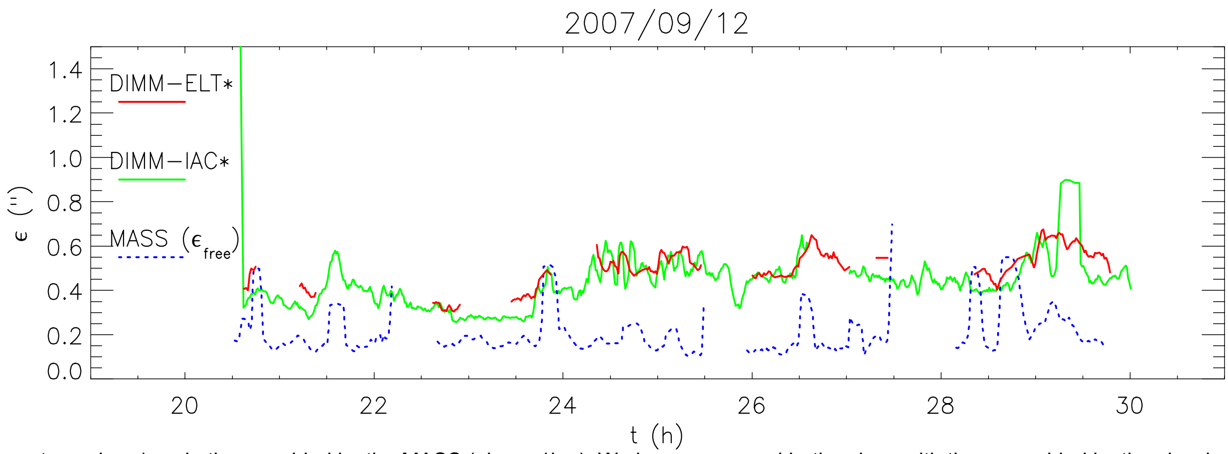
WP2.1.1 IACDIMM and MASS-DIMM calibration.

Under the Site characterization activity and as part of the selection campaign for the future E-ELT site, a MASS-DIMM was installed at the ORM, at the previous site of the IAC-DIM. The MASS (Multi Aperture Scintillation Sensor) makes it possible to take samples of vertical profile atmospheric turbulences, bearing in mind that it has low resolution at lower layers and a DIMM (Differential Image Motion Monitor) which provides an integral measure of the whole atmospheric turbulences.

The intensity of the turbulences at the lower layer can be measured using both of them, called the MASS-DIMM. Other MASS-DIMMs with the same specifications will be operating in selected sites for the E-ELT.

The latest results of the calibration campaign are shown in the following figure:

Figure: MASS-DIMM provides two seeing values: one recorded by the DIMM (from the ground to infinity, integrating full



atmosphere) and other provided by the MASS (above 1km). We have compared both values with those provided by the classical IAC/DIMM. There is good agreement between seeing measured by MASS-DIMM (red points) and IAC/DIMM (green points). The free atmosphere seeing provided by MASS (black points) device is, as expected, always lower as it does not include the first kilometre. The time evolution of "seeing" values retrieved by both exhibit highly correlated variations, showing the same main features.

The main results can be summarised as follows:

1. There is good agreement between MASS-DIMM and IAC-DIMM measurements. The time evolution of seeing values retrieved by both exhibit highly correlated variations, showing the same main features.
2. The free seeing provided by MASS device of MASS-DIMM is lower than that observed by DIMM part.
3. Seeing values from DIMM devices were compared. The histogram of their relative differences fits well with a normal distribution with mean value 4.5% and standard deviation 22.4%. For a seeing value of 1.5", this means that the mean difference between instrument measurements is expected to be 0.07" ± 0.34", with the DIMM part of the MASS-DIMM device expected to be higher than that of IAC-DIMM.

The complete technical information is available in a document, see **Section 3: Use and dissemination of knowledge.**

WP2.1.2 DIMMA

In January 2008 solar panels and batteries were mounted to make the DIMMA (at Las Lajitas, ORM) self powered. After a commissioning time, some incidents related to the dome were detected. This setback was overcome by improving the software of the dome. The DIMMA has been fully operative since March 2008.

Close to the DIMMA we have installed a concrete pillar and the DIMM has been mounted on this. The preliminary results showed a good agreement between the DIMMA and the DIMM. The following figure shows the seeing values (full width half maximum longitudinal and transversal) measured by the DIMMA in March 2008.

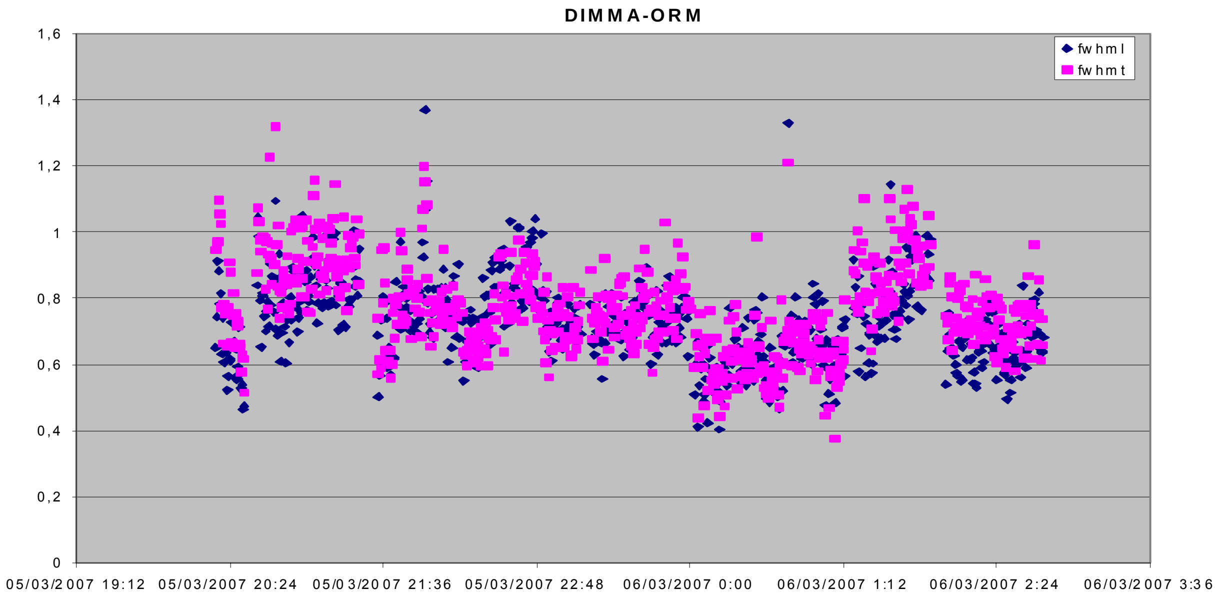


Figure: Seeing profiles (fwhml and fwhmt) provided by the ORM DIMMA. The ORM DIMMA has been operational since March 2008 at Las Lajitas. More batteries and solar panels were required for fully automatic operation. The DIMM operates next to the DIMMA for comparison of data.

WP2.2 Co-ordination of day-time seeing measurements at ORM

Daytime seeing provided by the DOT has been recently incorporated at the IAC site testing web page.

The DOT has a database online, containing all multi-wavelength high-resolution films of photosphere and chromosphere of the sun collected since the autumn of 1999. It is freely accessible thanks to the DOT open data policy. All data is speckle-reconstructed and stored as films and single images, nicely aligned in the form of data cubes, on a high-volume data server in order to make the data easily accessible. Part of the database is a user-friendly graphical interface showing for every day with worthwhile data a thumbnail pictorial index of what was collected. A search engine has been available since February 2008. This helps finding specific data and accepts many search criteria. It should be pointed out that the database provides also information of the seeing quality (Fried parameter, r0), which can be used for seeing analysis. For every observing run, the average, maximum and minimum r0 values, in 15 to 30 seconds cadence, are given and one can ask for a graph showing all values of the run. The database is accessible via the DOT website http://dotdb.phys.uu.nl/search/ or via http://dot.astro.uu.nl/DOT_data.html.

Apart from these telescope seeing measurements, the DOT is at this moment being equipped with a network of temperature-, wind- and pressure sensors which will monitor the local conditions around the telescope, in order to study in more detail local seeing effects.

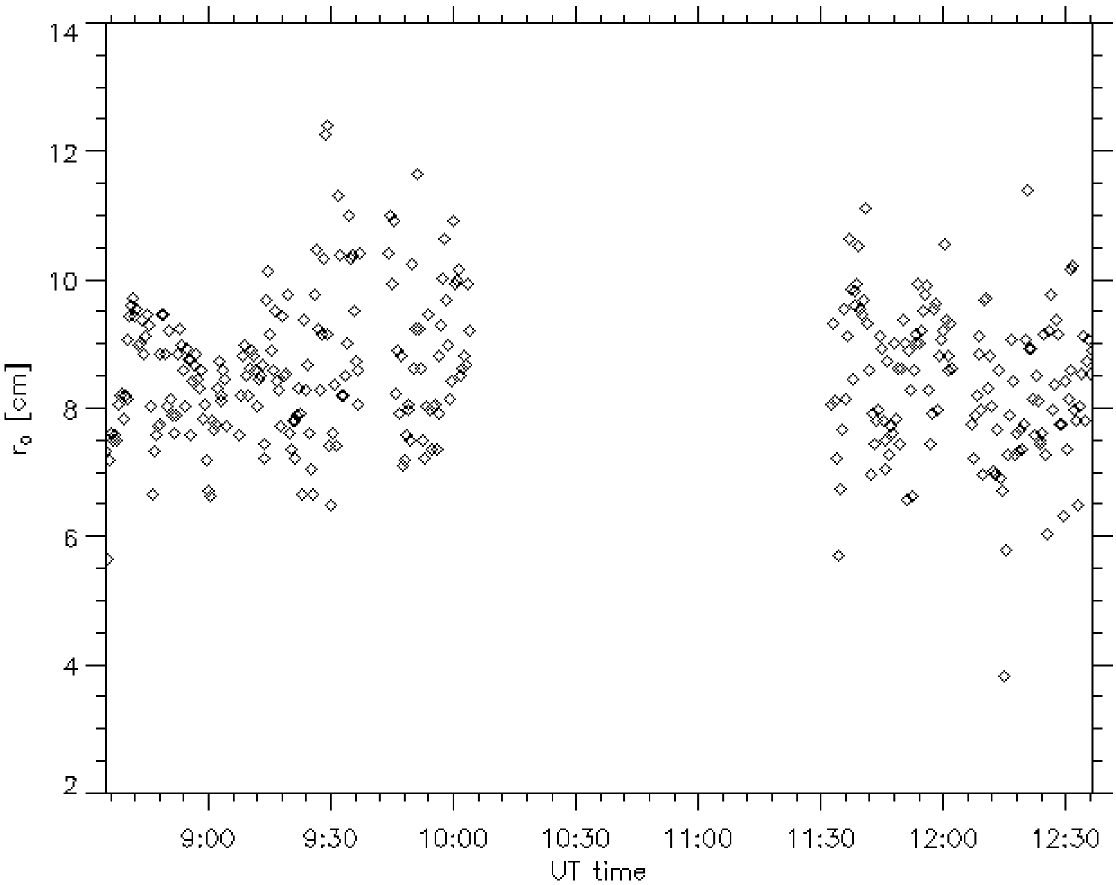


Figure: Example of an r0 plot from the DOT database.
Target : Quiet sun - Type : Speckle reconstructed data - Time : 08:35 - 12:36 UT
Location : / μ=0. Mees AR Map Quality r0 : (G-band avg-max-min): 8.5 - 12.4 - 3.8
Data kindly provided by DOT team (contact F.C.M.Bettonvil@uu.nl).

WP2.3 Joint actions for meteorology, dust, extinction and Sky Background:

ING, NOT, TNG, MAGIC, and IAC weather stations at the ORM and IAC, GONG and BRT weather stations at the OT remain in operation providing continuous meteorological data.
(http://www.otri.iac.es/na2/weather_conditions.html). A total of nine weather stations are included in this website.

With regard to the parameters obtained from NOT, they are available at the 'Archive-Content Panel' section with meteorological information since 1997 and about aerosols since 2007. More details at: http://www.not.iac.es/weather/index.php

Figure: Joint meteor webs at both observatories

WP2.3.1 Local Dust:

The IAC airborne particle counter has been removed to be calibrated by Vertex. It was installed at the NOT telescope and it is operating with a sample rate of one data every minute. Main properties:

6 channels: 0,3 – 0,5 -1 –3 – 5- 10μm
Caudal: 1 c.f.m.
Light source: laser diode

The sensitivity of an airborne particle counter is determined by the size of the smallest particle the unit can detect. This one has sensitivity of 0,3microns with 95% percentage.

The data of the aerosol measurements are available at the site-testing website under the instrumentation section where it is possible to choose from the different channels data since May 2007. In the following figure we show the mass of airborne particles (including dust) measured in September 2008.

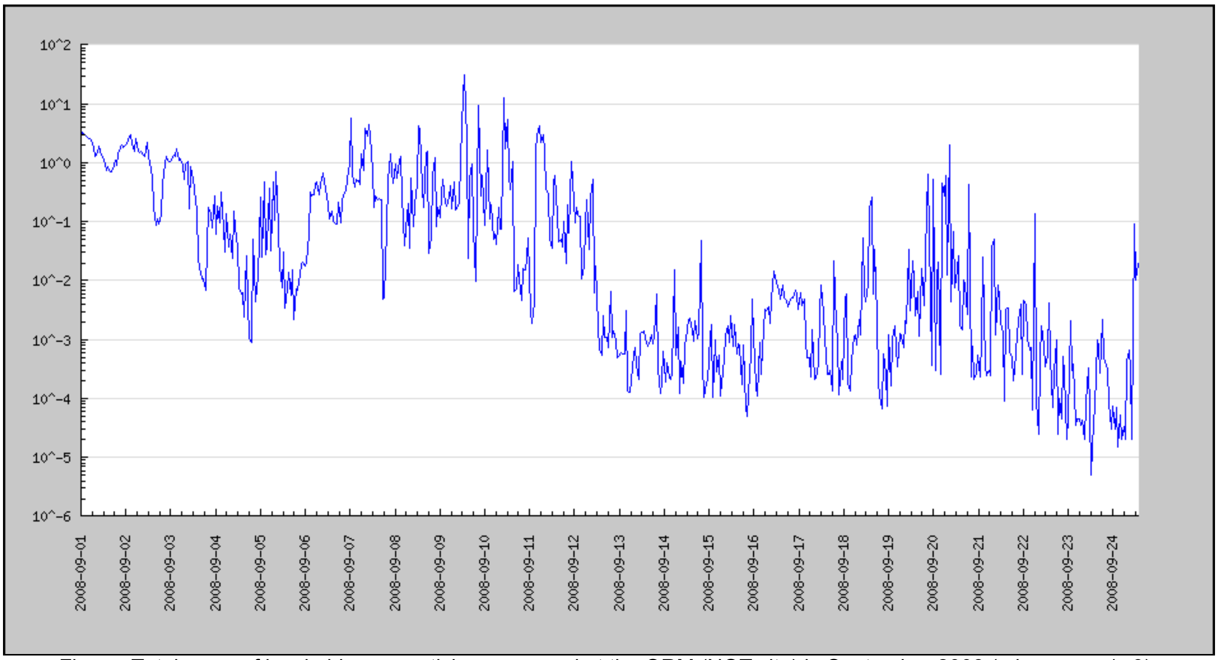


Figure: Total mass of local airborne particles measured at the ORM (NOT site) in September 2008 (micrograms/m3).

- The IAC dust meter is similar to the Airborne Aerosols Counter at Paranal http://www.eso.org/gen-fac/pubs/astclim/paranal/aerosol/

WP2.3.2 Atmospheric extinction

The atmospheric extinction can be measured by using in situ techniques (airborne particle counters, telescopes, etc) or satellite data. However the usefulness of satellite data for characterizing the aerosol content above the atmosphere of an astronomical observatory is determined by the correlation between the aerosol index (also called aerosol optical thickness) and the atmospheric extinction.

In previous works we concluded that aerosol parameters provided by TOMS was not a appropriate tool for site characterization due to its low resolution and inadequate channels and a new publication in the 'Mon.Not.R.Astron.Soc' was published in October 2008, 'Astronomical site selection: On the use of satellite data for aerosol content monitoring'. It confirms that aerosol data provided by satellites are not yet reliable enough for aerosol site characterization, and in situ data are required.

The analysis of new approaches to the study of the properties of astronomical sites is the main goal of a joint action started on April 2006 between the Sky Quality Group of the IAC and the Padova University (Dr. S. Ortolani and C. Bertolin). In particular, satellite data measuring aerosols have recently been proposed as a useful technique for site characterization and searching for new sites to host future very large telescopes. Nevertheless, these data need to be critically considered and interpreted in accordance with the spatial resolution and spectroscopic channels used. In this paper we have explored and retrieved measurements from satellites with high spatial and temporal resolutions and concentrated on channels of astronomical interest. The selected datasets are OMI on board the NASA Aura satellite and MODIS on board the NASA Terra and Aqua satellites. A comparison of remote sensing and in situ techniques is discussed. As a result, we find that aerosol data provided by satellites up to now are not reliable enough for aerosol site characterization, and in situ data are required.

See **Section 3: Use and dissemination of knowledge** for details of the above publication.

WP2.3.3 Atmospheric extinction

The fraction of useful time is a key parameter for site characterization. A summary of percentages of clear nights at ORM has been recently added at the site-testing website under "Canary Islands' Astronomical Observatories (ORM & OT) contribution to 2008 ESO-SSAC report" with:

The fraction of useful time at ORM is with In-situ measurements:

- 78% from Murdin, 1985.
- 75% is deduced over 11-years (1989-2000) ING Annual Report 1999 & Rutten, 2001 .
- 72.7% - 77.5% over 4-years (2000-2003) from Lombardi et al., 2006

The fraction of useful time at ORM is with data from satellites:

-83.7% is the photometric time at the ORM, from A Study conducted for ESO, Erasmus & van Rooyen, 2006

WP2.3.4 Meteorological common database:

All ORM real time meteorological data and site parameters are provided by the NOT web page at http://www.not.iac.es/weather/index.php

WP 2.4 Joint actions for Measurement of turbulence and wind vertical profiles.

Participants in this work package have developed software to filter a spurious low level noise detected in the perpendicular axis of the autocorrelations needed in Generalized-SCIDAR (G-S). This software has been tested and implemented in the Cute-SCIDAR installed at Paranal Observatory.

The software, developed the last semester by this team for the Paranal Observatory within The "European Extremely Large Telescope Design Study" (FP6-WP12000) to obtain the atmospheric turbulence profiles in quasi real time from G-S observations, is in the process of being installed in the Cute-SCIDAR instrument installed at Roque de los Muchachos Observatory (ORM), including the low level noise filtering algorithm. This work package involves software and hardware modifications (both in the computers and mechanical pieces) that are been carried out.

A gradual drop in the signal to noise ratio (SNR) was detected during 2007. Several maintenance works to improve the SNR in G-S at ORM have been carried out. We compared the SNR of two different detectors installed in the instrument in different runs. The CCD showing the best behaviour was selected and is now permanently installed in the instrument. The JKT telescope primary mirror cleaning was also carried out by the Isaac Newton Group in January 2008. The whole reflectivity increased ~25%.

We have continued with the systematic turbulence monitoring runs at Teide Observatory (OT) and Roque de los Muchachos Observatory (ORM) with G-S technique. Observations have been performed on a basis of 8 nights per month at ORM and 4 nights per month at OT. ORM runs are carried out with a fixed frame, temporally centred in the new moon (dark nights). G-S data are reduced and backed up, both in DVDs and DAT tapes..

As well as the daily electronic log that is filled out each night of observation with G-S, a specific electronic log has been set up (first filled in March) to summarize the complete run aspects, including the useful time percentage.

The large statistical coverage (since 2002) has allowed us to analyse the seasonal evolution of the turbulence vertical structure above both Canary Islands observatories (ORM and OT). The results obtained provide the required data to establish the limits for the Adaptive Optics systems, through the input parameters: Fried parameter, isoplanatic angle and coherence time.

The papers and publication details for this WP are listed in **Section 3: Use and dissemination of knowledge**.

WP 2.5 Distribution and discussion of results and participation at scientific forums.

Representatives of the working group have participated on the following forums in 2008:

Name of Meeting	Date and Location	Web address
OSC meeting	27 February 2008 La Palma	http://www.otri.iac.es/na2/
SPIE: Remote Sensing	June 08 Florence	
OTAM: Optical Turbulence Astronomy meets Meteorology	15-18 September 2008 Alghero, Sardegna (Italy)	http://forot.arcetri.astro.it/otam-08/

FP6 meeting	1-3 Jule 2008 Nice, France	http://www.iac.es/site-testing/
OSC meeting	15 October 2008 La Palma	http://www.otri.iac.es/na2/

WP3: Joint Information System and Transfer of Knowledge

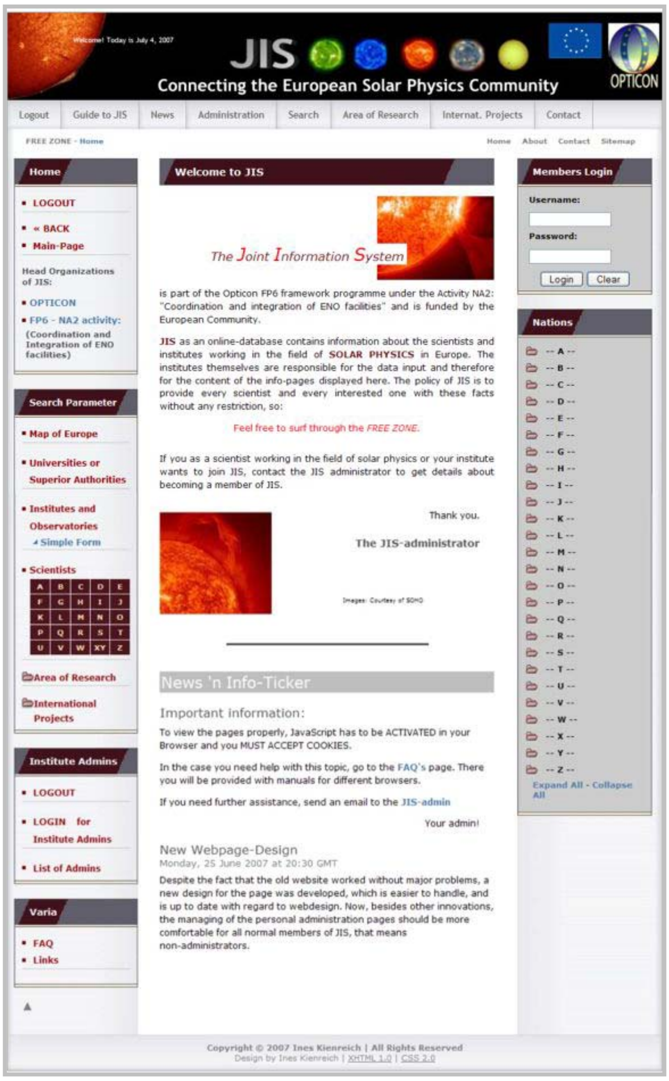
WP3.1: Development of a Joint Information System for Solar Physics (JIS):

The Joint Information System (JIS) is a computing tool, which is a combination of a database and interactive web pages, reachable under the web address http://www.solarJIS.com. Over the last year the working group has concentrated efforts in promotional and maintenance activities of this tool. Further promotional events/seminars are expected in France, Austria and Germany.

JIS as an online-database contains information about the scientists and institutes working in the field of SOLAR PHYSICS in Europe. The institutes themselves are responsible for the data input and therefore for the content of the info-pages displayed here. The policy of JIS is to provide every scientist and every other interested person with these facts without any restriction.

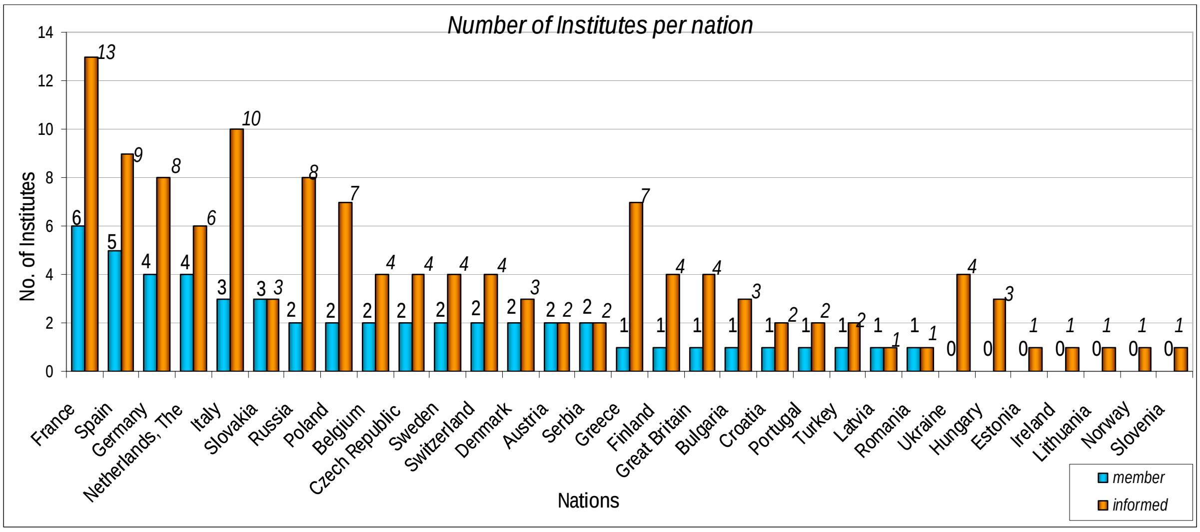
The JIS should ease the life of a scientist, because he/she doesn't need to search the internet to find other scientists/institutes working in a special field of work. He/she simply logs into the page and can find all information he/she needs.

A complete set of supporting documents have been updated or elaborated (available on the Website):
Guide for Administrators: contains information for handling the data input
Duties of the Administrator
Questionnaire for institutes/observatories joining JIS:

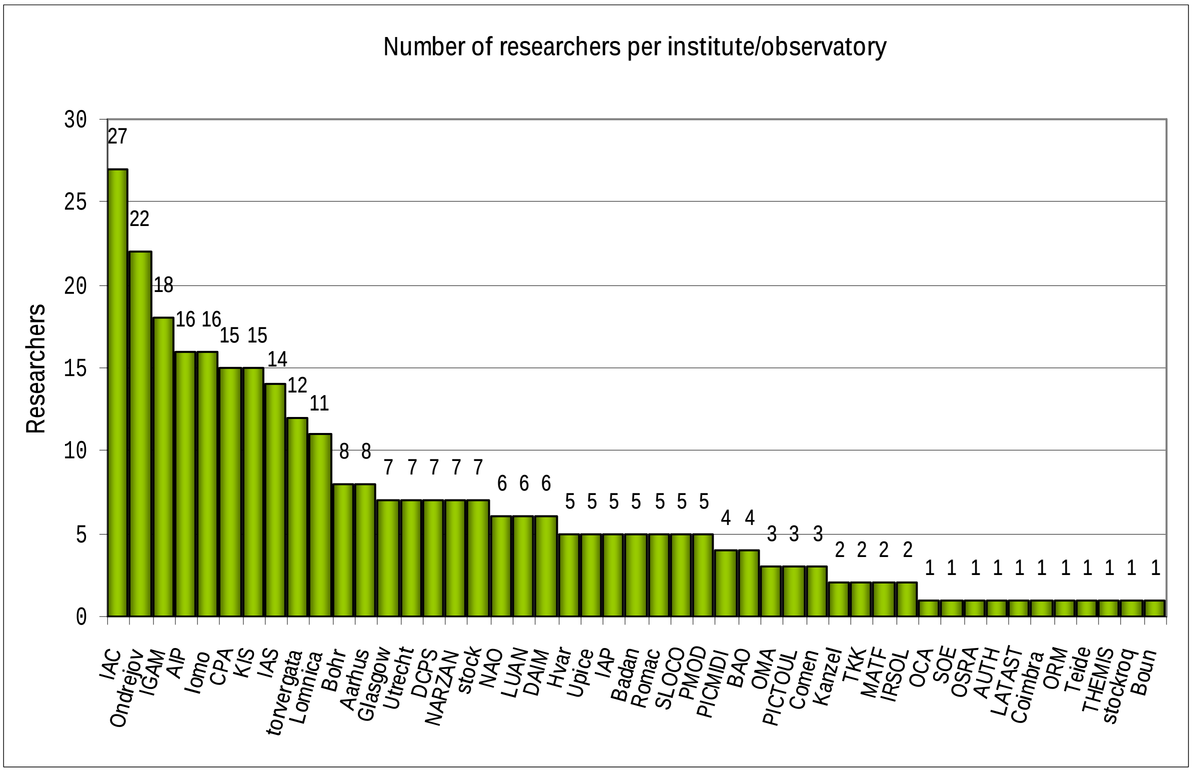


New layout of the JIS Website

A total of 125 institutions have been notified about the JIS tool and how to register their institutions and researchers. As a result of this promotional action a total of 57 institutions from 25 different countries have been included in our database (see next table)



Around 307 researchers have been already registered from 47 different institutes/observatories (see following graph).



WP3.2: Co-ordinated actions on transfer of knowledge and public outreach:
The ninth coordination meeting of the group was organized last February 15th in La Palma. The main actions to be carried out in 2008 were proposed and planned.
Among such actions we emphasize the following ones: reinforcement of the Public Outreach Website, organization of Open Days at ORM & OT, a touring exhibition on the Tenerife tram, elaboration of specific audiovisuals for each facility, distribution of new promotional material (AstroNewsletter) and the final installation of new permanent panels at ORM.
The Public Outreach working group has also collaborated with the UNAWE International Initiative (Universe Awareness for Young Children) to foster the exchange of astronomical outreach material and to promote a durable collaboration between both initiatives. In this way, a set of didactic units for children has been elaborated to improve the astronomy public outreach in developing countries (see figure on the right).

***WP3.2.1* Public Outreach Website: www.eno.iac.es**
New sections for the joint ENO Website have been implemented, including new promotional material and much relevant news related to the Canary Islands' astronomical observatories.
A new and final Website layout will be available shortly (see figure on the right) with a user-friendly structure and contents. The website includes now a detailed list of specifications and links to the different facilities of the Canary Islands' Astronomical Observatories. The idea is to keep this website quite independent of daily maintenance.

A special section with downloadable self explanatory astronomical sheets for children will be included.

After 2008, this website will continue to guarantee access to the educational and promotional material which has been developed.

New layout expected for the Web: www.eno.iac.es

WP3.2.2 Short audiovisuals “ASTRONOMICAL FACILITIES AT THE CANARY ISLANDS’ OBSERVATORIES”

The Public Outreach working group and collaborators of the Canary Islands’ astronomical observatories have produced a final series of short audiovisuals that display in depth the characteristics of the astronomical facilities in these observatories. This initiative seeks to bring to the non-specialized audience the science that takes place in ORM and OT. It is a project based in Information and Communications Technologies to allow access to educational and latest information.

Panoramic shots, close-ups, day and night scenes and breathtaking astronomical images are carefully mixed to offer a collection that will help us to illustrate our telescopes in detail. Thanks to the collaboration of several astronomers on both observatories, the bank of images of various astronomical telescopes and the technical team, this initiative will be ready soon.

There are a total of 16 audiovisuals of two minutes of average duration and with English and Spanish subtitles. This new collection complements the DVD "The astrophysical observatory in the Canary Islands” as well as other audiovisual contents included in the ENO website.

WP3.2.3 Tram Exhibition and Astronomical talks at the Science Museum.

The Public outreach working group of the Canary Islands’ Astronomical Observatories has taken a step forwards in its communicating astronomy role by setting up a touring exhibition in one of the trams connecting the cities of La Laguna and Santa Cruz de Tenerife.

This activity was inaugurated in May 2008 on the occasion of the Canary Islands' Day, and went on until the end of July, under the framework of the "The Universe within reach" initiative, an innovative way of promoting Astronomy fostered by the international astrophysical community among the general public, especially in Tenerife.

The whole sign tram has become a touring exhibition, including some of the most powerful images ever taken at the telescopes located in Tenerife and La Palma islands.

The itinerary of the "astronomical" tram has been reinforced by setting up several distribution points with promotional material produced by the working group, with special emphasis on the activities programmed for summer 2008.

A thematic website was developed to complement the contents of the touring exhibition, available through the web address: www.elcielodecanarias.es. Specific information of the Canary Islands' Astronomical Observatories, the implementation plan of the working group and links to different audiovisual content was included in the website.

The visual impact of this initiative has been assessed not only with the registered visit to the website but also with the great participation of public in the programmed activities of June 2008.

Several lectures about the Moon, the Sun, the history of astronomy and the Archeoastronomy, as well as an innovative show call “Magic of the stars”, took place at the Science & Cosmos Museum in Tenerife with successful feedback from the general public.

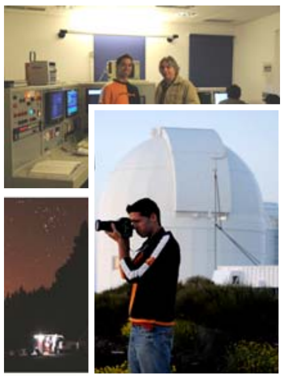
To bring astronomy closer to everyone, particularly young people, by showing them new ways to learn about the universe, the collaboration of Metropolitano de Tenerife has contributed in a positive way to our efforts at communication, guaranteeing a successful milestone to be taken into account with a view to the current International Year of Astronomy (IYA 2009).

WP3.2.4 astroNewsletter of the Observatories in the Canary Islands
This publication is available at the ENO Website, containing news, articles and events related to the Observatories. By circulating this new online publication we are fostering the dissemination of the science carried out at Canary Islands’ Astronomical Observatories among the general public. The astroNewsletter can be downloaded in Spanish and English. It can be easily distributed through mailing lists (no printed version is expected).

Three numbers have been already published in 2008: in January, April and September.

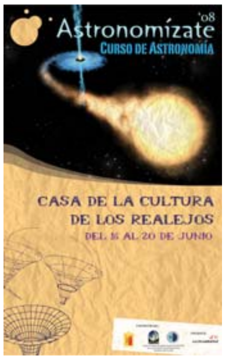
Moreover it is expected to produce a final issue by the end of the year, including several articles related to the operation of the telescopes, the most relevant scientific outputs, programme of activities expected for the IYA 2009 and the role of the ORM as candidate Site for the installation of the E-ELT.

WP3.2.5 Specifics visits to the Observatories
Last November a thematic visit to the Teide Observatory for students of the UNED University studying astronomy was organized. The visit was organized by Dra. Mª Antonia Varela, who guided the group throughout their stay at the observatory. Several talks by telescope operators and astronomers as well as an introductory observation of the sky contributed to this pilot experience. This initiative takes part of the set of activities



planned under the national approved proposal.

In May 2008, under the agreement with the Art School “Fernando Estévez” a workshop in astrophotography was organized at Teide Observatory.



In June 2008, the Public Outreach activity collaborated in the workshop “Astronomízate” organized by the city council of Los Realejos in Tenerife. A visit to the Teide Observatory was offered to the participants, including live observations and a guided visit to the OT facilities.

WP3.2.6: 2008 Open-doors Day

The “The Universe at your hands” initiative had as its main activity the organization of the Open-days visit to the Teide Observatory, taking place on June the 27th and 28th.

The ORM organized several visits in July and August during the weekends.

As in previous years, the Public Outreach working group has collaborated in the organization of such Open-doors Day at both observatories, receiving more than 3500 visitors during the summer.

Promotional material developed by the working group was distributed at these events, complementing the guided visit and the organized activities (live observations and workshops).

The long collaboration set up by members of the several facilities operating at both observatories should continue to guarantee future concerted promotional actions, especially next year with the celebration of the IYA 2009.

Milestones and Deliverables achieved:

Deliverable/ Milestone No	Deliverable/Milestone Name	Work-package /Task No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
D1	Updated Progress report	WP1.1	IAC	60	60
M1	Regular ENO meetings	WP1.1	IAC, IOA-KUL, INAF, NOTSA, THEMIS, IFAE, UCAM, Jodrell Bank.	58	58
M4	Dissemination of results	WP2.1	IAC	58	60
D1	Measurements of extinction and dust	WP2.3	IAC	58	60
M1	Campaigns at OT & ORM	WP2.4	IAC	58	58
D1	Annual Report on discussion forums for site-selection	WP2.5	IAC	58	60
M1	Workshop	WP2.5	IAC	56	Did not take place
D3	Compendium and Publication of results	WP2.5	IAC	60	60
D6	Annual Report with the maintenance activities carried out	WP3.1	IAC	60	60
D7	Report of the promotional activities related to JIS	WP3.1	IAC	59	60
M1	Open-doors days at OT and ORM	WP3.2	IAC, STFC, INAF, IOA-KUL, IFAE	54 -55	54 -55
D1	New editions of outreach material	WP3.2	IAC, STFC, INAF, IOA-KUL, IFAE	58	55-60
D3	ENO website. Updated version	WP3.2.	IAC, STFC, INAF, IOA-KUL, IFAE	60	60
D5	Exhibition elements and educational material	WP3.2	IAC, STFC, INAF, IOA-KUL, IFAE	54	54

Meetings and Workshops table

WP1.1 Dissemination of good practices

Date	Title/subject of meeting /workshop	Location	Number of Attendees	Website address
24th November 2008	Eighth ENO meeting	La Palma	8	http://www.otri.iac.es/na2/
10-11th November 2008	OPTICON Board meeting	Oporto	27	http://www.astro-opticon.org/mtr.html

WP2 Site Characterisation of the Canaries Observatories

Date	Title/subject of meeting /workshop	Location	Number of Attendees	Website address
27 February 2008	OSC meeting	La Palma	12	http://www.otri.iac.es/na2/
June 08	SPIE: Remote Sensing	Florence	100	http://www.otri.iac.es/na2/
15-18 September 2008	OTAM: Optical Turbulence Astronomy meets Meteorology	Alghero, Sardegna (Italy)	64	http://forot.arcetri.astro.it/otam-08/
1-3 July 2008	FP6 meeting	Nice, France	15	http://www.iac.es/site-testing/
15 October 2008	OSC meeting	La Palma	12	http://www.otri.iac.es/na2/
24 November 08	SUCOSIP	La Palma	8	http://www.otri.iac.es/na2/

WP3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities

Date	Title/subject of meeting /workshop	Location	Number of Attendees	Website address
1-6 June 2008	JIS presentation	IHY Meeting at Sozopol, Bulgaria,	25	http://www.solarjis.com
8.-12. Sep 2008	JIS presentation	EPS Meeting at KIS, Freiburg,	25	http://www.solarjis.com
29 April 2008	JIS presentation	Toulouse University,France.	30	http://www.joso-info.org
Aug 2008	JIS presentation	Hvar Astrophys. Coll, Austria,	30	http://www.solarjis.com

WP 3.2 Co-ordinated actions on transfer of knowledge and public outreach

Date	Title/subject of meeting /workshop	Location	Number of Attendees	Web address
21st January 2008	9th Coordination meeting	La Palma	11	http://www.otri.iac.es/na2/

1.3.2 NA3: Structuring European Astronomy

Participant number	2	2b	
Participant short name	STFC	UKATC	**Total**
Person-months	(WP5 = 4.2)	4.73	**8.93**

WP1: ELT

Introduction
The objective of N3.1 is to develop the science case for an Extremely Large Telescope (ELT). The activity involves over 100 astronomers from around Europe.

In previous years we have sponsored a series of meetings on the ELT science case and produced a science case document and executive summary. In April 2006 the OPTICON science case activity merged with the then newly-formed ESO ELT Science Working Group. The resulting joint SWG continues to provide close scientific guidance to the project, and the OPTICON ELT project scientist (I. Hook) is joint Chair of the SWG.

Progress
Since the 2007 annual report the following activities have been carried out or are underway.

- OPTICON jointly sponsored (and organised) a session on ELT science in Vienna, Austria on 8-12 September 2008, connected with the JENAM. The session was well attended (about 100 participants). 22 presentations were given, 6 of which were about the status of the project and the remainder on science and instrumentation. More information can be found at http://www.eso.org/sci/facilities/eelt/science/meetings/jenam08/ and in a summary article by G. Monnet, in The Messenger (ESO).

- The SWG held two in-person meetings and four telecons in 2008. Information about the SWG activities, meetings and resolutions can be found at http://www.eso.org/sci/facilities/eelt/science/

- Development of the Design Reference Mission has continued, using as input the observing proposals produced by the SWG. The SWG has monitored progress on simulations of these cases (carried out outside the OPTICON programme, largely within a dedicated WP in the EU FP7 "ELT Prep Phase" programme). The DRM has already been used to help guide SWG discussions on instrumentation specifications, which in turn influenced the specifications of ESO's calls for ELT instrument studies. The DRM is now being used to guide discussions on the impact of the site choice on science.

- A final report on the science case as it stands at the end of OPTICON FP6 has been produced (deliverable N3.1 D2)

- The SWG web site has now been integrated into the E-ELT project web pages hosted at ESO: http://www.eso.org/sci/facilities/eelt/science/. The OPTICON ELT mailing list continues to be maintained and has been used to distribute various ELT announcements.

- Preparation for the start of the OPTICON FP7 programme has been carried out. The approved OPTICON FP7 programme includes a networking activity for the next phase of ELT science case development, during which the project will seek funds for construction, and the first phase of the instrumentation suite will be defined. This OPTICON networking activity will play an important role in providing continued community scientific input to the project during this key period through the organisation of science meetings.

WP2: Network for UV Astronomy (NUVA)

Coordination and Management of the European Network for UV Astronomy (NUVA). The Network is constituted by 120 European astronomers with strong connections with USA, Russia, India and China. The board of the network is composed of:

Board Member	Institution	NUVA Responsibilities	Scientific Background
Ana I. Gómez de Castro	Univ. Complutense de Madrid, Spain	Chair Coordination with Virtual Obs., Web site	Formation of stars Jets & Disks
Michel Dennefeld	Inst. Astrophysique de Paris, France	Coordinations with Ground Based telescopes	Galaxy Formation and Chemical Evolution
Noah Brosch	Tel-Aviv University, Israel	UV detectors Multiwavelength surveys	Solar System, Star Formationin Dwarf Galaxies and Surveys
Norbert Kappelmann	University of Tuebingen, Germany	UV Instrumentation	UV Instrumentation
Martin A. Barstow	Univ. of Leicester, UK	UV detectors	White Dwarfs and Interstellar Medium
Isabella Pagano	INAF-Catania, Italy	Coordination with high energy astrophysics	Cool stars
Boris Shustov	Inst. Astron. Russian Academy of Sciences, Russia	Coordination with Russia	Star Formation Interstellar & Intergalactic Medium
Domitilla de Martino	INAF-OACNa, Italy		Interacting Binaries
Huib Heinrichs	Univ. of Amsterdam, The Netherlands		Massive Stars
Wollfram Kollatschny	US Goettingen, Germany		Active Galactic Nucleii

Introduction /Objectives:

The Network for UltraViolet Astronomy objectives were to:

- Formulate and operate a UV astronomy Network
- Plan and execute a road mapping activity
- Carry out exploratory analysis to define scientific requirements for the future and critical assessment of the publicly available information in various archives.

Progress in 2008

A NUVA board meeting was held in Madrid in May 2008. The objective of the meeting was to review the status of the documentation to be delivered to the EU. It was decided that the most appropriate manner to evaluate the needs/interests of the community on future UV instrumentation was to run an on-line questionnaire on UV astronomy.

An on-line questionnaire was developed and make public to the Astronomical Community world wide (http://www.ucm.es/info/nuva/). It was answered by 177 astronomers around the world: about 140 European and 22 US-residents and 26 Russia residents. The results were analyzed and made public on the NUVA web site. A summary has been also submitted to the Bulletin of the European Astronomical Soc. and should be published in June 2009. This is milestone M3.

A final meeting was held in Madrid in December 2008 to define the strategy of the NUVA for the coming years (especially after the decision made by the OPTICON board not to keep funding the NUVA workpackage in FP7 due to the budgetary reductions). The final recommendations were elaborated at that meeting.

In addition to that, Prof. Ana I Gómez de Castro has attended the end-of-FUSE meeting organized by NASA to discuss on the future of UV spectroscopy. The NUVA questionnaire was presented there: this is the reason of the response from US-astronomers.

Final recommendations: **of the NUVA Activity**

1. On the science case:
Three topics are clearly identified as requiring UV instrumentation to make significant advance in astrophysics: research on the cosmic web (both the diffuse component and the variation of the star formation rate with redshift), research on the formation and late evolution of Solar-like planetary systems and identification of the chemical composition and properties of the atmospheres of extrasolar planets. The science case is well developed in the NUVA books. There is however, an open issue that has not been yet developed: to which extent UV information is going to be required for the scientific interpretation of the results of the planned next large infrared and X-ray missions. In the same vein, it is not clear how the desired capabilities of future UV instruments would complement (or extend) those of the planned giant ground-based telescopes.

***2.* The missions road map** is defined by the plans of the European Space Agency and the National Space Agencies in Europe:

a) **Till 2013 HST with the new instrument COS** will provide unique opportunities to run high sensitivity pointed studies of the IGM and star formation at all scales. The sensitivity of this instrument for R~10000 and spectral range 102nm-170nm will not be matched till 2025-2030 when the next large UV missions are operated. In the mean time the American/French GALEX mission will provide, for the first time, a survey of the UV sky. The ***NUVA recommendation*** is to set-up an Intensive Training Network to form new specialists in UV data while exploiting rapidly the Archives to guarantee the maximum scientific return from the European participation in the HST/COS mission. The fact that E.S.A. has decided not to support the European

Coordination Facility of the Space Telescope (ECF-ST) makes of the NUVA community the best suited to successfully carry out this challenging work.

b) ***From 2013 till 2023, the WSO-UV*** will provide a 2m class facility for UV astronomy: imaging and spectroscopy. The imaging instrument is defined to extend the GALEX work in the study of individual objects and the spectroscopic instrumentation will nicely complement the HST capabilities providing unmatched sensitivity with spectral resolution R~55,000 and R~2000 in the entire 110-330 nm range. Two EU countries participate in the project: Spain and Germany. The NUVA network will be vital to harmonize the collaboration between the European members of the WSO-UV consortium and the rest.

c) ***In the long term, after 2025, a new large UV mission needs to be developed*** most likely in close collaboration with non-European Space Agencies. A cost-efficient structure for the management of such a large collaboration implies the implementation of trans-agency working groups that analyze the science case and identify the key technologies, at scales larger than the European Union since the very early stages.

The NUVA has run an analysis of the on-going European projects and the demands of the European astronomers (through the on-line NUVA questionnaire). Most of the researchers are interested in the 110-320nm range to resolve and analyze AGNs, exoplanets, disks and starburst. The NUVA has agreed to run a detailed scientific analysis on the technological capabilities of Fresnel interferometer for this purpose.

2. On the technology: there are many technological issues to be addressed for the development of efficient UV instrumentation. To mention but a few characteristics to be improved: the inefficiency of the coatings, the difficulty to select the information in narrow spectral bands without heavy loss of flux, the detector technology, the optical designs to minimize the number of reflections and select the spectral band in non-standard manners (like i.e. in Fresnel interferometry) or the search of materials with good optical performances in the 90nm-180nm spectral range. The NUVA integrates several instrument building teams that work in close collaboration with European companies however, there are not clear tools that allow to carry out research and innovation (R&I) joint projects for space investigation outside the framework of the European Space Agency (unfortunately, this kind of tools are only available for projects already approved by the Astronomy Working Group). As a result, national agencies are taking the responsibility of R&I for several areas of space research. An unpleasant consequence is that while European astronomers are able to work together as a single European entity, the industrial consortia are still driven by national interests.

Finally, it is worth mentioning that the R&I plan for UV is rather close to the currently on-going plans for the optical range as described in the OPTICON package "Smart Instrumental Techniques".

WP3: High Time Resolution Astrophysics (HTRA)

This WP was completed in 2007.

WP4: Astrophysical Virtual Observatory (AVO)

Much of the OPTICON support for this WP was completed in 2006, but some activities are carried out in collaboration with WP6 (FASE).

WP5: Key Technologies Network

The main objectives of the Key Technologies Network (KTN) in 2008 have been to develop a constructive relationship with ESA for common technology planning, and to revise and to update the Technology Roadmap in response to the ASTRONET Infrastructure Roadmap. Both of these objectives have been achieved.

The first activity was started with a meeting in March between the KTN Chair Colin Cunningham, Frank Molster of NOVA and Didier Martin, who is the new ESA head of technology planning. This was very useful in uncovering common technology requirements, in particular for Infrared Detectors. This led into a workshop on that topic held in Oxford in July, where representatives from instrument teams, industry, ESO and ESA met to develop ideas for future developments. It is likely that this will lead to successful bids to ESA for a major programme to address the needs for IR detector capability in Europe, coordinated with ground-based requirements led by ESO.

The second activity was arranged around a technology roadmapping workshop held in Edinburgh in November, aimed at revising the roadmap, and producing a comprehensive document to form the basis of the KTN activities in FP7. This was developed by the innovation group at the UK ATC, who followed up the issues raised at the meeting by visits and telecons with key experts in the Opticon community.

The final activity of the FP6 KTN was a workshop held at the Merate Observatory near Milan, which addressed issues regarding the use of novel optical and structural materials at cryogenic temperatures for IR instruments. This was a very fruitful opportunity to bring together instrument builders in IR astronomy with industry and other users of cryogenics in related sciences such as gravitational wave research. We expect the output of this workshop to be published, but more importantly, we are setting up a web-based community to share information on problems, solutions and best practice in cryogenic engineering – called LTnet.

Colin Cunningham gave an invited talk on future technologies for Optical and IR Telescopes and Instruments at ESTEC during the conference celebrating 400 years of the Telescope. Much of the material was based on the work of the OPTICON KTN. He has also been invited to write a commentary for Nature Photonics on Future optical technologies for telescopes and instruments.

WP6: Future Astronomical Software Environment

All work within the Working Group 6 has been done on a volunteer basis and are not charged to OPTICON.

The main objectives of the WP 6 are, as defined in 2004, to discuss the needs for '*Future Astronomical Software Environments*' (FASE) and identify high-level requirements and architectural concepts for such systems. A more detailed discussion of scope and objectives for WP 6 is available on the Network 3.6 Twiki which is also used for exchange of ideas and proposals. Monthly phone meetings were held to ensure that all members are update on discussions (minutes can be found on the TWiki). After a thorough Internet wide review, the high-level requirements document was release. The architectural concept had been discussed in depth earlier but was now edited into a White Paper to give a better presentation to a broader community of astronomer. Finally, work was started on a detailed design which addressed both the structure of major system components and their interfaces. Prototypes made through collaboration between Marseilles and Milan were presented and gave important input to the discussions. It was decided to structure the final Network report as 3 separate documents (i.e. high-level requirements, architectural concept, and detailed design) to make it more useful for the community as not all parts of the report are of equal interest to any specific user.

The discussions with the North American community were intensified (e.g during the ADASS conferences) to ensure that objectives and views were shared. A common understanding was achieved with the aim of collaborating on high-level concepts and interfaces. This being one of the major objectives of the Network. Closer links to the VO community were established (e.g. with respect to messaging protocols). This will ensure that the work of this Network is fully consistent and complementary with the VO efforts and makes the maximum use of the VO experience.

All remaining milestones and deliveries were achieved during the final year of the Network 3.6 as listed in the table below. A first discussion of the interfaces required for future environments took place at the face-to-face meeting in ESO, Garching in January 2008 (M3b) while a more complete list was drawn up at a small face-to-face meeting in July 2008 (M3c). The detailed design including a summary of subsystems and interfaces was compiled in a document called the *Applications Framework* (M3). It was decided to collect the ideas on the architectural concept (M5) in a White Paper. The last version of the documents constituting the final report (M6) was discussed during the last face-to-face meeting of the Network in Marseilles, December 2008.
The final report consists of three documents which summarize the work of the Network. They are available through the Web:

- High-level requirements: http://archive.eso.org/opticon/twiki/pub/Main/WebHome/HLReq.pdf
- White Paper on Architecture: http://archive.eso.org/opticon/twiki/pub/Main/WebHome/WPArch.pdf
- Applications Framework: http://archive.eso.org/opticon/twiki/pub/Main/WebHome/AppFramework.pdf

The eighth face-to-face meeting included a final review of the High-level Requirements and a first discussion on the detailed design of future environments. After several phone meetings during the spring of 2008, a small face-to-face meeting in July, 2008, was arranged to have a in-depth discussion of the subsystem structure and associated interfaces. This led to a first draft of the *Applications Framework* document. The tenth and final face-to-face meeting of the Network was held in Marseilles December 2008. It included discussions on the final report which was structured as 3 separate documents. The experience obtained through the Marseilles-Milan prototype work was presented at the meeting. Finally, future work within the OPTICON FP7 programme was also considered. Agendas, presentations, and minutes of the meetings are available at the Web through the URL's:

- Face-to-face meeting 2008-01-28,

- Face-to-face meeting 2008-07-17, and
- Face-to-face meeting 2008-12-11

After a wide Internet review, the high-level requirements for Future Astronomical Software Environments (FASE) were consolidated providing a shared view on the main needs for the astronomical community in this area. Further, input was provided to the Astronet Roadmap report emphasizing the importance of availability and sharing of astronomical software.

In discussions with colleagues in North America, we are now confident that a shared vision on both requirements and architectural concept for a future environment can be established.

The final report with its 3 documents, including requirements, architecture and detailed design, provides a solid foundation on which a first reference implementation can be built. Thus, the two main objectives of the Network 3.6 were accomplished namely to provide a high-level description of FASE and achieve a wide agreement within the astronomical community on these concepts.

Milestones and Deliverables achieved:

Deliverable/ Milestone No	**Name of deliverable/milestone**	**Work-package /Task No**	**Lead Contractor(s)**	**Planned (in months)**	**Achieved (in months)**
M1	ELT Conference (at JENAM, Vienna)	WP1	STFC	57	57
D2	Final Science Case Book	WP1	STFC	60	61
M4	NUVA Board Meeting	WP2	STFC	51	53
M3	Final NUVA Meeting, Madrid	WP2	STFC	60	60
D3	Final Report + Roadmap	WP5	SFTC	58	60
M3b	Draft of interfaces required	WP6	ESO	51	51
M3c	Detailed list of interfaces required	WP6	ESO	57	54
M5	Architectural concept document	WP6	ESO	57	60
M6	Final report	WP6	ESO	60	60

Major Meetings And Workshops Organised During The Reporting Period:

Date	**Title/subject of meeting/workshop**	**Location**	**Number of attendees**	**Website address**
28 January 08	WP6 Eighth face-to-face meeting	ESO, Garching, DE	12	http://archive.eso.org/opticon/twiki/bin/view/Main/FaceToFaceMeeting20080128
May 2008	WP2 NUVA Board Meeting	Madrid, ES	9	http://www.ucm.es/info/nuva/
1st/2nd July 2008	WP5 IR Detectors Astronomy Requirements and European Industry Capabilities	Oxford, UK	15	https://forge.roe.ac.uk/twiki/bin/view/Optikeytec/PresenTations
17 July 08	WP6 Ninth face-to-face meeting	ESO, Garching, DE	6	http://archive.eso.org/opticon/twiki/bin/view/Main/FaceToFaceMeeting20080717
September	WP1 conference at	Vienna, AT	~100	http://www-astro.physics.ox.ac.uk/~imh/ELT/

2008	JENAM Meeting			
20 -22 October	WP2 attendance at FUSE End-of-Mission conference	Annapolis, USA	~177	http://futureofuv.gsfc.nasa.gov/ www.ucm/info/nuva
13th/14th November 2008	WP5 Roadmap Update Workshop	Edinburgh, UK	12	https://forge.roe.ac.uk/twiki/bin/view/Optikeytec/RoadmapDocument
4 - 5th December 2008	WP2 Review and strategies for FP7	Madrid, ES	5	http://www.ucm.es/info/nuva/
4th/5th December 2008	WP5 Material Property Measurements for Cryogenic Instruments	Merate, Milan, IT	18	http://www.astro-golem.it/opticon/workshop_merate/
11 December 08	WP6 Tenth face-to-face meeting	Marseilles, FR	13	http://archive.eso.org/opticon/twiki/bin/view/Main/FaceToFaceMeeting20081211

1.3.3 NA4: Mechanisms for synergy in space-ground coordination

This activity is complete.

1.3.4 NA5: Interferometry forum

Participant number	12	21b	34	
Participant short name	NOVA	ULg	NCU/UNK	**Total**
Person-months	0	0	0	0

Milestones and deliverables

Milestones/ Deliverables	Deliverable/Milestone Name	Workpackage/ Task no.	Lead Contractor(s)	Planned (month)	Achieved (month)
WP1					
M2	Annual call for applications	1	NCU	1	3
M3	Collate list of applicants	1	NCU	2	4
M4	Selection of exchange visitors	1	NCU	4	4
D1	Report from participants	1	NCU	12	12

Milestone WP1.M2, WP1.M3, and WP1.M4 occur once in the year 2008 since applications for the Fizeau Exchange Visitors Program were accepted every 6 months, but for the last time in March 2008.

Date	Title/subject of meeting /workshop	Location	Number of attendees	Website address
10 -11 March 08	EII Meeting including NA5	CAUP, Porto, PT	22	http://www.mpia-hd.mpg.de/euinterf/

Although the group has been very active, no staff efforts (Table N5.1) have been charged to the project. Only travel and material cost have been charged to the project.

The flyer on the Network activities, which had been produced in 2005, was again distributed at a number of venues.

The European Interferometry Web-site that contains the most up to date information about the European Interferometry Initiative (EII) activities and the Network Activities has been moved to a new server. The new web address is http://www.mpia-hd.mpg.de/euinterf/.

1.3.4.1 Fizeau exchange visitors program

New announcements of the Fizeau Exchange Visitors Program have been widely distributed through relevant mailing lists, web-pages (http://www.mpia-hd.mpg.de/euinterf/), and direct mailing. A poster with the announcement was mailed to a long list of astronomical institutions in Europe.

On 15 March (call 2008A) a new application round for the Fizeau Exchange Visitors Program was closed. The applications were reviewed by the Network Board, suitable candidates were identified, and travel funds awarded. A total of nine exchange visits could be funded. Most exchange visits involve scientists from institutions that do not have much expertise in interferometry; many of these are from central European countries.

1.3.4.2: Working groups

Three working groups hade been established in 2004. These were: “Interferometric scientific council”, “Radiative transfer”, and “Atmospheric modelling”. The latter two groups were merged by request of the group members in 2005. Following an initial meeting in Paris in June 2006, this group held a focused workshop near Lyon in May 2007. Proceedings from this workshop have been written up an were published in 2008 (EAS Publication Series Vol. 28, Eds. S. Wolf, F. Allard, and P. Stee). A new working group on “Interferometry and asteroseismology” was established in 2005 and met for the first time in November 2005 in Porto, with subsequent discussion conducted by teleconferencing. The report from the Porto workshop was finalized in 2007 and has appeared as a review article in “Astronomy and Astrophysics Reviews” (Cunha et al. A&AR 14, 217-360).

Scientific Council

The “Scientific Council” met several times by teleconference, and in person in Porto on March 10/11, 2008. The main focus of this meeting was a discussion of the plans for OPTICON FP7. The terms of the president and vice president of the Scientific Council ended in September 2008. At the March meeting, Guy Perrin was elected new president and Walter Jaffe vice president, with terms to begin in October 2008. Minutes of the meetings have been compiled and distributed.

1.3.4.3 Next-generation interferometric infrastructure

A proposal for a design study for a kilometric optical interferometer (KOI) was prepared by many participants in the working group on “Next-generation interferometric infrastructure” and submitted for the FP7 deadline on May 2, 2007. The proposal received excellent marks by the referees, but was not funded. Plans for a re-submission of a similar proposal to the next call were discussed at the March meeting in Porto. Several presentations were made to the ASTRONET science and roadmap WGs and to explain the plans and needs of the European interferometric community. A joint meeting with colleagues from the US was held in conjunction with the SPIE conference in Marseille on June 24, to discuss cooperation and coordination of the technology development for the next decade.

1.3.5 NA6: OPTICON Telescope Network

Participant number	7	10	
Participant short name	IAC	ASTRON	**Total**
Person-months	15.75(15.75)	1.39	17.14 (15.75)

WP1: Telescope Directors Forum

The Telescope Directors' forum comprises the directors of all those telescopes in the Trans-national access programme, and hence represents all modern 2-4m telescopes with European involvement. The primary responsibilities of the group are oversight of the trans-national access programme, planning for future co-operation and preparing for FP7 opportunities. The group is chaired by the Project Scientist whose time is accounted to management effort.

A splinter meeting of the forum met for a working lunch during the ASTRONET symposium in Liverpool, Jun 2008. The annual Directors' meeting was held in Amsterdam. At this meeting a review of the allocations under the access programme was made and a final agreement reached on the spend profile reaching ~100% by the end of 2008. There was further discussion of our FP7 plans, and agreement in principle to adopt a single pool/common TAC process. It was agreed that presentations of many of these telescopes would be given in public sessions at the next JENAM meeting. Minutes for both meetings can be found at http://www.astro-opticon.org/meetings.html

WP2: Operation of the Trans-national Access Office

In 2008 the Access Office has devoted a total human effort of 18 person-months. During this year its two main objectives (management of the Trans-national Access Programme and interface between the bodies and communities involved) have been accomplished. Therefore, its role as a reference node between telescope operators, the OPTICON Project Office, the Telescope Directors' Forum, and users continues being highly appreciated.

As a complement of the full assistance provided to the Telescope Operators in the fulfilment of their obligations (according to Annex I of the *Basic Contract*, page 45) the Access Office has implemented the following actions during 2008:

Maintenance of the database powered website of the Access Programme

The Access Office staff has periodically updated the contents of this key interface with users for sharing relevant information, application forms, reports, documents, statistics, etc.

Publicity of the Trans-national Access Programme

As a complement of the publicity made through the website of the Access Programme (and through the OPTICON site), our team has sent announcements of opportunity by email and standard mail.

4. Trans-national Access Programme. Impact, progress and output

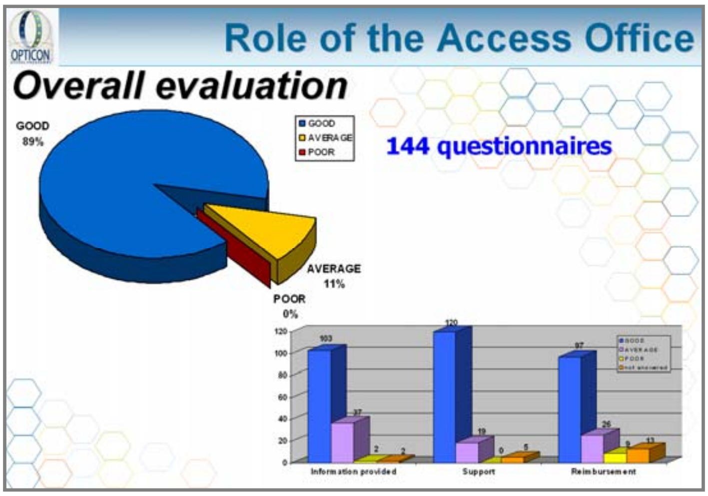
Beyond the daily operation and promotion of the Access Programme, the Access Office carries out major efforts to meet EC reporting requirements (annual reports, etc.) and to analyse the impact and progress of this activity, by assessing the scientific output, user questionnaires and feedbacks, identifying new users, analyzing the procedure of awarding time, etc.

4.1 Progress reports to be delivered in accordance to Annex I of the contract.

Each four-month period, the Access Office has delivered standard progress reports by collecting and providing to the Telescope Directors' Forum detailed statistics about type and characteristics of observing runs supported under the Access Programme (see table with such deliverables).

4.2 User questionnaires and feedbacks

User groups awarded telescope time under this Access Programme have been invited to complete a user questionnaire.



Information from these questionnaires and other feedback tells us more about the various users of the Access Programme. This information helps us to understand our users' needs and their opinion about the services provided. It enables us to meet those needs by making the Access Programme as useful as possible.

4.3 International partnership. Analysis of current situation and trends.

The Access Programme provides opportunities for international partnerships that contribute to implement an effective, efficient, and focused international astronomical research.

As part of the analysis carried out by the Access Office to monitor the impact of the Access Programme among the Astronomical Community, we have analyzed the establishment of such international partnership in those observing projects submitted for telescope time, with special attention to those awarded time under this Trans-national Access Programme.

4.4 Scientific fields addressed by OPTICON user teams.

The astronomical research carried out under the OPTICON Access Programme is focussed in optical and infrared observing projects as well as in solar physics observations. As part of the progress and outputs of the Access Programme in this period, the Access Office has collected all the projects summary reports of such observing projects asking astronomers for their corresponding scientific fields

Milestones for this WP, as defined by the implementation plan, have been successfully achieved.

NOTE: See the reports about the Access Programme for further details about this WP.

WP3: Enhancement

The year 2008, last year of the OPTICON FP6 contract, saw the peak of this activity. On one hand, three different Neon schools were organised:

- A traditional "Observing school" in La Palma, the major European observatory in the northern hemisphere, where we used two 2.5m telescopes (INT and NOT) with 16 students of 11 different nationalities. Of particular interest for the young researchers were the visits organised to the other major facilities of the mountain, including solar telescopes and the Cerenkov telescope Magic.

- In early autumn, an "archive school" was organised at ESO, with emphasis on multi-wavelength analysis of combined ground and space data. Here 20 students of 16 different nationalities worked in five groups, on scientific projects using VLT data and taking advantage of the European HST archive facility which is located at the same place.

- A new type of school was also organised in 2008, to facilitate the use of some modern, complex instruments. The topic chosen was "Integral Field Spectroscopy", a new type of instrument now starting to be available at several major observatories. Specialists in the field brought sets of data obtained with five different instruments, from observatories well distributed over the world and accessible to European astronomers (ESO-Chile, Gemini North, La Palma, Calar Alto), to be analysed by the participants. This workshop was opened not only to PhD students, but also to more advanced scientists wishing to get first hand experience with such data. In total, 30 participants (including 8 more advanced researchers) worked in six groups on the various data-sets. The experience was very successful, and demonstrated the need of life-long training when new types of instruments are entering service in modern observatories.

A substantial effort was devoted in 2008 to the analysis of the activities during the five years of this contract the objective was to address some shortcomings and improve the scheme for the future. The major problem is the large oversubscription factor of all the events, demonstrating the validity of the concept. This can only be addressed by organising more events, a move which would however require much more funds and manpower, which unfortunately seem not to be available at the moment. The other concern was the need to better integrate the communities from the new EU member states, raising their interest in the most topical questions in astrophysics, and to encourage them to use the best available observing facilities. This will be addressed during the next (FP7) contract, by organising specific events in those countries, provided the financial means are available. Overall, it was felt that the progress of this activity during the FP6 contract was very satisfactory and the interest raised was encouraging enough to call for more developments in this area in the future.

Milestones and Deliverables

Milestones No	Milestones /Deliverable name	Workpackage No	Lead Contractor	Planned (in months)	Achieved (in months)
M3B	Peer review of Aristarchos Telescope	WP1	STFC	53	Not complete*
M2	Annual Directors Meeting	WP1	STFC	53	54 + 57
M2	5th Report to Directors forum	WP2	IAC	56	56
D3	Report on Scientific Output.	WP2	IAC	58	60
M3	IFU workshop, Potsdam	WP3	CNRS, IAP	53	53
M4	NEON School	WP3	CNRS, IAP	54	54
M5	ESO Archive School	WP3	CNRS, IAP	57	56
M2	Enhancement Working Group Meeting	WP3	CNRS, IAP	57	62 **

* Aristarchos Telescope not yet fully commissioned
** Moved to early 2009 and merged with NEON end of contract meeting.

Meetings and workshops

Date	Title/subject of meeting/workshop	Location	Number of attendees	Website address
17 June 2008	Telescope Directors Splinter Meeting at the Astronet Roadmap conference	Liverpool, UK	16	http://www.astro-opticon.org/meetings.html
3 September 2008	Telescope Directors Forum meeting	Amsterdam, NL	14	http://www.astro-opticon.org/meetings.html
19 – 24 May 08	IFU workshop	Potsdam, DE	30	http://opticon.3d-school.aip.de/
23 June – 5 July 08	NEON school	La Palma, ES	16	http://eas.iap.fr/neon2008.html
27 Aug - 6 Sep 08	ESO archive school	ESO, Garching, DE	20	http://www.eso.org/sci/meetings/neon-2008/

1.4 TRANSNATIONAL ACCESS ACTIVITIES

1.4.1 OPTICON Trans-national Access Programme

1.4.1.1 Description of the publicity concerning the new opportunities for access

The Trans-national Access Programme Website (OPTICON Access Website: http://www.otri.iac.es/opticon/) is the main tool used to publicise the new opportunities for access to the telescopes involved in the OPTICON Access Programme.

After this five-year contract running this programme, most of the international scientific community is aware of the advantages offered under this initiative, especially for new users and European young researchers. Representatives of the Access Office participated in several promotional talks and events, including participation in a summer school organized in Lithuania and the presentation of the results achieved by this programme to the Scientific International Committee of the Canary Islands Astronomical Observatories. The oversubscription of eligible teams in most of the OPTICON telescopes provides clear evidence that the appropriate dissemination has been achieved.

Users awarded with OPTICON time (receiving full scientific, technical, logistical and financial support) under this five-year contract

The Trans-national Access Programme website is a key reference to keep users updated about deadlines for each telescope. In addition, a complete contact list of scientific and technical support is at their disposal, guaranteeing the most suitable level of support for users.

Moreover, we have updated brief descriptions of each telescope (location, instruments, full address, funding sources, etc.), a guideline on how to apply for access, criteria of eligibility, travel and subsistence grants, information on allowable expenses, etc.

As a complement to the information available in the Public Area, this website provides users with a list of useful links to Observatories, Survey data / Catalogues, Literature / Directories, astronomical and physics links, as well as a section of the OPTICON facilities' newsletter and a download section of the Access Office with promotional material about the Access Programme.

Promotion of the Trans-national Access Programme at other Websites:

Similarly, information about the Access Programme can be found on the corresponding web sites of each of the 22 participant telescopes. Each observing campaign is widely advertised there. Announcements of Opportunity are normally published twice a year via Internet as well as via extensive distribution to the international astronomical community.

As a complement to these electronic tools, the Trans-national Access Office has sent by post a general advertisement of the Programme to many members of the international astronomical community.

1.4.1.2 Description of the selection procedure

Observing time is awarded following standard selection procedures at each telescope or group of telescopes, which are based on scientific merits and feasibility. Since 22 medium-sized telescopes are offered under the contract, and they are operated by different legal entities / countries, specific criteria of eligibility differ from one telescope to another. The procedure to apply for telescope time under this EC contract is to do it in response to the different Announcements of Opportunity for observing time at each telescope.

Once the deadline for submission of proposals has been closed, Time Allocation Committees (TACs)[11], composed of experts of international reputation, evaluate the proposals received and approve a ranked list for distributing the observing time available among the most highly rated proposals.

The prime consideration of these TACs in making awards is scientific merit and technical feasibility, taking into account the interests of the astronomical community as well as scientific output from previous time awards. Teams compete on the basis of equal opportunity. However, new users, young researchers and users from countries with no similar research infrastructures are especially encouraged to apply for observing time.

Following EC guidelines, criteria of eligibility of the astronomers who want to benefit from this Access Programme are based on the country of origin of the user group (as defined below), and the ownership of the telescope for which observing time is applied to (or country of the entity/ies responsible for its operation). These criteria apply separately to each telescope.

To be eligible to benefit from access to a particular telescope under the contract, a user group[12] must satisfy the following conditions:

- both the user group leader and the majority of the users must come from Member States or Associated States;

[11] See Annex 2: Selection Panel members list.

[12] **User:** means a researcher within a user group, including the user group leader. **User group:** means a research team of one or more researchers given access to the infrastructure under the project. Each user group is led by a user group leader.

- both the user group leader and the majority of the users must come from a country other than the country(ies) where the legal entity(ies) operating the infrastructure is(are) established;

In order to prioritize applications from actual external users (specially new users), i.e users not having access by right to these telescopes because of any formal agreement signed between their institutions and the telescope operator, two other additional criteria were considered when awarding time under the EC contract:

- the institution of affiliation of the user group leader and the majority of the users shall not have access by right to the facility being applied to.

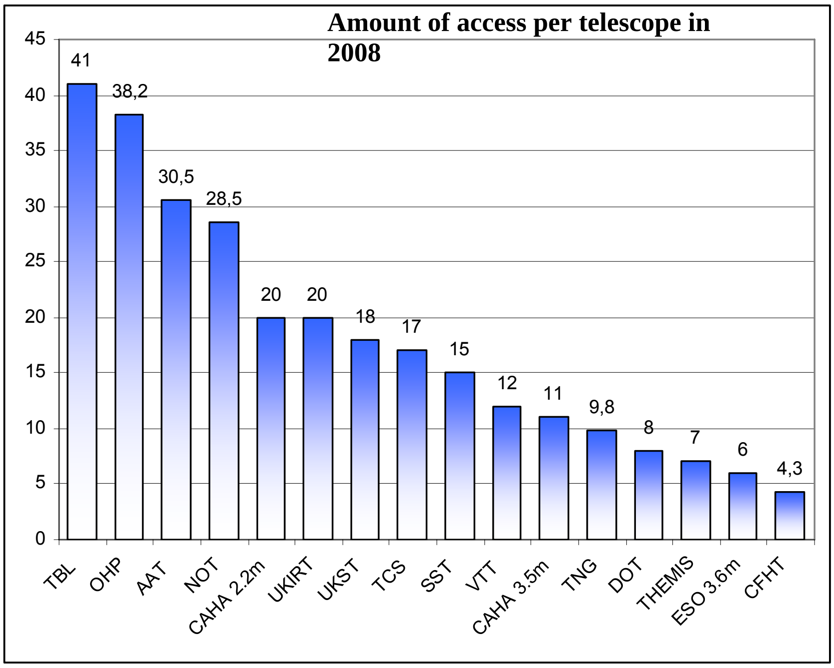
- in no case shall a user be eligible for travel and subsistence support to access his/her own facility through this programme.

User groups meeting EC criteria of eligibility, and awarded telescope time by the TACs, are informed by the Trans-national Access Office (located at Instituto de Astrofísica de Canarias, Spain) about this funding opportunity. They receive full information about how to apply for travel and subsistence grants, how to get scientific and technical support to carry out their observations, application forms, etc. Application forms and reports can be completed on-line.

1.4.1.3 Trans-national Access activity

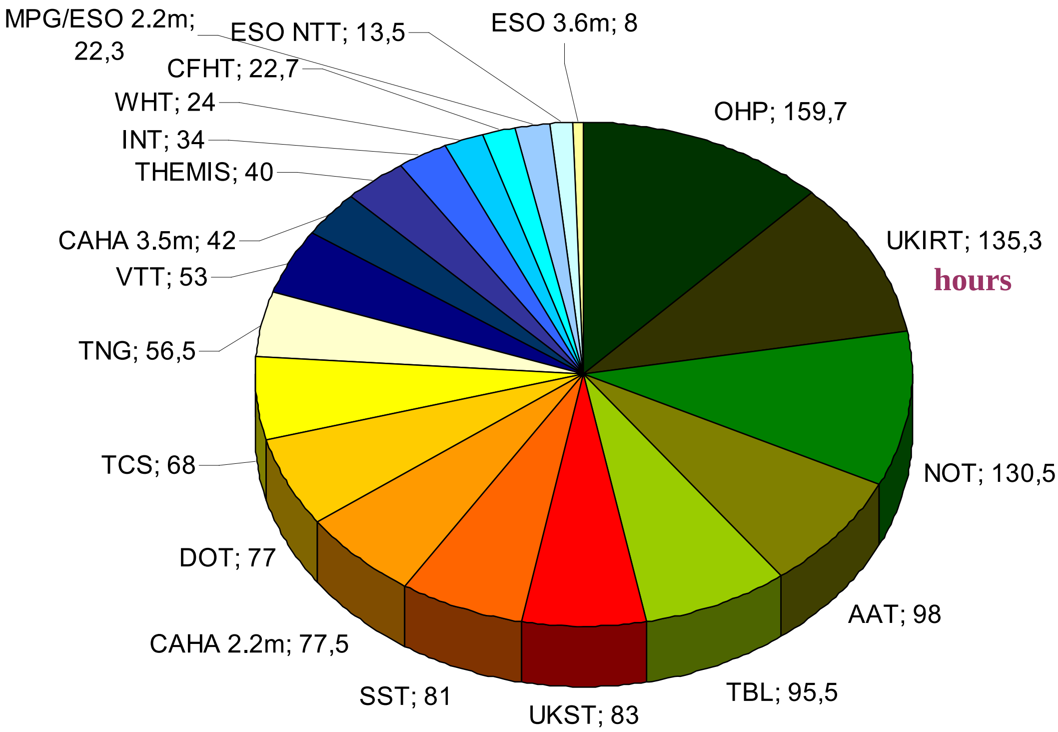
Amount of Access delivered:

19,84 % of the total amount of access to be provided under this five-year contract has been delivered in 2008. This means 286,3 units of access (days/nights/hours) in 2008.

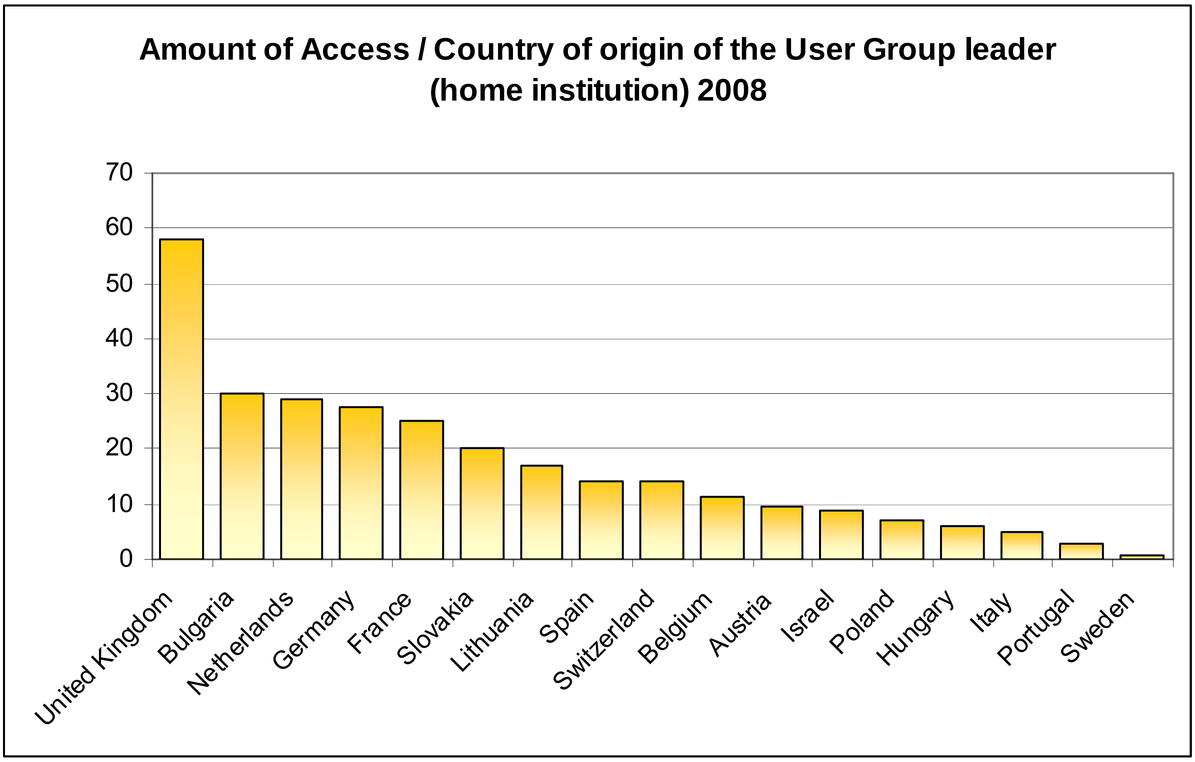


The Telescope Bernard Lyot and OHP 1.93m Telescope (Observatoire de Haute Provence), have been those telescopes which have delivered more observing time during 2008 (41 and 38,2 nights respectively).

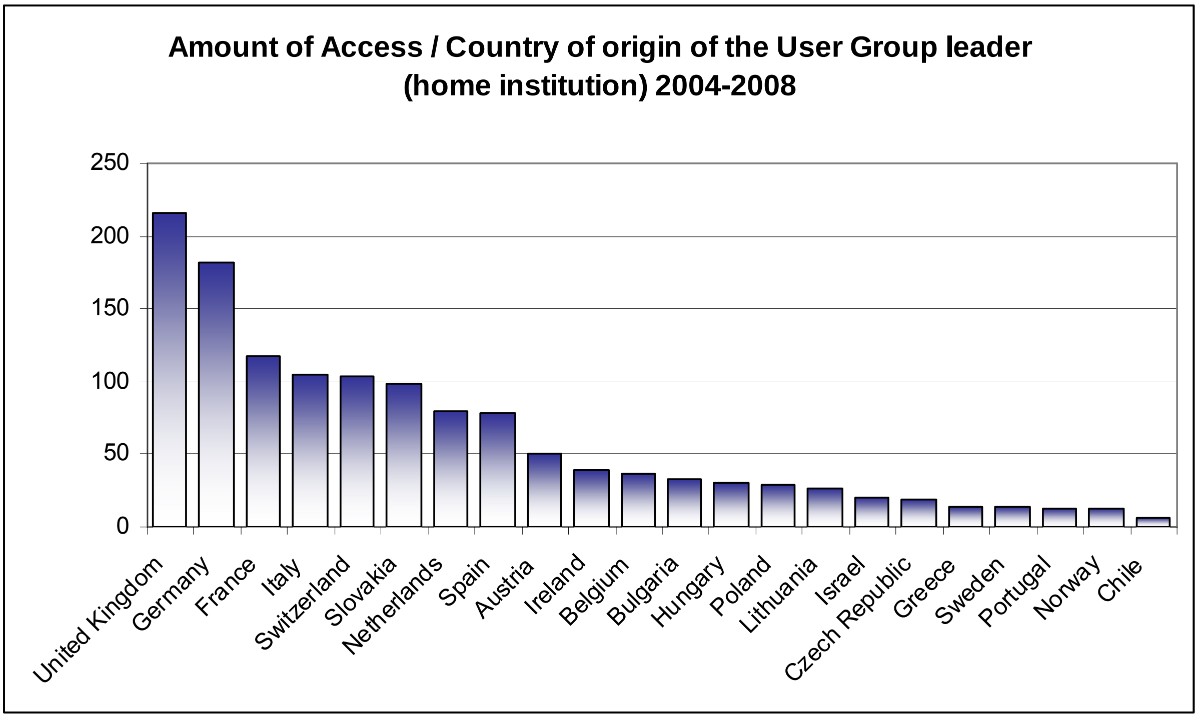
The allocation of time for the whole duration of the contract has been well distributed according to the initial estimation of the contract. Only the Liverpool Telescope and the 2.3m Aristarchos Telescope did not allocate OPTICON time under this contract since they joined the Access Programme late in the programme.



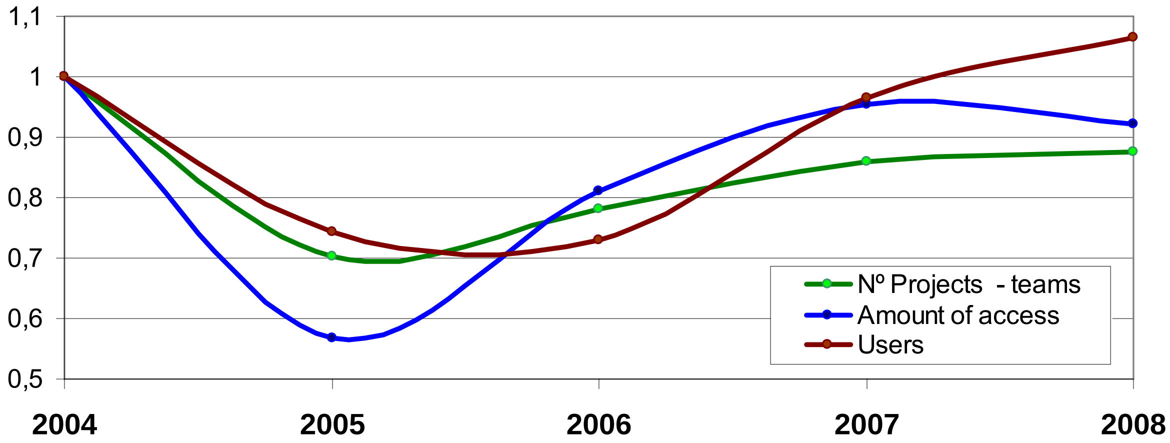
Statistics on users awarded with telescope time:
Most of the telescopes have allocated observing OPTICON time under the contract during 2008. With regard to the P.I.s home institutions, the group leaders from United Kingdom clearly lead the allocation of time in 2008, followed by Bulgaria and Netherlands P.I.s



The same graphics for the whole duration of the contract shows a clear number of successful observing runs of P.I.s coming form British and German institutions.



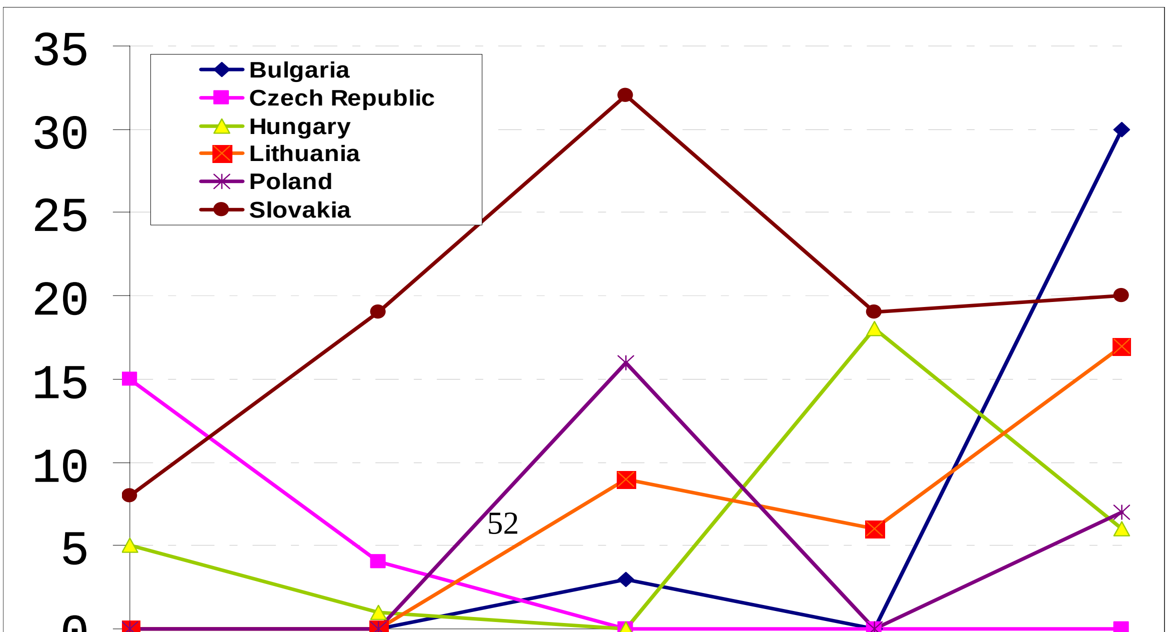
Projects and access: The results for 2008 show a positive trend of the number of projects after the strong decrease registered in 2005. With regard to the amount of access, this last year has been quite positive in the sense that the allocation profile has been quite similar to 2007, hardly surpassed by the results achieved during the first year of the contract, where a spending profile plan had not been fixed yet. The maximum quota fixed for the 2005, 2006, 2007 and 2008 had forced a reduction in the allocation of time in order to guarantee a regular allocation during



the five-year contract, and the results achieved support this plan.

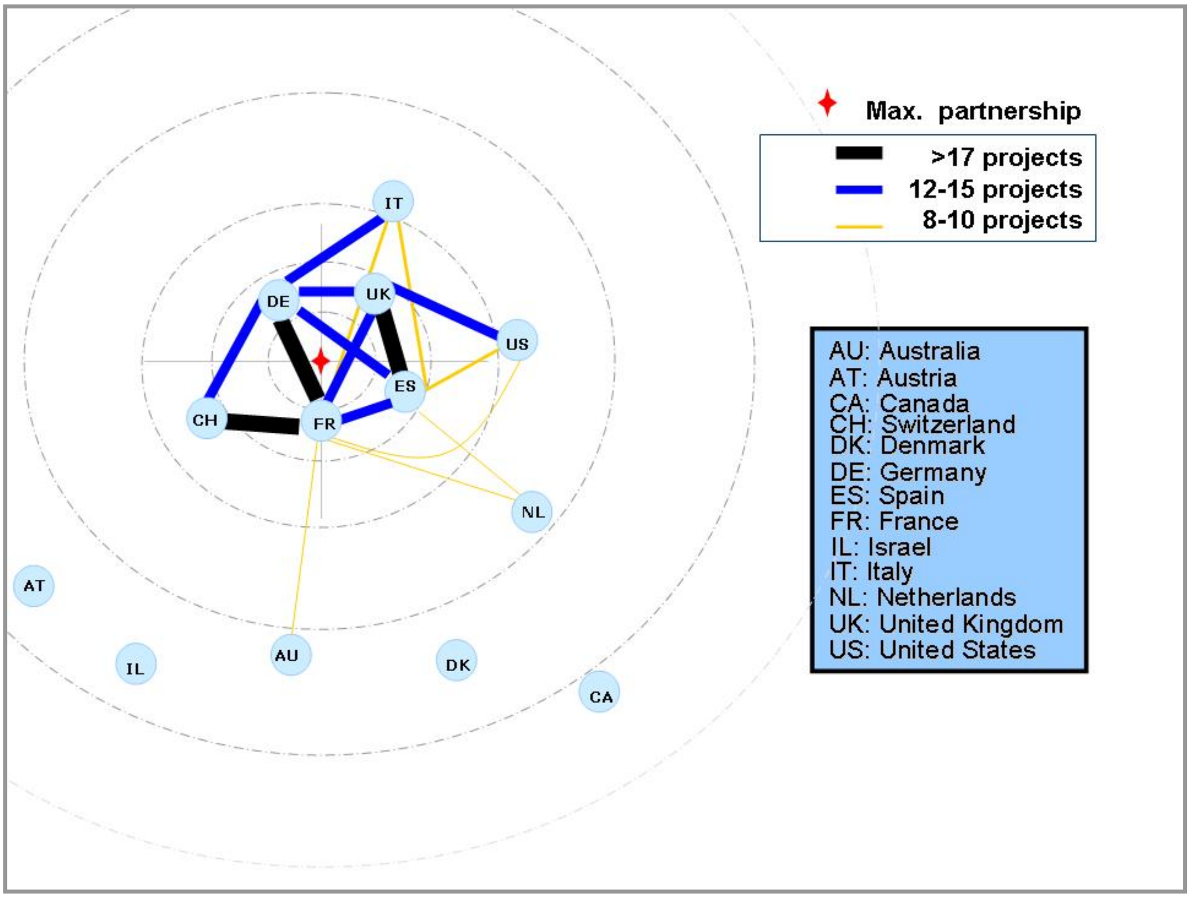
- *User groups:* As displayed in the previous figure the number of users in 2008 has increased considerably in comparison with previous years. In fact the rate of users per project in 2008 is the highest one since the beginning of the contract with an average of 6,36 users/project. The estimated number of users to take advantage of the Access Programme expected for the whole contract has been clearly surpassed with almost 226% of the expected value.

- *Observing time for astronomers from Central-Eastern Europe:* The Access Office promotes the participation of new users, young researchers and specially, users from Central and Eastern Europe. In this way, it should be remarked that Slovakia, Lithuania and Bulgaria have achieved a good take up of OPTICON time, followed by Poland and Hungary. The following figures show the take up for the different Central-Eastern European astronomers as well as the trends for Slovakia, Hungary and Poland.



Impact of the Access provided by telescope:
The Access Programme provides opportunities for international partnerships that contribute to implement an effective, efficient, and focused international astronomical research.

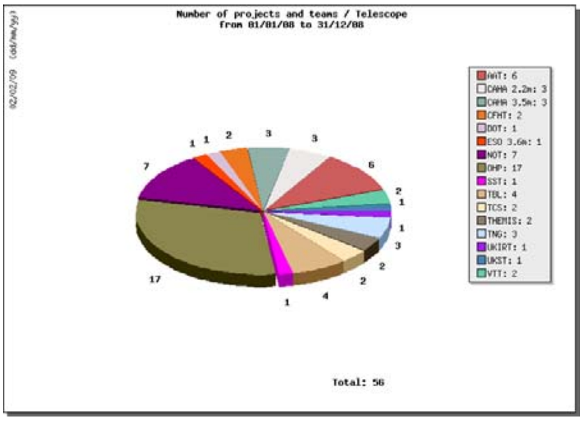
As part of the analysis carried out by the Access Office to monitor the impact of the Access Programme among the Astronomical Community, we have analyzed the establishment of such international partnership in those observing projects awarded time under the OPTICON Telescopes during the period 2004-2008.

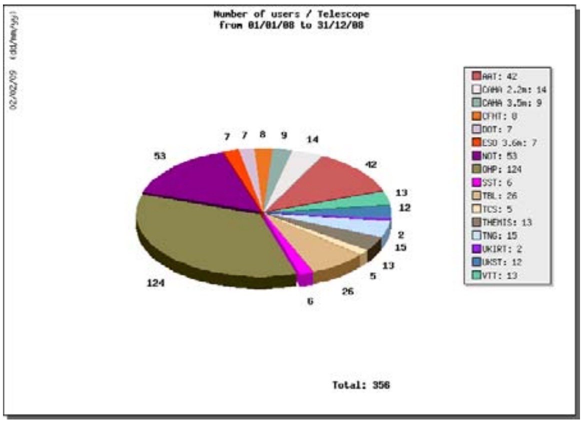


- The core of this international partnership is leaded by astronomers from France, Germany, Spain, United Kingdom, followed by Switzerland and Italy.

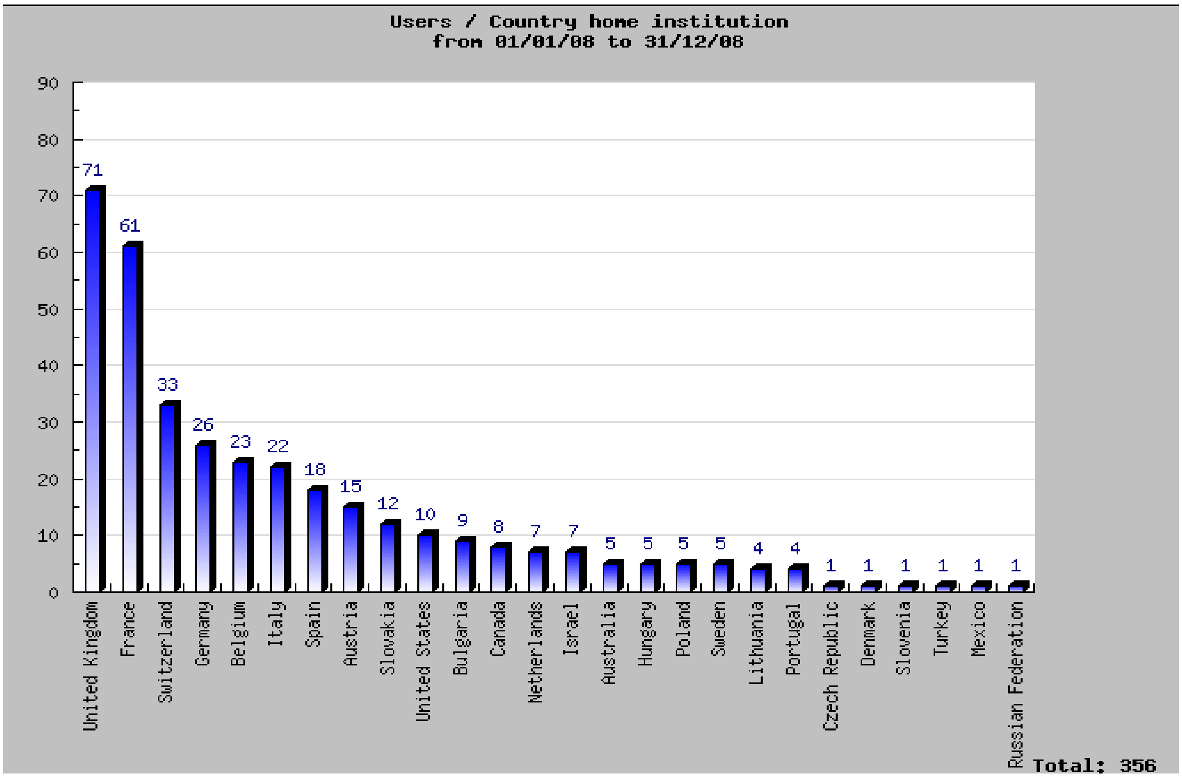
It is significant the low take up of astronomers from Central and Eastern Europe in those projects awarded time under the OPTICON Access Programme. The main reason has been a combination not only of low participation of users from Central Europe in successful proposals but also a low rate of success proposals involving astronomers from those countries.

Impact of the Access provided by telescope:
356 users from 26 different countries have benefited from this Access Programme during 2008 (members of the user groups).



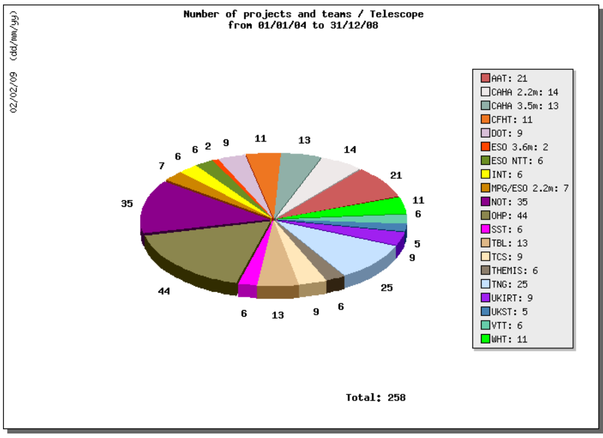


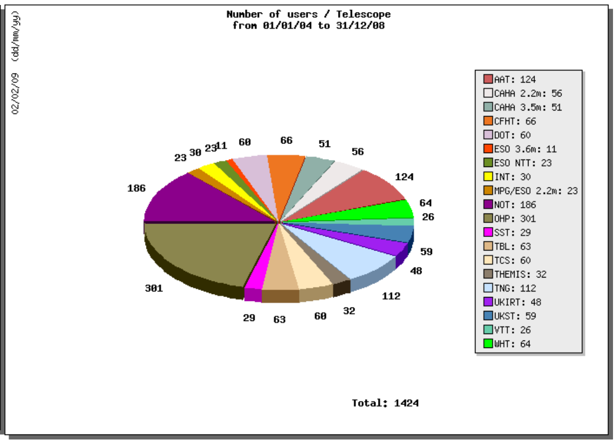
United Kingdom and France were those EU countries involving more users. (*see next* figure).



Astronomers from Central Eastern Europe has reinforced their participation with presence of Slovakia, Bulgaria, Hungary, Poland, Lithuania and Slovenia

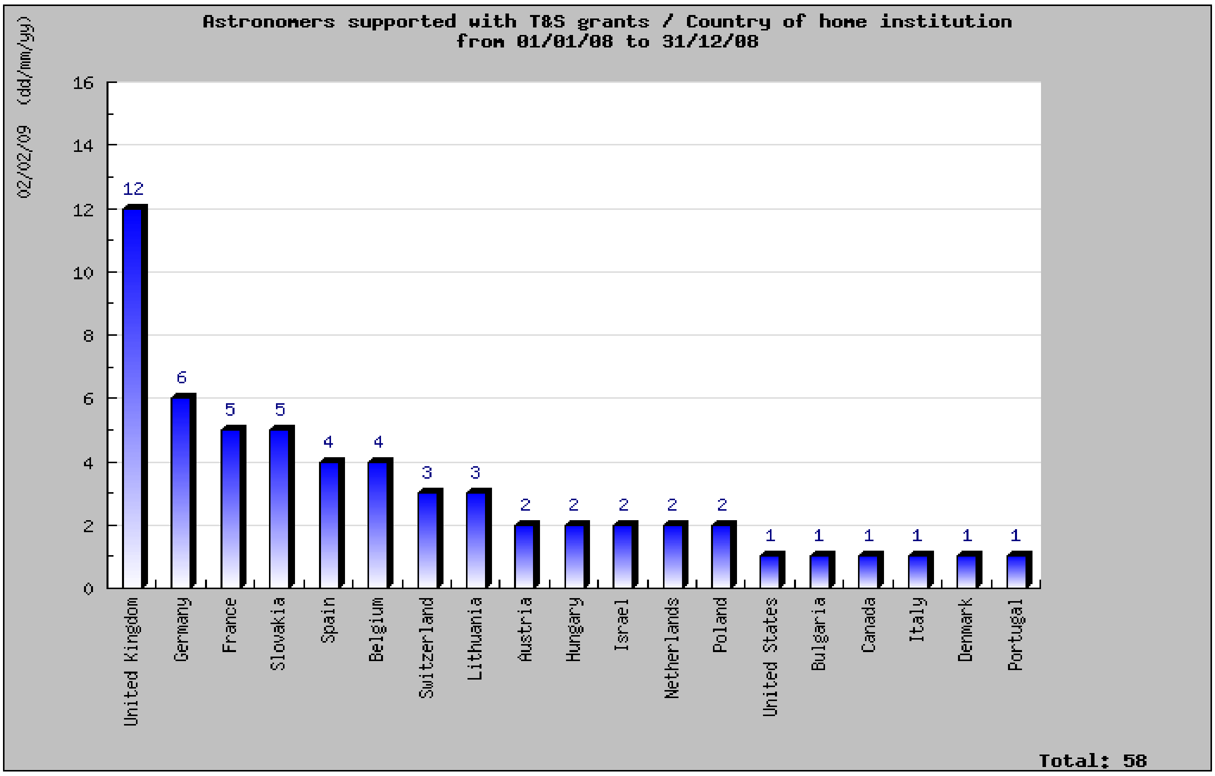
If we consider the whole duration of the Access programme, then the amount of users increase up to 1424 astronomers participating in 258 observing projects.



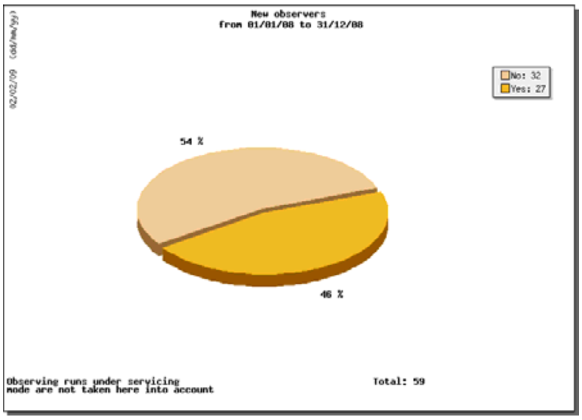


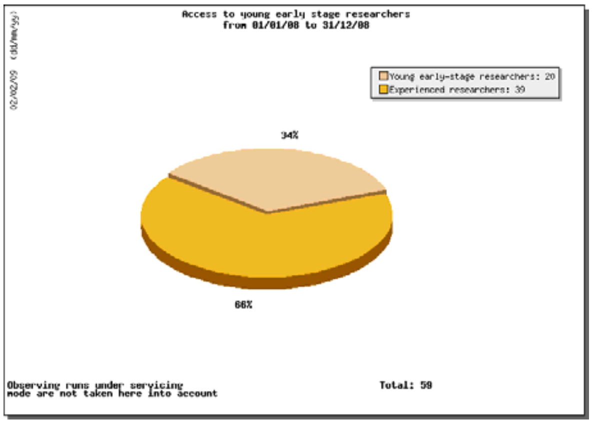
Travel and subsistence grants:
In 2008 a total of 59 of these 356 users have been granted for Travel and Subsistence (T&S) support when visiting the facility to carry out the observations (basically one observer per project, apart from those special cases in which two grants were needed and awarded). See Annex 4.

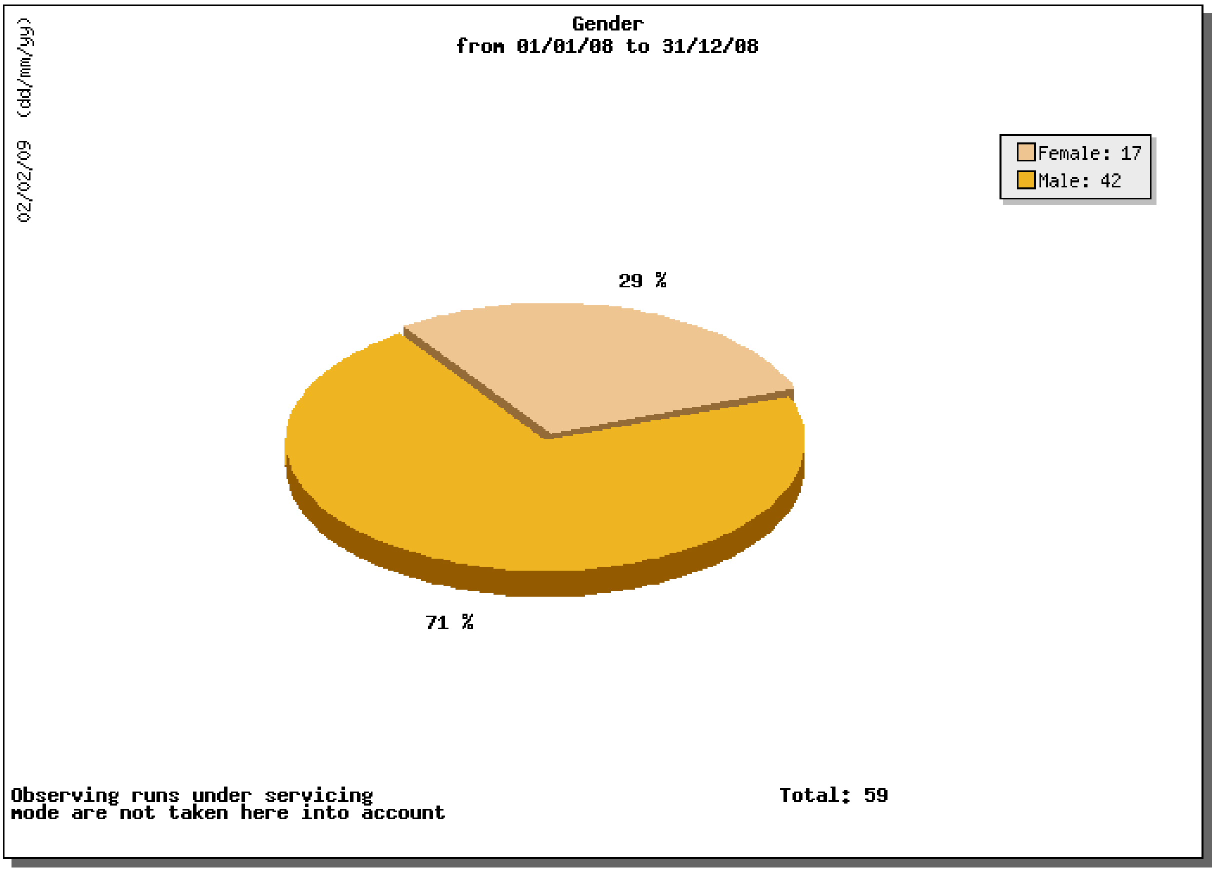
Following charts offer more information about these travel and subsistence grants:



New Observers: Over 54% of those astronomers supported with T&S grants in 2008 are new users. This result is quite positive since the OPTICON Access programme has been run for five years and we still receive a high percentage of new users. On the other hand 34 % were young-early stage researchers. The gender ratio among users with T&S grants is 29% female and 71% male.







1.4.1.4 Scientific output of the users at the facilities.

During this year the Access Office has gathered a list of publications related to observations based on results of observing projects carried out with the OPTICON Trans-national Access Programme support, mainly in 2006 and 2007.

As expected for our science field, feedback provided by users suggest that gathering all the scientific outputs arising from the first years of the contract will take a couple of year from now due to the long publication cycle.

The Access Office has faced up to this challenge by half-yearly surveys to our users as well as by tracking possible acknowledgement of our Access Programme in papers (ASTRONOMICAL JOURNAL, ASTRONOMY & ASTROPHYSICS, ASTROPHYSICAL JOURNAL, etc).

Moreover, we have uploaded to our website an online-form to compile these scientific outputs (http://www.otri.iac.es/opticon/frame.php?pagina=output). In this way, some users has collaborated with the Access Office to prepare a Scientific Output report submitted together with this activity report.

1.4.1.5 User meetings

No user meetings during the whole contract are expected to be organised.

1.5 JOINT RESEARCH ACTIVITIES

1.5.2 JRA1: Adaptive Optics

Participant number	4	6	8b	11a	12	19	31	35	
Participant short name	ESO	INSU/CNRS	INAF-Arcetri	MPIA	NOVA	GRANTECAN	ONERA	Univ Durham	**Total**
Person-months	11.57	9.3	15.69	25.92 (20.04)	0	1.97	8.082	TBD	

The Total human effort deployed during this reporting period for JRA1 is summarized in the above table (in parenthesis additional manpower only for AC cost model):

WP 1: Coordination of JRA1

Past years:

This JRA1, managed by ESO, was launched in March 2004. ESO created a dedicated web page to disseminate the information and reports produced in the frame of this JRA1 (http://www.eso.org/projects/aot/jra1/). Some documents are password protected. General meetings have been organised every 9 months as planned (see meeting table). Dedicated meetings or video-conferences have allowed accurate monitoring of the individual WPs. Strong interactions between JRA1 & 2 have been maintained since the beginning of the contract as JRA2 R&D (Adaptive Optics CCD detector) is one of the key element of the projects developed within JRA1.

The management (ESO) of JRA1 has been actively solicited since the beginning of OPTICON to prepare the subcontract technical specifications/Statement of Works, to negotiate the contracts and to monitor the progress of the Adaptive Optics key components (1370 actuators piezo deformable mirror, Thin Zerodur glass shell, 1170 actuators Adaptive secondary design, piezo DM Drive electronics, micro and mini deformable mirrors, wavefront sensor CCD). Six general meetings have been organised.

In 2008, the General meeting 6 (deliverables M1 of this WP 1) was organised by ESO: September 25 & 26th at ESO Garching. ESO has continued the monitoring of the JRA1 FTE and HW expenditures.

ESO has also presented the JRA1 results at the OPTICON board meeting in Porto on Nov. 10th & 11th.

Monitoring of other subcontracts has continued.

WP 2: System design

WP2.1: XAO system Study

Past years:

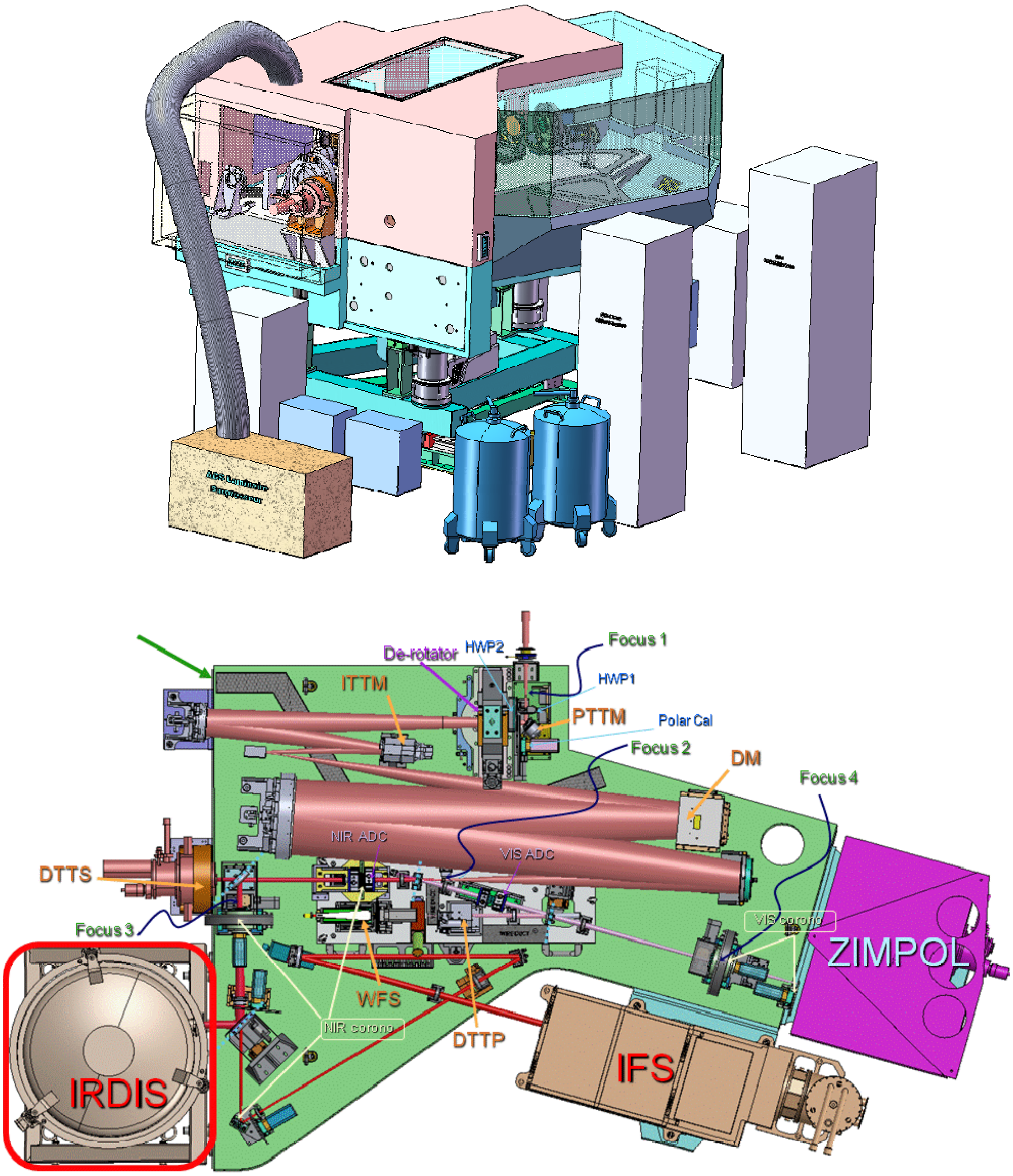
Following two competitive feasibility and conceptual design studies of the VLT XAO system achieved by INSU and MPIA-INAF and reviewed by ESO in the fall of 2004, the ESO Scientific and Technical Committee (STC) recommended in April 2005 to establish a collaboration of both teams under the lead of INSU-LAOG as the P.I. institute. The main goal of this collaboration was to enhance Planet Finder's scientific capabilities by the inclusion of the science instruments (integral field spectrograph and differential polarimeter) proposed by the former MPIA led consortium. To support this merging, in 2005 ESO launched a Post-phase A contract with the aim of providing enough resource to perform the R&D activities between the end of the phase A and the start of the VLT Planet Finder design and construction phase.

The newly merged consortium submitted a consolidated instrument concept and a strong coherent system and project management plan to the ESO Scientific and Technical Committee (STC) in October 2005. Documentation presenting efforts of the two former consortia towards these goals including an executive summary has been produced. STC recommended to the ESO Council that this project should be continued. The new Consortium consists of: INSU-LAOG, INSU-LAM, ONERA, INSU-LESIA, MPIA, ETH Zurich, INAF-Padova, Geneva Observatory, University of Amsterdam, Utrecht University, ASTRON, and ESO. The renamed VLT SPHERE project (standing for Spectro-Polarimetric High-Contrast Exoplanet Research) has successfully accreted several new European Institutes outside the original JRA1 partners. This interest is due to the potential high scientific return of this future facility: the direct detection of Extrasolar Planets. In June 2006, ESO Council decided to proceed with and fund the full development of SPHERE as part of the 2nd Generation instrument programme of the Very Large Telescope and to allocate 260 Guaranteed Observing nights to the Consortium building this facility. These observing nights on the VLT will actually be used to start a large scale survey for the direct detection of exoplanets. In 2007, the Consortium has passed the SPHERE Optical Preliminary Design Review March 6th and has completed the Preliminary design documentation (Final delivery D1 of WP 2.1).

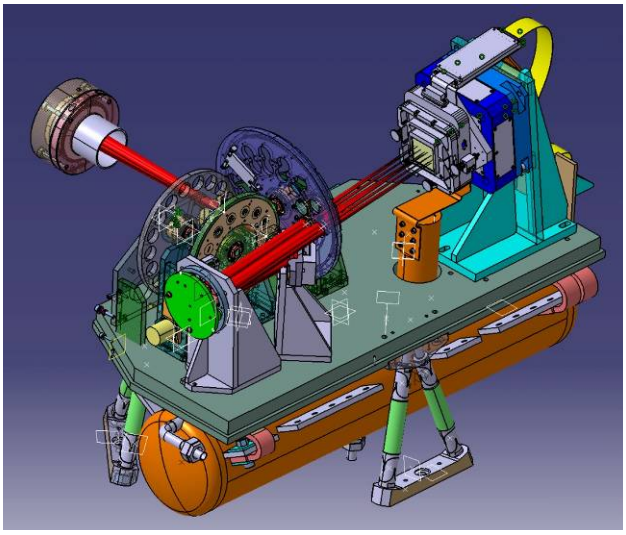
In 2008:

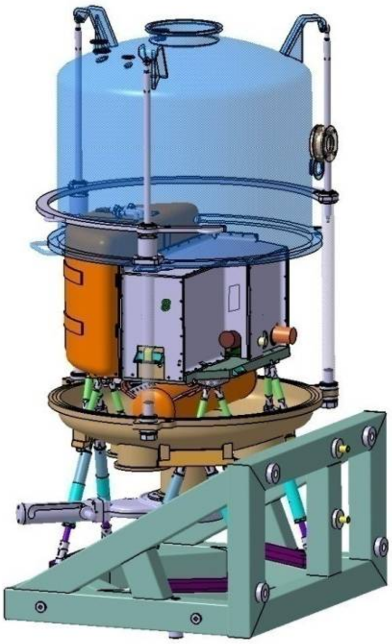
Although the activities planned in the frame of the OPTICON contract were completed last year, design activities of SPHERE have been pursued in 2008 with two major project milestones achieved and several prototypes completed: the Optical Final Design and the Final Design review May 27th December 16-17th 2008. The manufacturing and construction of SPHERE funded by both ESO and the Consortium is now on-going.

SPHERE, as a planet hunting instrument to be installed on the VLT, is considered as an important pathfinder for the European Extremely Large Telescope, the E-ELT, a new European facility included in the ESFRI roadmap. Research efforts which have been invested in SPHERE are crucial for the development of the high contrast instrument required to meet the challenging scientific objectives of the E-ELT: detection of cold Jupiters or of rocky planets.

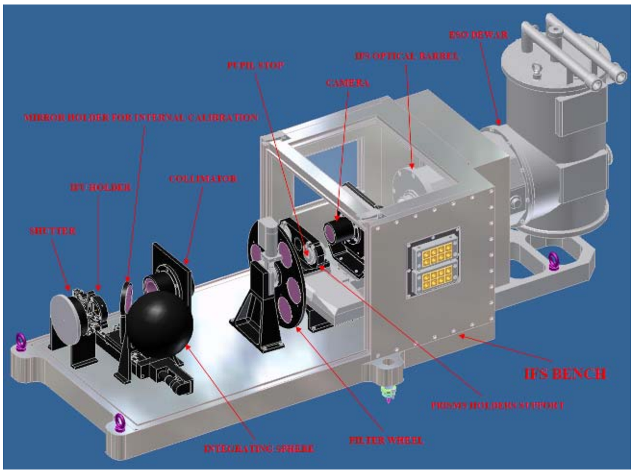


Implementation of SPHERE on the VLT Nasmyth platform

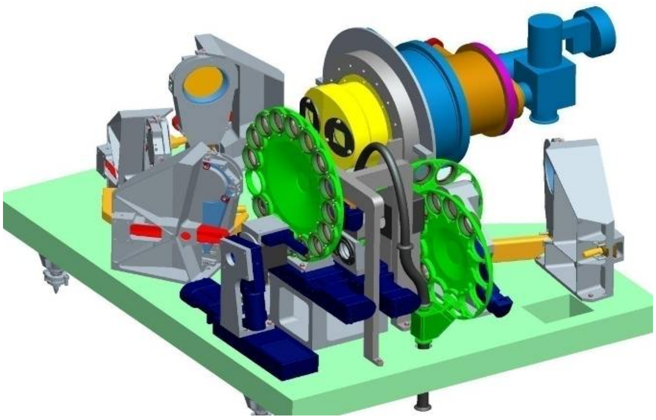




Left: Design of the differential imager (IRDIS); Left: cryogenic detector jitter system;
Right: <1nm rms IR filter prototype; Bottom: differential imaging optomechanical design.



Design of the NIR 3 D Spectrograph (IFS)



Design of the differential polarimeter: ZIMPOL

WP2.2: GLAO System Study

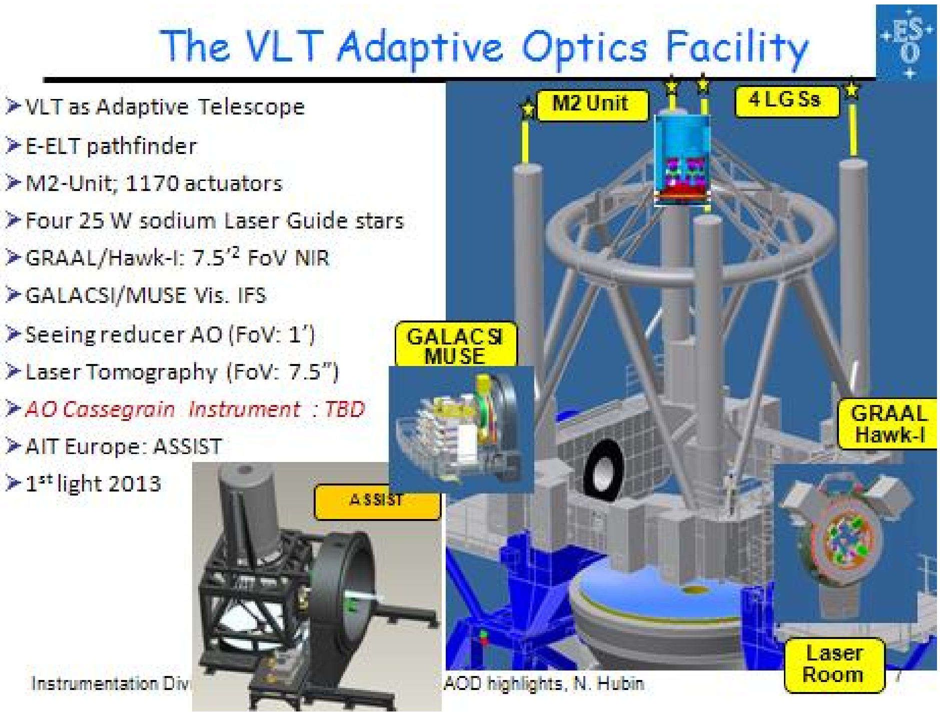
Past years:

Following the two GLAO conceptual designs (GALACSI and GRAAL) performed in 2004 and the work started on the feasibility of the VLT Deformable Secondary Mirror (DSM), WP3.5, the ESO-INAF-NOVA/Leiden project team was requested to provide the design of a fully integrated VLT Adaptive Optics Facility (AOF) consisting of GALACSI, GRAAL, DSM as a full secondary unit, the laboratory test facility (ASSIST) and the Laser Guide Star Facility with 4 laser projectors. The goal was to have a better understanding of the whole project and a better estimate of the cost to completion of this new European Facility in view of its approval by the ESO committees.

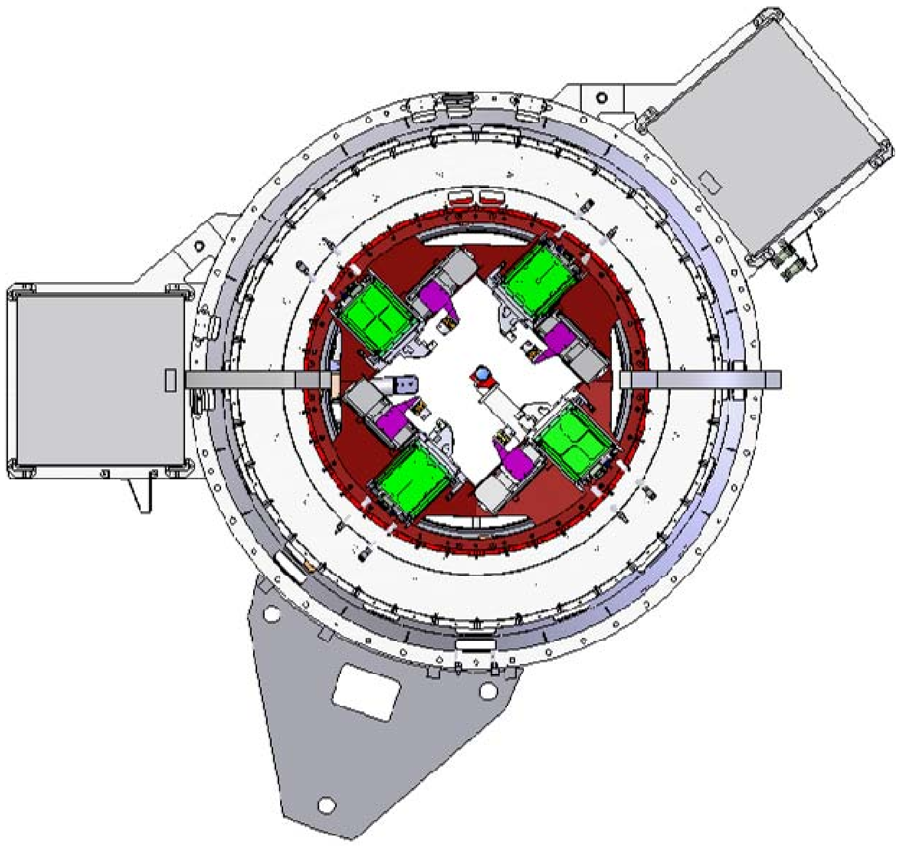
In 2005 the new Adaptive Optics Facility conceptual design was performed and the design documentation package was produced by ESO-INAF-NOVA/Leiden. A conceptual design review involving ESO and international reviewers was conducted on September 29^{th}-30^{th}. The outcome of this design review was that AOF was technically feasible and scientifically worthwhile while risks were considered acceptable and controlled. Following this recommendation from the review board, ESO Scientific and Technical Committee and ESO Council (respectively in October & December 2005) have decided to proceed with the development and construction of this new facility. In 2006, NOVA/Leiden and INAF worked on the Preliminary design of this facility: NOVA/Leiden has focused its effort on the design of the required test facility ASSIST while ESO has worked on the design of the Ground layer AO modules (GRAAL and GALACSI) and on the 4 Laser Guide Star Facility (4LGSF). Deformable Secondary Mirror design activities are included in WP 3.5 and have been supported partially by INAF. In 2007, GRAAL Preliminary design was passed March 12^{th} 2007 (Final delivery of WP 2.2), Deformable Secondary Mirror Preliminary design was passed March 5^{th} 2007, Final design Dec 18^{th}. The laboratory test bench ASSIST had its Design review in October 30^{th}.

In 2008:

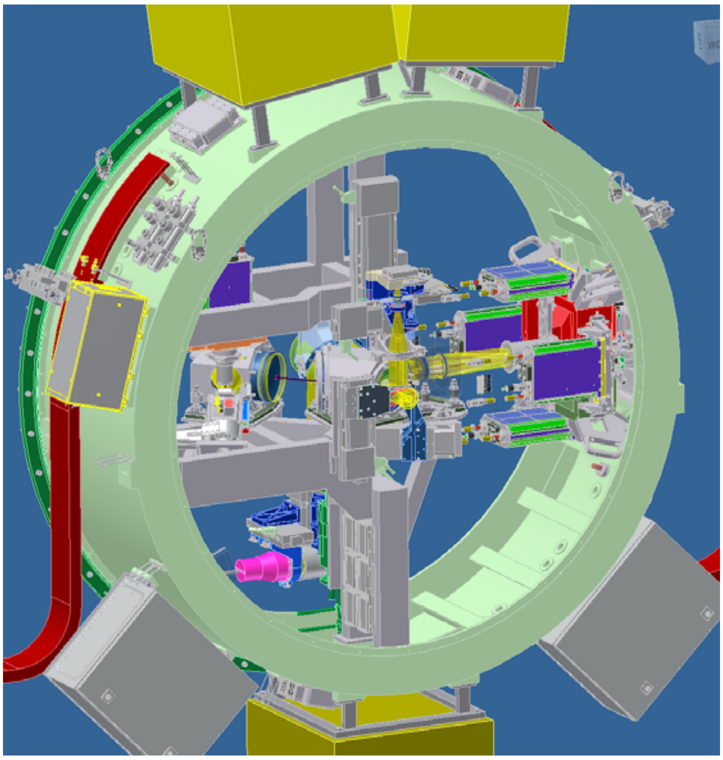
Although this activity was completed in 2007, the Final design of GRAAL and Preliminary design of GALACSI have been pursued. GALACSI PDR was passed Sept 23^{rd}. GRAAL mechanical design was passed Dec 9^{th}.



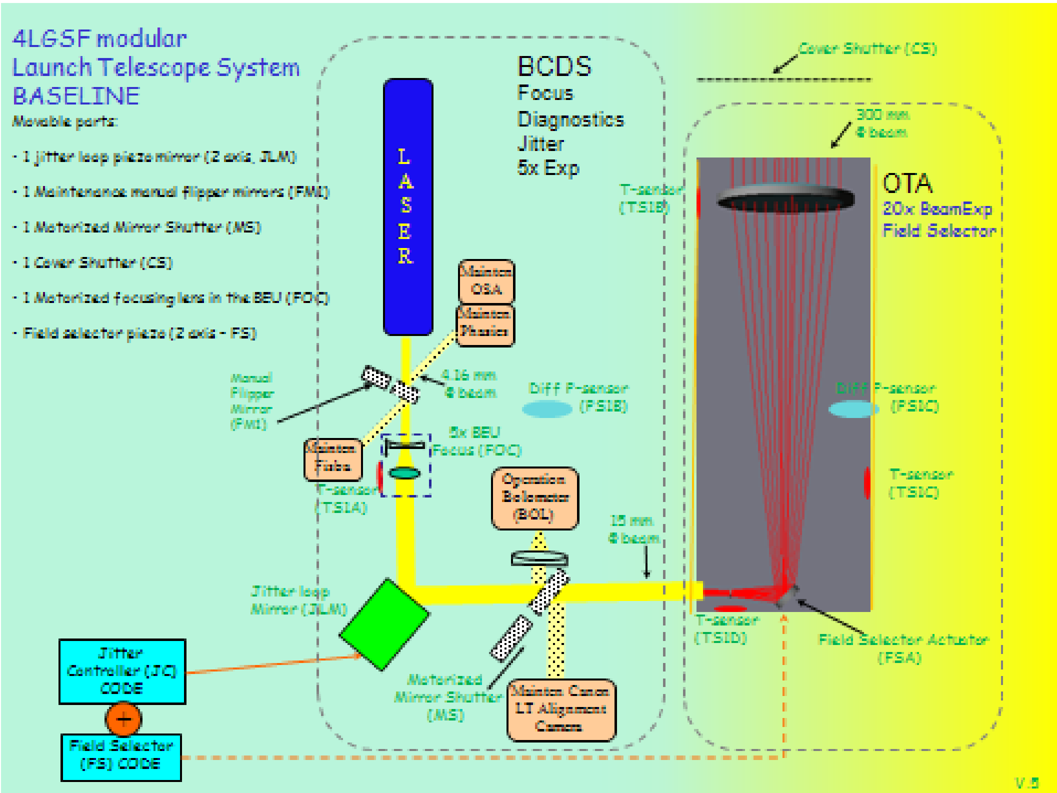
Overview of the VLT Adaptive Optics Facility included the two Ground Layer Adaptive Optics systems: GRAAL, and GALACSI (WP2.2), the Deformable Secondary Mirror (WP3.5) and the 4 Laser Guide Stars.



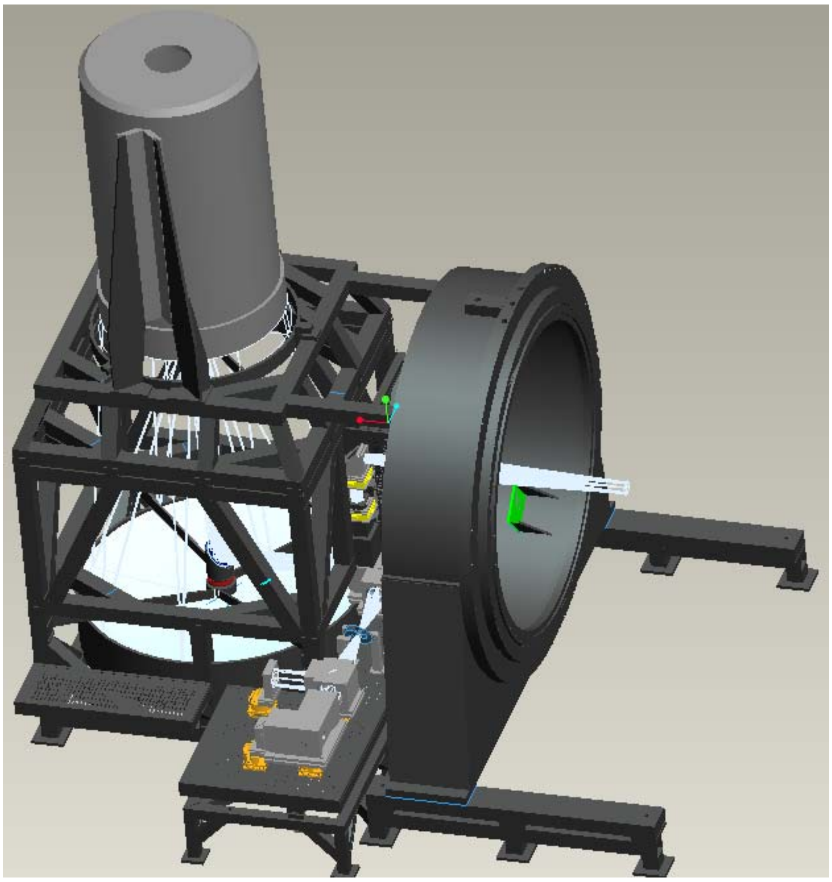
Front view of the GRAAL, Ground Layer Adaptive Optics for the VLT.



Overview of the GALACSI, Ground Layer Adaptive Optics for the VLT.



Overview of the Laser Guide Star Facility at the VLT



Overview of the Adaptive Optics test facility (ASSIST): on top the Deformable Secondary mirror, on the right the mounting flange for GRAAL or GALACSI. On the bottom: the turbulence generator.

WP2.3: Multi-Object WFS for GTC

Past years:

The original work proposal of the GTC Project Office (GTC PO) consisted of the conceptual study, design and fabrication of a multi-object wavefront sensor based on the concept of curvature wavefront sensing. In 2004, GTC carried out the simulation software development to test the conceptual feasibility of the multi-object curvature wavefront sensor concept.

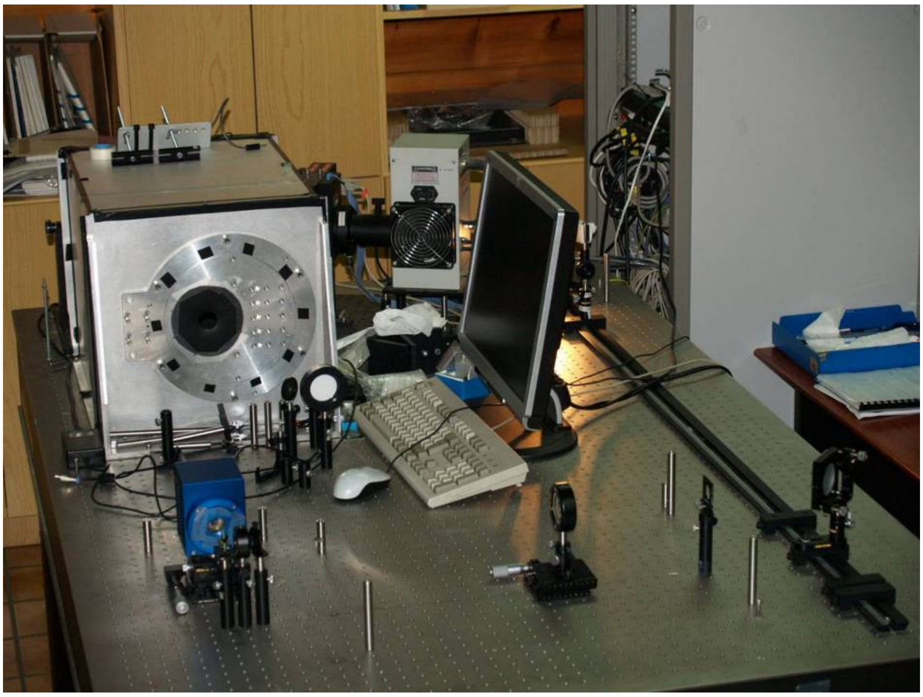
Simulations conducted at the beginning of 2005 showed that multi-object curvature wavefront reconstruction using several randomly distributed objects in the Field of View (FoV) with free-noise measurements was not good enough. The interpretation is that a better sampling of the recorded images will greatly improve the reconstruction (i.e. deconvolution) of the defocused pupil images which constitute the input to the wavefront reconstruction algorithm. In addition, the defocused pupil images reconstruction algorithm is based on at least square minimization algorithm which might benefit from a more sophisticated constrained linear least squares minimization where the “non-negativeness” of images is explicitly imposed.

Based on the results obtained so far, it is essential to address the reasons leading to the degradation of the reconstruction with a laboratory single object curvature wavefront sensor in which the problem is similar to the multi-object wavefront sensor. In addition, this approach fits better the plans and the needs of the GTC Adaptive Optics Facility. In 2006, the GTC team developed the design of the GTCsim system. In 2007, mechanical design for the Curvature WFS and final integration and alignment of the complete prototype using CCD47-20 in the Curvature WFS was completed.

In 2008:

Due to internal person power shortages in the first half of 2008 (higher priority to be given to the GTCAO design activities), this activity was put on hold. During the second half of 2008, the test set-up was completed and measurements (see figures below) were recorded with the curvature WFS.

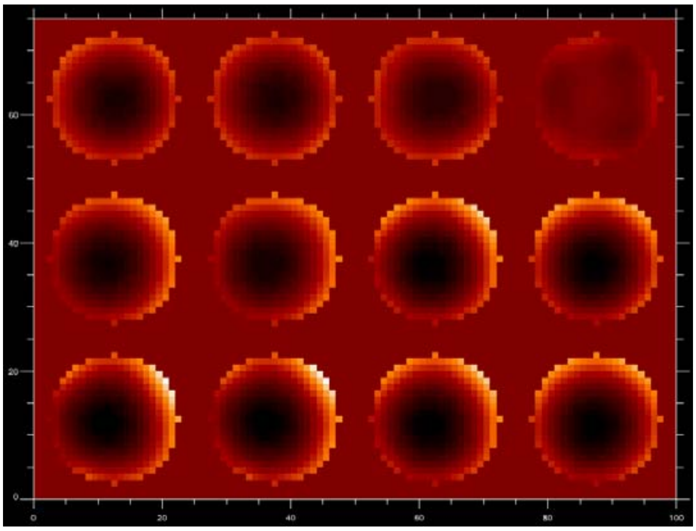
As of September 2008 GTC team had already aligned and reconstructed wavefronts when introducing a defocus aberration by moving the pinhole along the rail. However, they got stalled on working with images with only defocus aberrations as they were not able to reconcile the Wavefront Reconstruction results with those expected from simulations. These results are the only ones GTC team has been able to produce to date.



Picture of the whole prototype showing the NIR camera (blue metallic box at the bottom left corner). In opposite direction to the light travel from the source we find in front of the NIR camera the WFS optics made of (from right to left) a J-band filter, the WFS collimator and a prism used to fold the collimated beam towards the NIR camera. To the right of the 3 posts there are successively the illumination system achromat, then the pupil mask and the fold mirror. In the background of the image, mounted on the same rail as the fold mirror, the pinhole and (blocked by the computer monitor) the light source.

Data were collected in September 2008 by GTC staff and were shown during the 6th General Meeting (late September 2008). The defocus distance between the defocused pupil planes with respect to the pupil plane is 15 mm. Several reconstruction methods were used to recover the focus applied to the system (see figure below).

The surprising fact about these reconstructions of the on-focus pinhole wavefront is that barely a couple of threshold values in the inversion agree when comparing against different inversion schemes. When performing the reconstruction of the wavefront from the pin-hole displaced 200 mm towards the fold mirror the GTC team encounters a more homogeneous situation, with a better degree of agreement between different algebraic equation inversion schemes, see figure below. However, following a series of measurements for extra-intra pupils of ±10mm and ±20mm, it has not been possible to identify the point at which the algorithm was not able to derive the right value for defocus. More work remains to be done to understand the reason for the disagreement obtained with the test setup. The test setup and test report with the results described above were delivered and represent the final delivery of this WP (**final delivery of WP 2.3**)



Wavefront reconstructions corresponding to pinhole moved 200 mm towards the fold mirror. Each row is the result of using a different inversion method of the algebraic equation. Bottom row is the direct inversion using sparse matrix methods and the conjugate gradient method. Middle row applies the sparse matrix and bi-conjugate gradient to $A^TAW=A^Tf$. Top row inverts the AW=f algebraic equation applying SVD. Each column corresponds to a regularization threshold of (left to right): [$5x10^{-5}$, 10^{-4}, $5x10^{-4}$, 10^{-3}].

WP2.4: Multiple FOV System with NGS

The objective of this WP is to develop a Multiple Field of View AO wavefront sensor (MFoV-WFS) prototype to be tested on the AO system of LINC-NIRVANA: a Fizeau Interferometer for the Large Binocular Telescope (LBT). The prototype system consists of a Ground Layer Wavefront Sensor (GWS), a High Layer Wavefront sensor, de-rotation units for the sensors (bearing and K-mirror), one deformable mirror, collimation and imaging optics (Collimator, FP20) for the High Layer wavefront sensor (HWS) and a patrol camera for monitoring the acquisition field of the HWS.

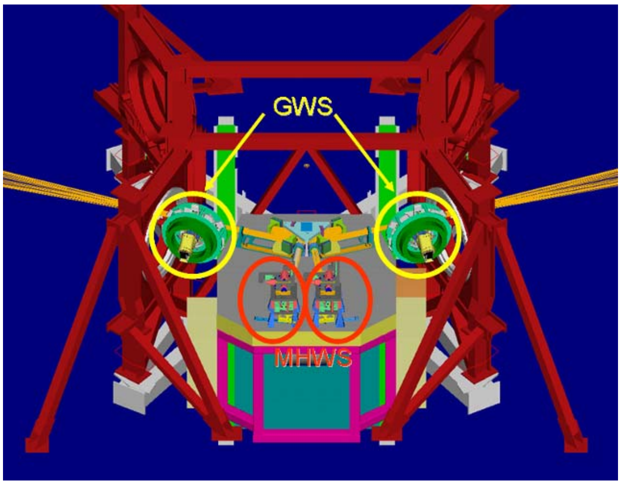
Past years:

In 2004, the LBT team worked on sky coverage and performance simulation. In parallel, the team received a 349 actuator deformable mirror which was tested and characterized. At the end of 2004 the GWS design report (M1) was delivered and the CCD and control electronics was ordered. In 2005, the Final Design Review of the complete LINC-NIRVANA instrument including the MFoV-WFS systems was completed. The High order wavefront sensor translation stages were tested and found out of specifications. The manufacturer started to re-work the stages to fix the problem. In parallel a re-evaluation of the sensor performance was conducted. In 2006, the re-work of the stages by the manufacturer was evaluated, but were not satisfactory. The high order wavefront sensor was however integrated in Bologna (INAF) with the existing translation stages while the Ground layer wavefront sensor, which is more sensitive to the translation stage accuracy, integration was delayed. It was decided to explore alternative translation stage designs. In parallel to the opto-mechanical activities, development of instrument control software was conducted in the framework of the overall LINC-NIRVANA instrument. In 2007, the high order wavefront sensor was integrated and assembly of the ground layer wavefront sensor bearing was achieved has been performed

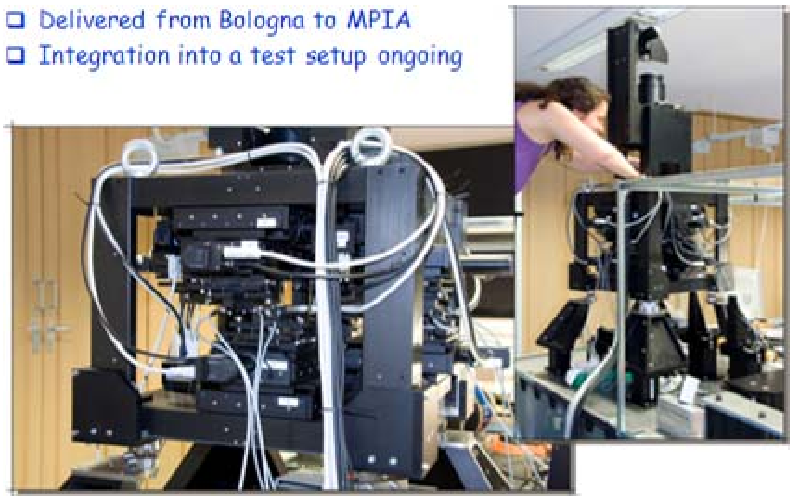
In 2008:

In 2008, the Ground layer and High layer Wavefront Sensors (GWS & HWS) and the patrol camera were integrated and aligned following individual component tests. The patrol camera mechanism was stiffened to reduce flexures, so as to meet system specifications. The HWS was delivered to MPIA but several non-compliances of its key components have been identified and corrected, delaying the system integration and testing. Finally, the loop was closed with one HWS pyramid using 10 to 20 modes. Additional pyramid WFSs and star simulator are planned to be integrated in 2009 in the HWS and the number of corrected modes will be increased. The GWS is being integrated at Observatory of Padova (INAF) following the key component testing and the delivery of the GWS bearing from MPIA. The HWS integration, first light laboratory testing and the delivery of the corresponding test report represent the final deliveries for this WP (WP 2.4 M2 & D1).

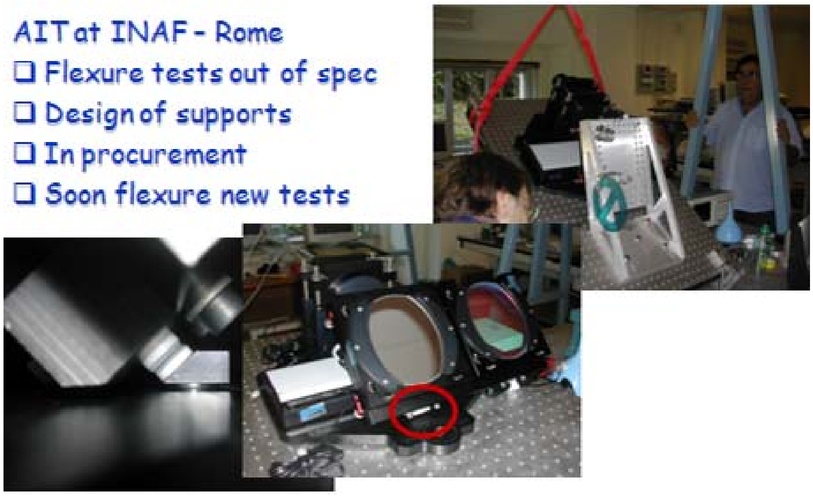
The lists of delivered corresponding documents are listed in **Section 3. Use and dissemination of knowledge.**



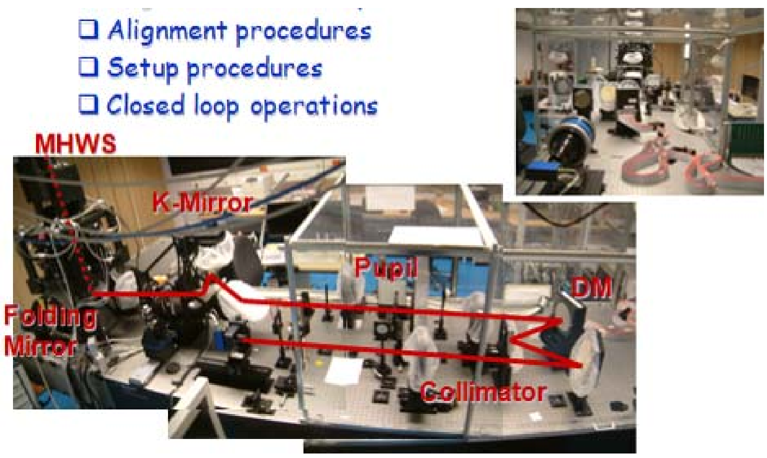
Overview of the LINC-NIRVANA Multi-Conjugate Adaptive Optics system: In yellow the Ground layer wavefront sensor to be delivered in the frame of JRA1

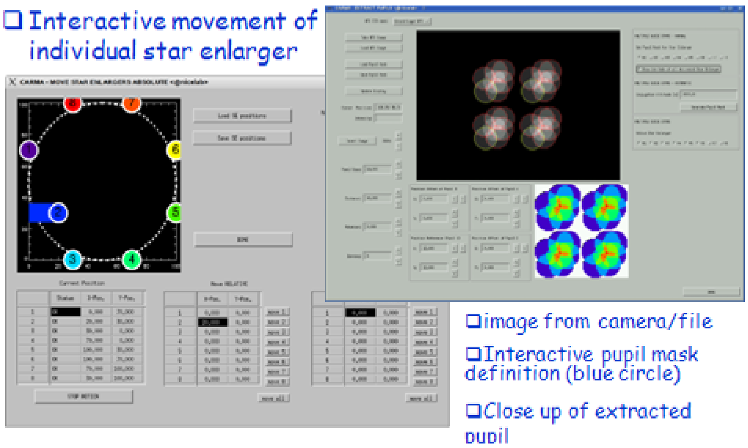


High layer wavefront sensor integration at Bologna



Patrol camera





Top: System testing of the High Layer wavefront sensor; Bottom: Control panel

WP 3: ENABLING TECHNOLOGY FOR 2nd GENERATION/ELT AO SYSTEM

WP3.1: 2nd Generation RTC Platform

Past years:

SPARTA (Standard Platform for Adaptive optics Real Time Applications) went through different phases of evolution in which ESO and Durham tried different solutions of various complexity. With the guidelines of using only COTS components and keeping the development of the platform as simple as possible, SPARTA started off in 2004 with an all-CPU solution. The participation of Durham into the WP brought expertise of FPGAs (Field Programmable Gate Array), which were included into the design through available commercial products. The first concept presented in 2004 included all these features, but an issue with board-to-board latency had already been identified.

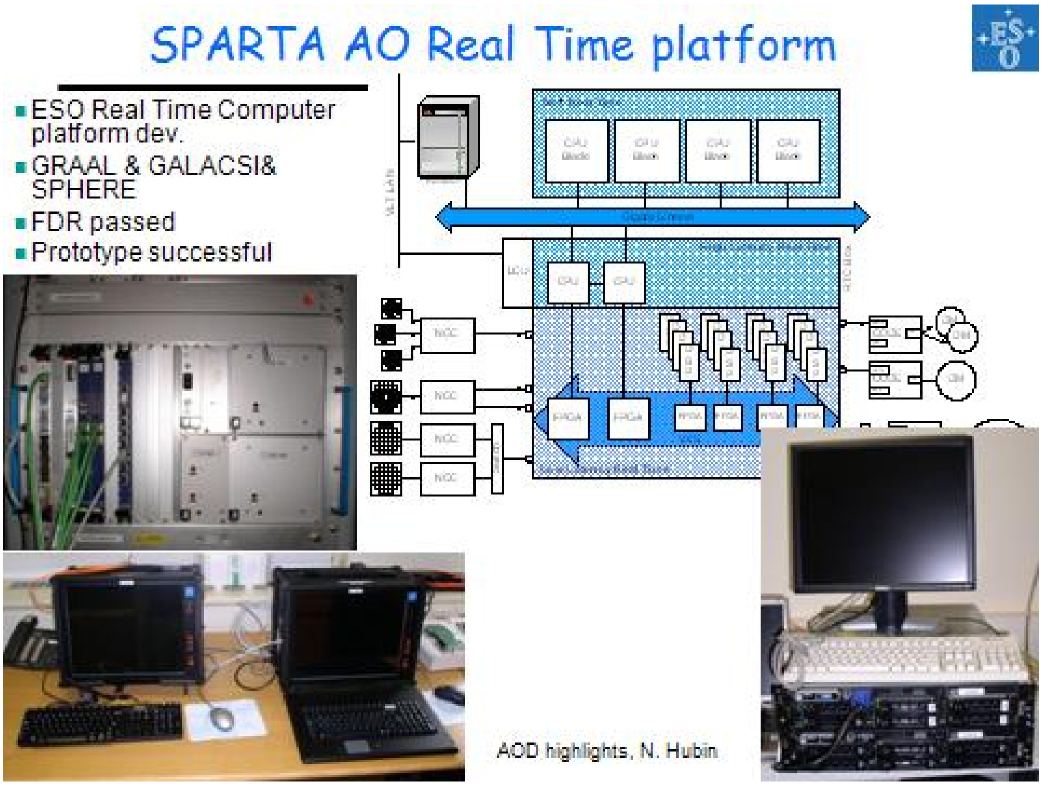
In the course of 2004 and 2005 we performed all the foreseen benchmarks and we realized that the architecture could not meet the requirements for two reasons: the computing power of the CPU did not meet the expectations and the measured communication latency was too high. The second SPARTA concept addressed the concerns of computing power and communication latency by increasing the use of FPGAs. In 2005, an internal conceptual design review was run between Durham and ESO to consolidate the architecture. However, the architecture seemed too biased towards FPGAs: the difficulty of their programming and the long development cycle raised concerns about their widespread use.

Towards the end of 2005, ESO and Durham developed a third concept for SPARTA based on a hybrid architecture that uses three different technologies for different purposes. FPGAs are used to pre-process the large incoming data stream to more manageable sizes (i.e.: from pixels to gradients, developed by Durham) and to implement the high-speed communication infrastructure that runs serial FPDP. DSPs (Digital Signal Processors) are in charge of the main mathematical operations and general-purpose CPUs (Central Processing Unit) perform more complex tasks or high level operations developed by ESO.

The first features 2 CPUs and 2 FPGAs (VMETRO VPF1) and it is used as front-end and back-end of the processing chain. The second features 8 DSPs and 2 FPGAs (Bittware T2V6). The same type of FPGA is present on both boards and this enables board-to-board communications. The high-speed communication layer runs over a VXS bus, a follow-on of the VME standard. The rack is completed by an ESO-standard LCU used to monitor the rack and control the T2V6 boards and a Zero-Latency-Switch (CSW1 from VMETRO) that connects the VXS slots with each other and also features several optical transceivers that can be directly routed to any VXS slot. This part is called the Real-Time Box, since only the core of the application runs here, the high-speed, low-latency, high-throughput hard real-time computation. In May 2006, this new concept was reviewed by an external board. In 2007, the SPARTA architecture design, the benchmark results as well as the results obtained on the prototypes were reviewed at the Preliminary Design Review July 6th (Deliverable M2 of WP 3.1) final delivery of this WP3.1.

In 2008:

Although this WP was completed in 2007, the Final design of SPARTA was pursued and a Final Design Review was successfully passed October 16th. A full end to end SPARTA prototype was built and this demonstrated that the architecture could meet the 2nd generation AO system requirements. Following the FDR, the serial production of SPARTA for VLT SPHERE and the VLT AOF has started.



SPARTA concept and end to end prototype

WP3.2: ***Optimal Control Methods for MCAO Systems***

Past years

The activity of 2004, 2005, 2006 and 2007 for WP 3.2 performed by ONERA consisted of the following:

- Optimal Control Methods for Multi Conjugate Adaptive Optics using Kalman approach. Off-axis Adaptive Optics control using this method has been numerically and experimentally demonstrated on the BOA bench at ONERA. From this successful experimental work, ONERA developed the specifications and the algorithms of this optimal control method for the ESO Multi Conjugate Adaptive Optics demonstrator (MAD).
- Theoretical studies on high performance wavefront sensors in Multi Conjugate AO have been performed. In particular, Sky coverage, comparison and optimisation of wavefront sensor measurement concepts (based on Star Oriented and Layer Oriented approaches) have been studied.
- VLT-like LTAO and Tomographic AO simulations with the optimal tomographic reconstruction. The optimal tomographic reconstruction brings a very significant gain in performance both in the NGS and LGS cases (several tens of Strehl ratio percent). However performance and global behaviour with respect to theField of View is quite different with NGS and LGS due to the cone effect.

The activities planned to be delivered by this WP were completed in 2007.

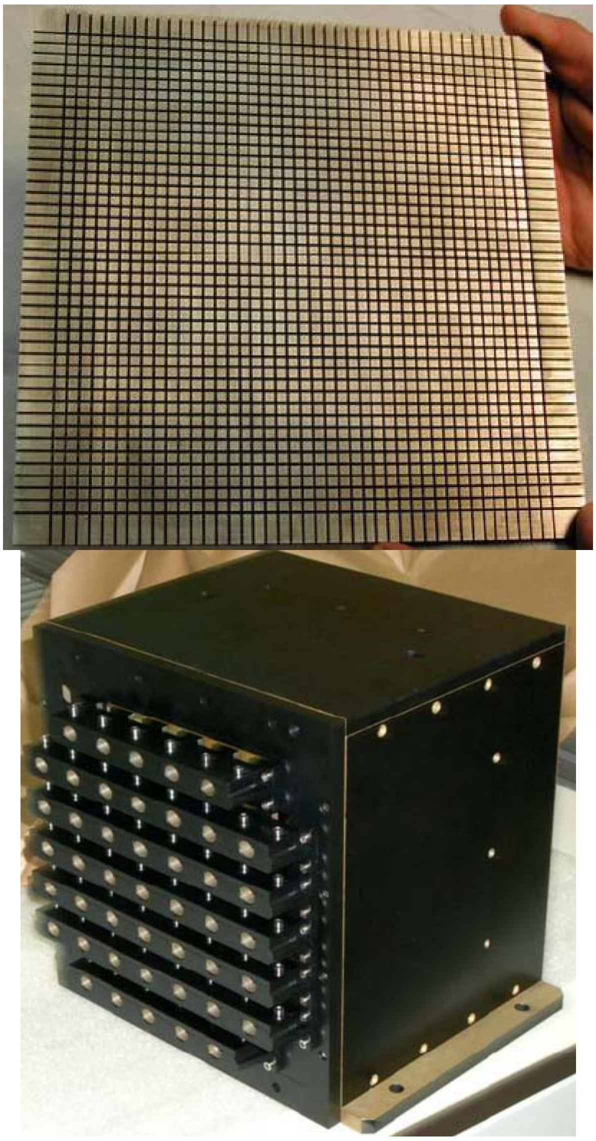
WP3.3: 2nd Generation Piezo DM

Past years:

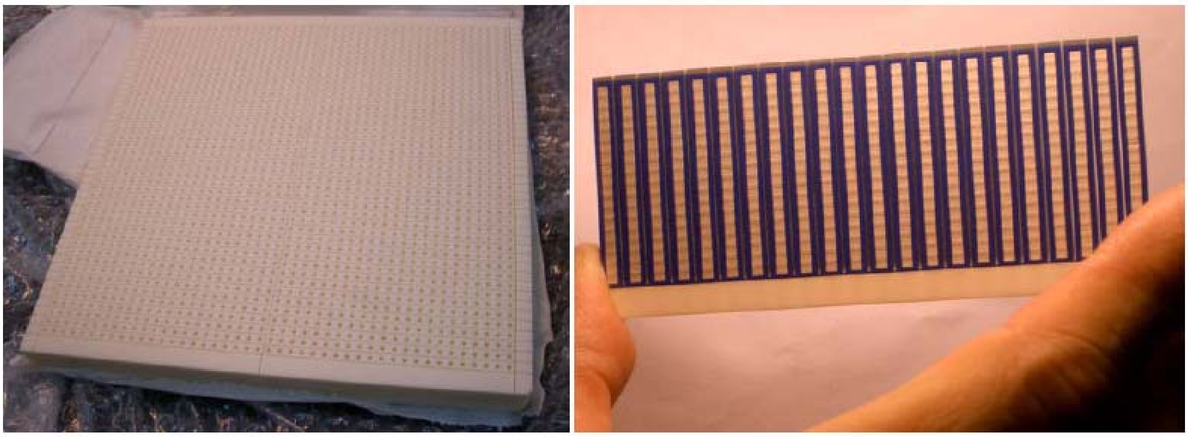
Following the VLT Planet phase A studies (WP 2.1), a top level specifications for the development of the 1370 actuator piezo deformable mirror prototype was produced by the SPHERE Consortium in 2004. These top level requirements were integrated into a Technical specifications and Statement of Work by ESO. In 2005 a Call for Tender was issued by ESO, and two proposals were received and evaluated. After difficult negotiations the contract was granted and signed with CILAS (France) in March 2005. The Kick-off meeting took place in April 2005. CILAS has developed the design of the 1377 actuator piezo-deformable mirror and a design review was organized by ESO in November 2005 (deliverable D1 of WP 3.3). In 2006, CILAS has developed a 57 actuator mockup to validate design parameters of the final unit. This mockup has been extensively tested to check the actuator stroke and inter-actuator stroke, the coupling between actuators, the optical quality of the best flat, hysteresis and dynamic characteristics. Results obtained on the mockup have shown that the performance conformed to the ESO technical specifications. In 2007, the manufacturing, assembly, integration and testing of the 1377 actuators were completed and acceptance of the deformable mirror was achieved in July 2007 at CILAS. The final test report was delivered in October 2007: final delivery of this activity together with the deformable mirror itself. Pictures are provided below to show the deformable mirror key elements as well as of the final unit. The successful development of this 1377 actuator deformable mirror is a world first from the view point of the number of actuators. This success has already led CILAS to negotiate with the Thirty Meter Telescope project for the manufacturing of two 60x60 actuator deformable mirrors and with the New Solar Telescope (40x40 actuator cooled deformable mirror). This is a good demonstration of European Research funding impact helping industry to capture new contracts outside Europe.

In 2008:

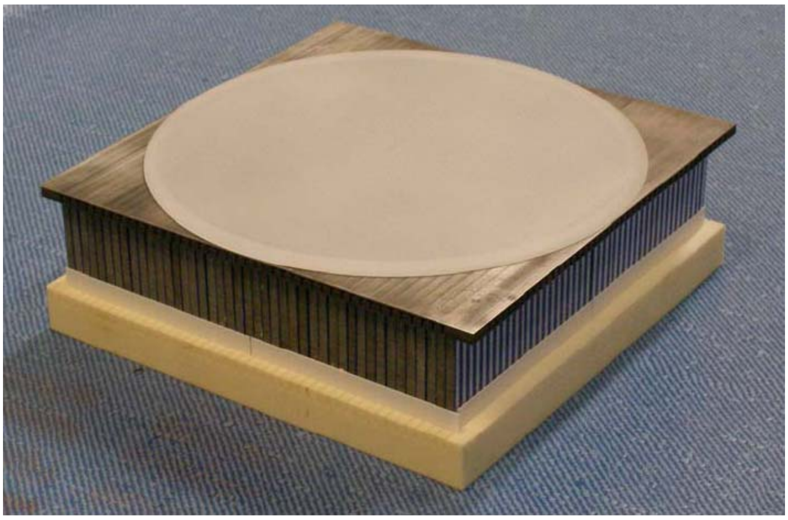
No further activities in 2008.



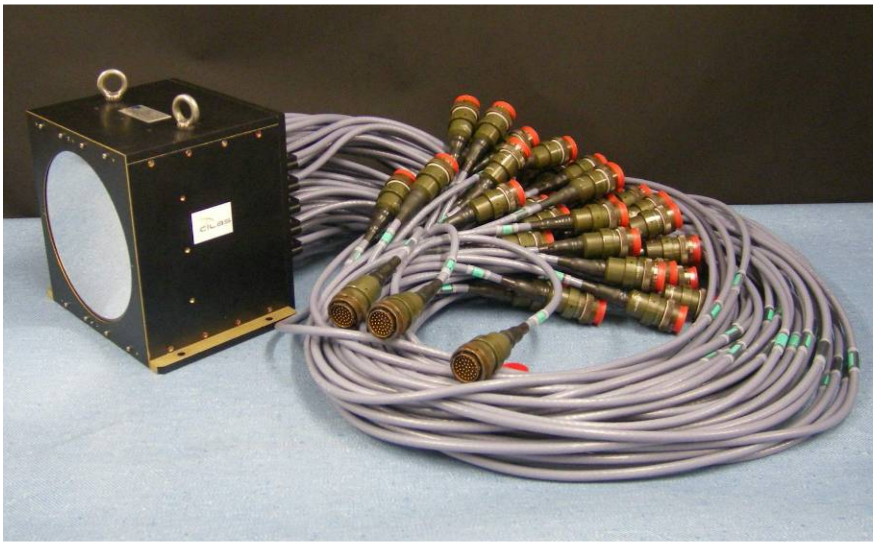
Left: 41x41 deformable mirror head; Right: housing



Base plate and line of actuators



Preassembly of the 41x41 actuator piezo DM



1377 actuator deformable mirror

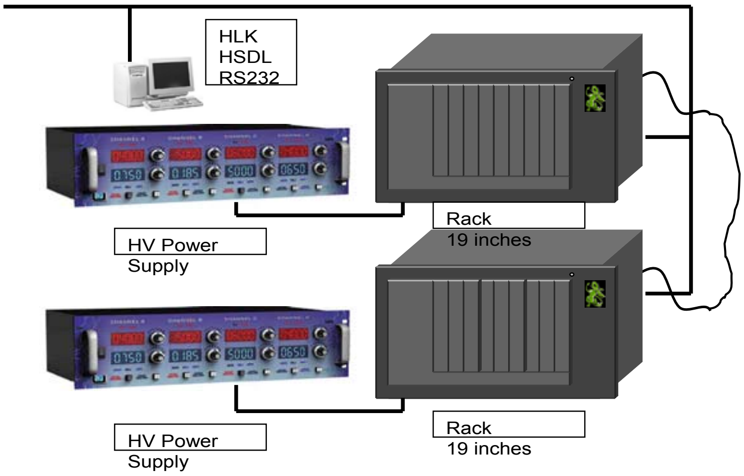
WP3.4: 2nd Generation Piezo DM drive Electronic

Past years:

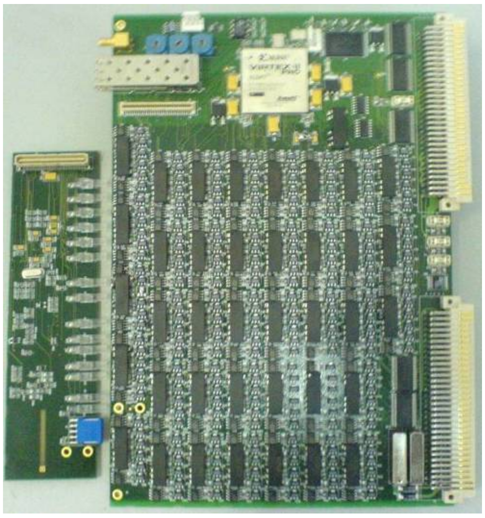
Following the design review of the piezo Deformable Mirror (WP3.3) and the corresponding interface definition (November 2005), ESO finalised the technical specifications and Statement of Work for the design and development of the Corrective Optics Drive Electronics (CODE) with 1500 channel and launched a fixed price (230k€) Call for Tender (17 companies contacted in Europe and in US). Two offers were received, the Shaktiware offer which was based on innovative technology that should achieve goal specifications in the critical areas of power dissipation and latency was selected and contract was signed in October 2006. The design review was successfully conducted in December 2006. In 2007, manufacturing of the Corrective Optics Drive Electronics was launched.

In 2008:

The manufacturing of the Corrective Optics Drive Electronics has been completed and an acceptance test was performed 2nd quarter 2008. A test report has been produced (Deliverable M2 of WP 3.4). This will complete the activity of this WP 3.4. Following the successful completion of the prototype, two additional units were procured for SPHERE (funded by ESO).



1500 channels piezo DM drive electronic architecture



Left: One high voltage amplifier board of CODE; right: DM drive electronic crate prototype with 750 channels.

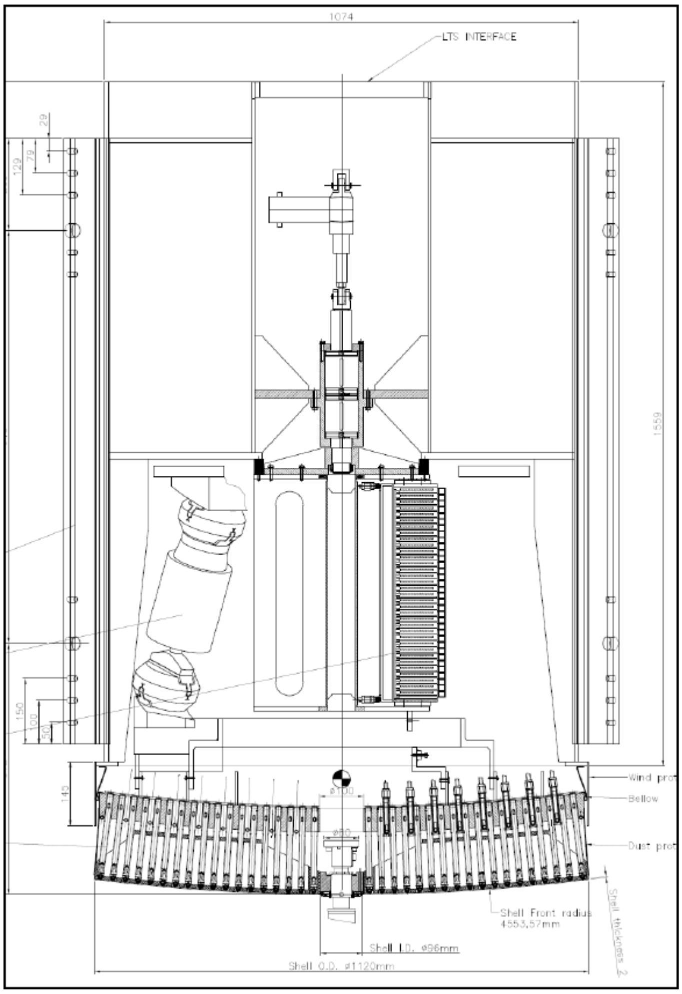
WP3.5: VLT Adaptive Secondary

Past years:

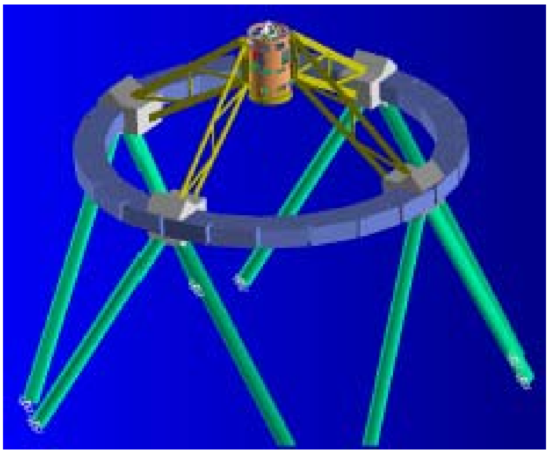
In 2004, ESO in collaboration with INAF, prepared the detailed technical specification and Statement of Work for the development of the VLT Adaptive Secondary. The contract (s) for the feasibility and conceptual design study part of this development was signed with Microgate (Italy) in July 04. Microgate has delivered a straw man design report including review of the critical interfaces and corresponding design review has taken place. INAF has produced the preliminary evaluation of the performance of the VLT adaptive secondary for this straw man design phase. In March 2005 the consortium of Microgate, ADS and INAF Arcetri presented a straw-man design for a complete VLT Deformable Secondary Mirror (DSM). In August 2005, the conceptual design of the VLT Adaptive Secondary was presented to ESO. In 2006 and 2007, the preliminary design was performed with a successful preliminary design Review in March 2007. A Final design review was held in December 2007 and key prototyping performed (Final delivery of WP 3.5).

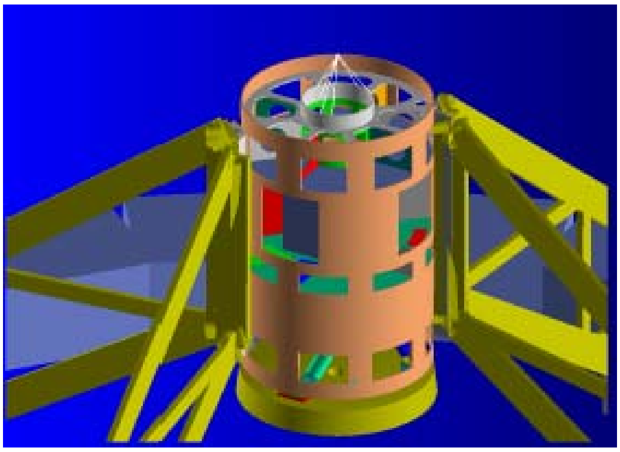
In 2008:

Although this WP was completed in 2007, the development of the VLT Deformable Mirror was pursued with an ESO funded contract for manufacturing, assembly integration and testing of the 1.1 m DSM. Kick-off took place in February 2008; large optical key components have been subcontracted out to SESO (France) other elements are being manufactured by Microgate and ADS in Italy.



VLT Deformable Secondary mirror components layout into the M2 hub





Deformable secondary Mirror mounted on the VLT

Deformable Secondary Mirror mechanical pieces (Hexapod)

WP3.6 Manufacturing and Demonstration of a large convex glass shell

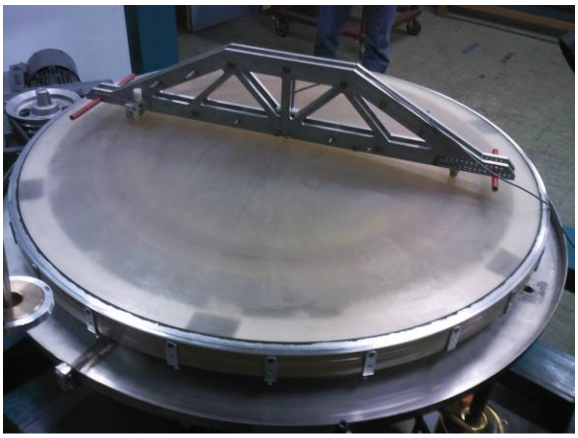
Past years:

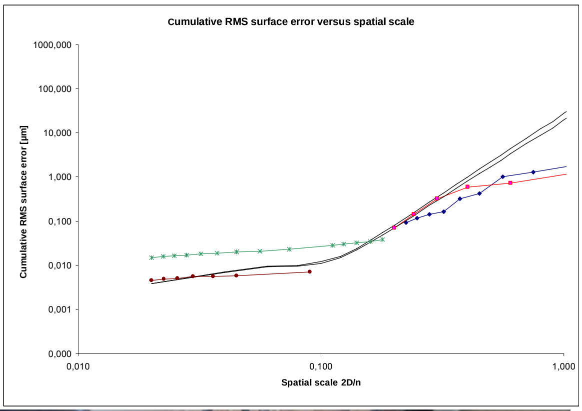
In 2005 ESO issued a Call for Tender for the “Manufacturing, Testing and Delivery of one 1.1m Glass Thin Shell at a firm price of EUR 300.000”. Two (2) answers were received but were considered non-compliant. The Call for Tender was closed and negotiations were conducted with both potential suppliers to identify areas of compromise. ESO issued an updated CfT in December 2005 to the 2 above mentioned suppliers. The compromises are that ESO will provide a supplementary blank (funded outside OPTICON funds) and the surface errors versus linear scale requirements have been relaxed. Answers to the second Call for Tender were received in January 2006; ESO Finance Committee approved the selection of the SESO (France) for the manufacturing of the 1.1m thin shell in collaboration with LAM. A kick-off meeting took place at SESO in April 2006, the final design review was in September 2006. The 1st Zerodur blank was delivered to SESO end of 2006. In 2007, INSU-LAM integrated the 1.5 m polishing machine, manufactured the 1 m polishing tools, manufactured the support ring on the tabletop of the polishing machine. The aspheric polishing process actually started in September. Fine spherical grinding was completed in December.

In 2008:

The depressure polishing of the 1.1 m aspheric convex Zerodur shell performed by INSU-LAM was completed in September. However, during the aspheric polishing a fault in the Schott blank was discovered (see figure below) and after analysis and dedicated test it was decided to inject special glue into the inclusion and to continue the aspheric polishing.   Extensive test of the shell prototype was performed and a test report was produced. The quality of the surface was deemed appropriate. The shell at that point with a thickness of 5 mm was then transferred to SESO for final thinning to 2mm (see figures below).

During the thinning process with the CNC milling machine, SESO reported on November 12th that the shell was cracked. The crack is converging to the location of the blank fault identified during the aspheric polishing at INSU-LAM (see figures below)




Cumulative RMS surface error versus spatial scale
Cumulative RMS surface error [µm]
1000,000
100,000
10,000
1,000
0,100
0,010
0,001
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0,010
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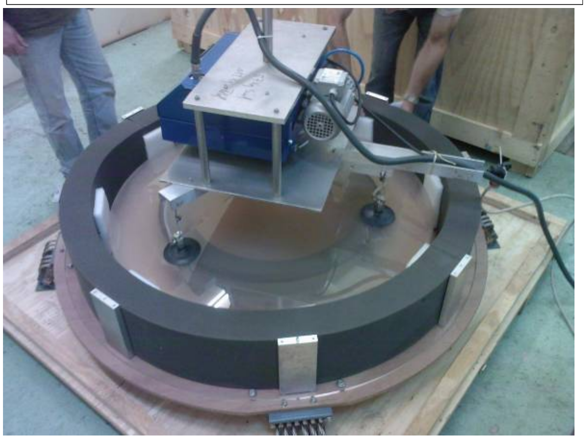
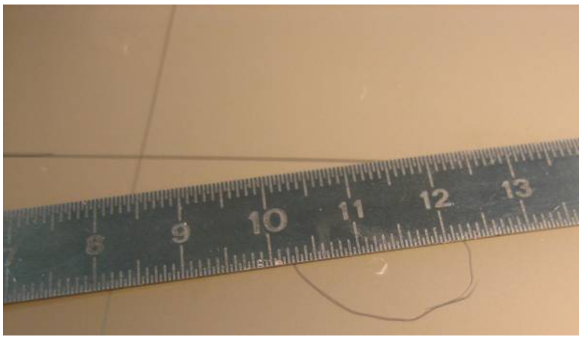
1,000
Spatial scale 2D/n




8
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From top to bottom and left to right at LAM: Aspheric polishing tool; end of 5 mm Zerodur shell aspheric polishing; radius of curvature measurement; Shell handling; optical quality measurement, aspheric shell packing before transfer to SESO; Inclusion in the Schott blank; Cracked shell during thinning at SESO; detail of the cracked shell showing the converging origin of the crack.

At this stage, it was decided to use the second Zerodur blank ordered by ESO 2 years ago to start the polishing of the Zerodur shell again. This time, it is planned to pre-polish the Zerodur blank (Zerodur blank will then be transparent) to allow a very detailed inspection of the blank for bubbles.

This WP is completed with the delivery of the “broken” prototype Zerodur shell and the aspheric polishing test report which demonstrated that stress polishing is one of the right approaches to polish a thin aspheric shell (WP3.6-M2). The production of the 2nd Zerodur shell will be pursued at SESO and INSU-LAM beyond the current OPTICON contract.

WP3.7 2k Actuator & low order Micro-Deformable Mirrors (MDM) R&D

The first activity of work-package 3.7 was the development of a prototype magnetic deformable mirror. This prototype was delivered in 2005 by LAOG and LAOG has since received a lot of requests for this device from the adaptive optics community (both astrophysics and ophthalmology). LAOG had to find a solution to manufacture and commercialize these deformable mirrors, and in 2005 the LAOG team decided to create a business unit called ALPAO within FLORALIS, a subsidiary company from the Grenoble University dedicated to technology transfer. ALPAO became a stand-alone company in June 2007 and is now employing 3 people. A second patent license was granted to the Imagine Eyes Company for non-astrophysics applications.

The second activity of work-package 3.7 is the development of a MEMS-based 2k actuator deformable mirror. A call for tender has been issued (JRA1-SPE-LAO-0003) and sent to 23 companies and research centers selected with the help of a private consulting company (Yole Development). Due to the lack of satisfying answers and the late availability of funding, LAOG decided to better adapt their strategy to both the available cash-flow and to the technical capabilities of possible subcontractors. After discussions with LETI, ALPAO and OKO/IPMS, LAOG decided to launch 2 smaller contracts in 2006.

• One with LETI for the development of a smaller MEMS-based deformable mirror. The kick-off meeting took place in September 2006 and a first progress report was delivered end of 2006.

• One with ALPAO for the development of an improved magnetic deformable mirror. The kick-off meeting of the feasibility study took place in August 2006 and a first progress report was delivered in December 2006.

The third activity of work-package 3.7 was the development of drive-electronics for the MEMS prototype (deliverable M3). A contract was signed in 2005 with Shaktiware for the development of 1024 channel drive electronics (CNRS contract N° M051104). This prototype was delivered in 2006 and is now fully operational at INSU-LAM. The requirements and the design were kept compatible with other MEMS devices, and the Shaktiware electronics are now used at ESO to drive a MEMS device manufactured by Boston-Micro-machine.

In 2007, the magnetic deformable mirror technology was pursued. The design phase of an 11x11 magnetic deformable mirror (ALPAO) was completed however there was a problem of bandwidth. A new contract was signed for the next phase at the end of 2007 for prototyping a magnetic deformable mirror with high bandwidth. The MEMs electrostatic technology from LETI did not reach the expected level and the final design did not address all issues related to the proposed zipping actuator concept. Therefore this technology was not pursued further as reported in last year’s report. Following intensive discussions with CILAS, a third technology based on the transverse effect of the piezo material was proposed reaching the 1 mm actuator pitch. To explore this technology further, a contract was given to CILAS to develop a 50x50 actuator mini deformable mirror based on transverse piezo electric forces. The KOM meeting took place in May 2007 (Milestone M1 of WP 3.7), the preliminary and the final design review was held in November 2007 (Milestone M2 and M4 of WP 3.7).

In 2008:

Magnetic Deformable Mirror

The KO meeting of the high bandwidth magnetic DM took place in January 2008.
2008 has seen the completion of the contract awarded to the FLORALIS/ALPAO company to design and manufacture a magnetic deformable mirror for MOAO and MCAO applications. A 97-actuator mirror prototype has been delivered (see figure below, left panel) and two reports have been submitted, see **Section 3: Use and Dissemination of Knowledge**. The test report demonstrates that the delivered prototype is fully within specifications. The major achievement of this study is the demonstration that the magnetic technology now makes it possible to reach bandwidths greater than 1 kHz (see figure below, right panel) while maintaining large strokes (> 30 μm for 3x3-actuator blocks), very good linearity and negligible hysteresis. The mirror prototype has also been qualified to operate at -40°, a very useful characteristic of MOAO instruments working in the near infrared, especially

long ward of 1.7 μm, where the instrumental background can be a limitation. INSU-LAOG has also procured dedicated drive electronics and is planning to further validate the prototype in actual astronomical conditions, i.e. on the sky.

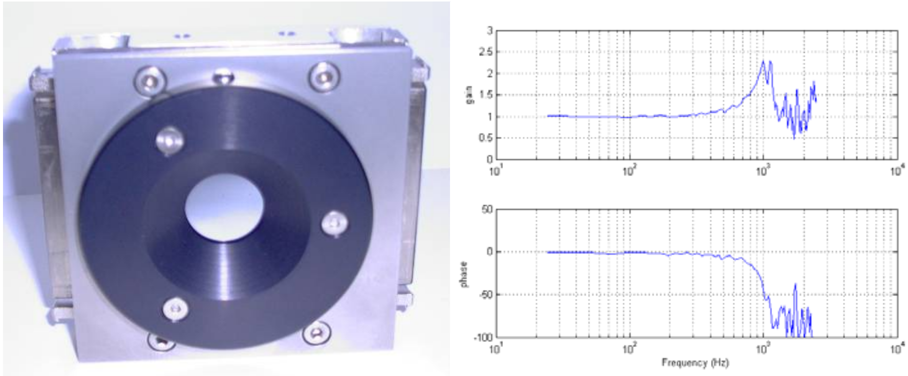


Figure: Prototype of the FLORALIS/ALPAO 97-actuator magnetic deformable mirror (left) and measurement of the achieved bandwidth (right).

CILAS has manufactured a small pitch, high order deformable mirror demonstrator, based on the piezo technology. The main goal of this development is to validate a possible approach for the manufacturing of very high order deformable mirrors, to be used for extreme adaptive optics systems dedicated to the direct detection of extrasolar planets. A 50x50 actuator prototype was manufactured and delivered during this contract (see figure below, left panel). Unfortunately, due to technical difficulties, it was not possible to obtain a thin enough head assembly for the mirror (which was 0.2 mm instead of the foreseen 0.1 mm). This limitation directly impacts the achievable inter-actuator stroke of the deformable mirror, 0.56 μm as compared to the specified 1.0 μm in this particular case. A recovery plan has been proposed by CILAS to demonstrate the feasibility of such a device without risking destroying the existing prototype. They produced a new head assembly fulfilling the 0.1 mm thickness specification using a new manufacturing process (see the figure below, right panel). Relatively simple mechanical simulations show that combining the newly obtained head assembly with the existing prototype body would definitively allow reaching the 1 μm inter-actuator stroke. Other functionalities and characteristics were tested on the existing prototype. Results are summarized in a final test report (ET-P-4104006-rev0000 "LAOG-ESO Mini-DM Final Report). This test report together with the mini-DM prototype represents the final delivery of this WP (WP 3.7-M6). The magnetic deformable mirror delivery and corresponding test report from the FLORALIS-ALPAO is an additional delivery not listed in the OPTICON delivery list.

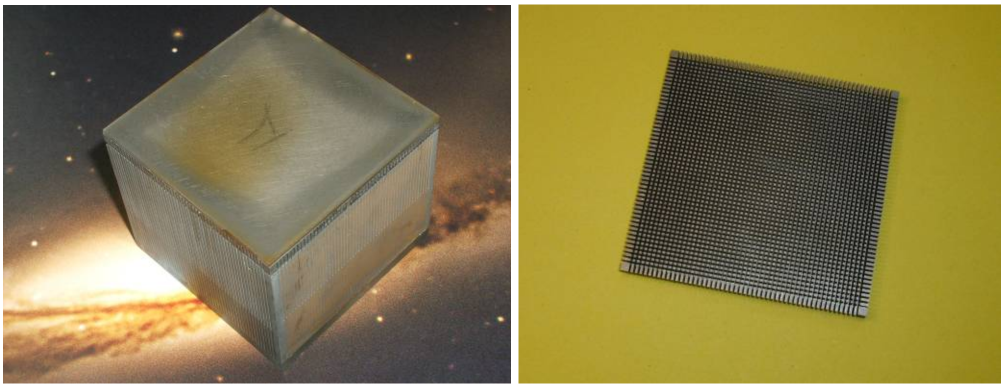


Figure: Prototype of the CILAS mini piezzo deformable mirror (left) and the new head assembly (right).

WP3.8 High Order wavefront sensor experimental study

Past years:

In 2004 & 2005, a theoretical study was performed by ONERA comparing the Shack Hartmann and the pyramid wavefront sensors for high order adaptive optics.

The top-Level requirements of the High Order Test bench (HOT) document was finalized by ESO in collaboration with Durham and INAF-Arcetri. The design of the HOT bench was developed by ESO, Durham and INAF-Arcetri, although some tunings were necessary during integration to cope with interface issues between the different subsystems. A survey of coronagraph was done in order to determine which coronagraph could be implemented in the future.

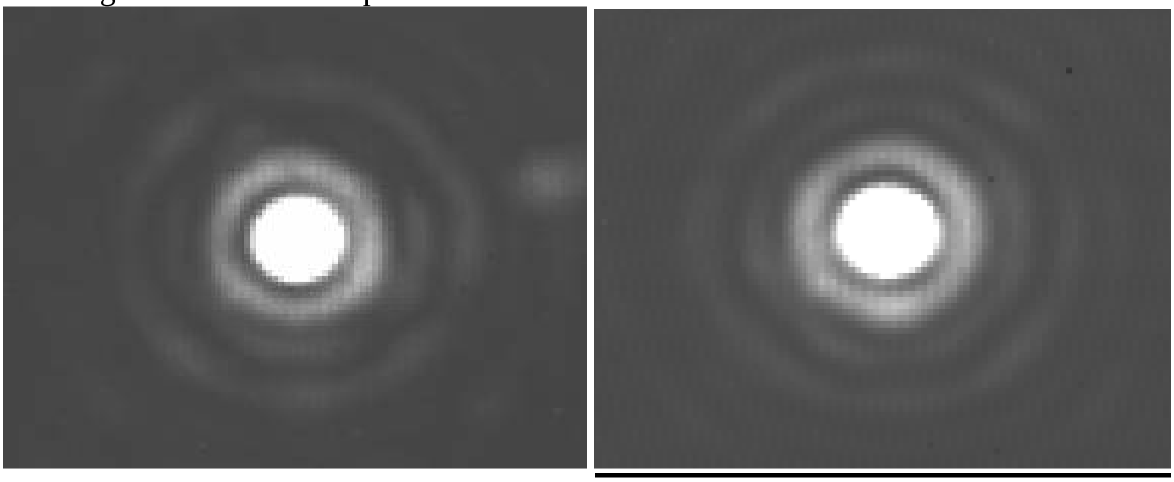
Key components were ordered: a 1k actuator Micro Deformable Mirror from Boston Micromachine, CCD cameras for the Shack-Hartmann and Pyramid WFSs from ANDOR and the micro-deformable mirror drive electronics from Shaktiware.

In 2006, the design of the whole system was finalized and a review organized, all components were ordered, the Shack-Hartmann (from Durham) and the Pyramid (from INAF Arcetri) wavefront sensors were delivered to ESO as well as the 2^{nd} Boston micromachine DM. All sub-systems were characterized.

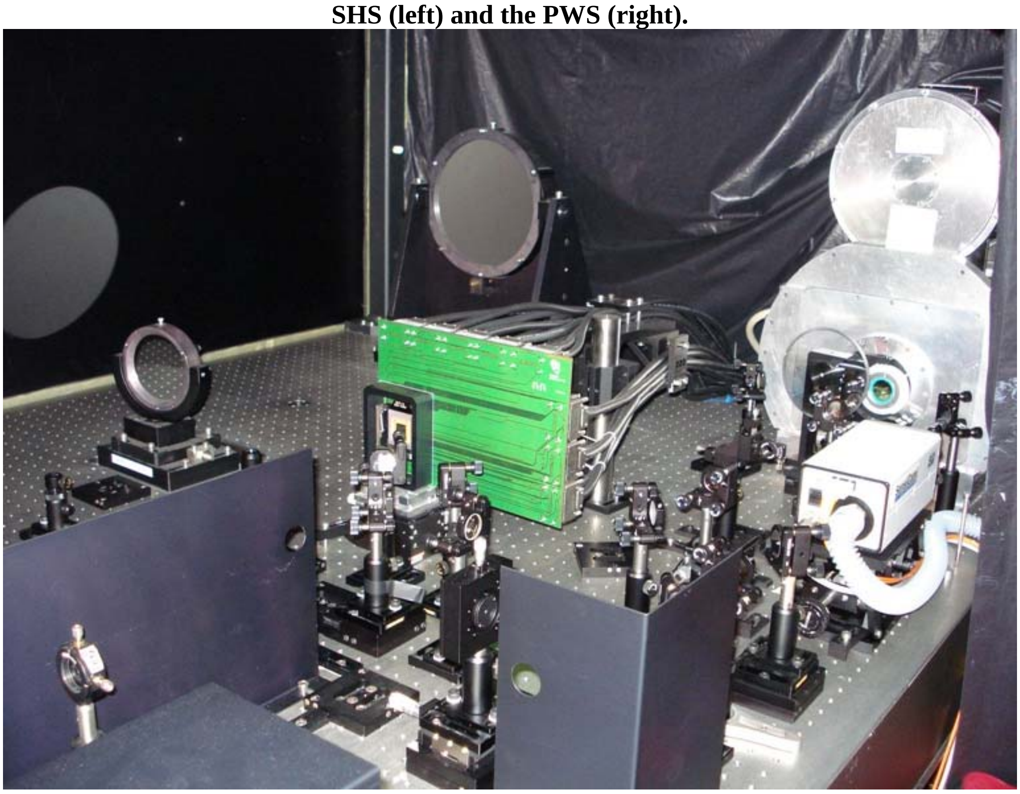
In 2007, the characterization of the key elements (deformable mirrors, wavefront sensors) and the final opto-mechanical alignment of the HOT bench were performed. The first closed loop with both the pyramid and Shack-Hartmann wavefront sensors was achieved.

In 2008:

Both Shack-Hartmann and Pyramid wavefront sensor operation have been optimised so as to achieve the best performance for both sensors. Comparisons have been conducted under the same atmospheric conditions and demonstrate some advantage for the pyramid wavefront sensor for high contrast applications. Test results are gathered in the test report VLT-TRE-ESO-14690-4724. This report is the final deliverable WP 3.8 D1 for this WP. The studies carried out on the bench demonstrated the viability of XAO system. As expected on the simulations, high performance in terms of Strehl ratio (~90%) was achieved. At the same time, it was possible to study the possibilities and limitations of new technologies. For example, the EMCCD has demonstrated its performance as a baseline detector for the next generation of AO systems. On the other hand, micro deformable mirrors are suitable for bench testing, but reliability issues related oxidation and actuator failures need to be resolved before using them at the telescope.



PSF images with high Strehl ratio (~90%) obtained on the infrared camera on close loop operation for the SHS (left) and the PWS (right).



View of the *"High Order Test Bench"*: On the center the *"Boston micro deformable mirror" (BMM) ;* on the right side the *"Infrared Test Camera" (ITC).*

The following table summarised the Milestones and deliverables achieved during the 2008 reporting period by JRA1:

Deliverable/ Milestone No	**Deliverable/Milestone Name**	**Workpackage /Task No**	**Lead Contractor(s)**	**Planned (in months)**	**Achieved (in months)**
M1	JRA1 General Meeting 6	WP1	ESO	57	59
M1	Delivery of the curvature wavefront sensor for GTC	WP2.3	GTC	51	57

M2	Delivery of the multi objects wavefront sensor opto-mechanics without translation stages and base plate.	WP2.3	GTC	55	60
D1	Test report on component and sub-unit tests of the multi object wavefront sensor	WP2.4	MPIA	58	58
M1	Complete development of the deformable mirror drive electronics and testing	WP3.4	ESO	51	51
M2	Manufacturing of a convex glass shell prototype for an adaptive secondary	WP3.6	INSU/ESO	60	60
M6	Delivery and testing of a 50x50 actuator mini piezo deformable mirror	WP3.7	INSU/ESO	57	60
M7	Delivery and testing of a 11x11 actuator electromagnetic deformable mirror	WP3.7	INSU/ESO	57	59
D1	High order Test bench test report	WP3.8	ESO	57	57

The table below summarised the major JRA1 meetings:

Date (2008)	**Title/subject of meeting /workshop**	**Location**	**Number of attendees**	**Website address**
September 25 & 26th	General Meeting 6 JRA1	Leiden, NL	20	http://www.eso.org/projects/aot/jra1/
Nov. 10-11th	Final OPTICON Board meeting	Porto, PT	20	http://www.astro-opticon.org/board_mtg6_november08.html
Weekly	Weekly telecon WP 2.1	Telecon	8	
May 27th	SPHERE Optical Final Design review (WP2.1)	Garching, DE	20	CD-ROM
Dec 16th & 17th	SPHERE Optical Final Design review (WP 2.1)	Garching, DE	20	CR-ROM
weekly	Weekly internal progress meeting (WP2.2)	Garching, DE	8	CDROM
Sept. 23rd	GALACSI Preliminary Design Review (WP2.2)	Garching, DE	20	CDROM
Dec 9th	GRAAL mechanical design (WP2.2)	Garching, DE	10	CDROM
Feb. 19th 22nd	LN Progress meeting/Topical meeting (WP 2.4)	Heidelberg, DE	10	CDROM
Oct. 22nd 23rd	LN Progress meeting (WP2.4)	Heidelberg, DE	10	CDROM
Every two months	Zerodur thin Shell progress meeting (WP 3.6)	Telecon	5	CDROM
Jan 9th	ALPAO: electromagnetic deformable mirror KO meeting (WP 3.7)	Videoconf.	5	CDROM
July 10th	ALPAO: electromagnetic deformable mirror design review (WP3.7)	Videoconf.	5	CDROM

Oct. 14th	ALPAO: electromagnetic deformable mirror design review (WP3.7)	Grenoble, FR	7	CDROM
Jan 9th	CILAS: Mini piezo DM Progress meeting (WP 3.7)	Videoconf	5	CDROM
Feb 5th	CILAS: Mini piezo DM Progress meeting (WP 3.7)	Videoconf	5	CDROM
July 4th	CILAS: Mini piezo DM Progress meeting (WP 3.7)	Videoconf	5	CDROM
Sept. 30th	CILAS: Mini piezo DM Progress meeting (WP 3.7)	Videoconf	5	CDROM
Nov. 19th	CILAS: mini piezo DM progress meeting (WP 3.7)	Telecon	6	CD-ROM
Sept. 18th	HOT Progress meeting (WP3.8)	ESO, DE	5	CD-ROM
Nov. 12th	HOT Progress meeting WP 3.8	ESO, DE	5	CD-ROM

1.5.3 JRA2: Fast detectors for AO

Participant number[13]	40	4	7	31	
Participant short name[14]	INSU/CNRS	ESO-INS	IAC	ONERA	**Total**
Person-months[15]	36	34	2(0)	0	**72(0)**

ESO and JRA2 have funded e2v technologies to develop a compact packaged Peltier cooled 24 µm square 240x240 pixel split frame transfer 8-output back-illuminated L3Vision CCD3, for Adaptive Optic Wave Front Sensor (AO WFS) applications. The device is designed to achieve sub-electron read noise at frame rates from 25 Hz to 1,500 Hz and a dark current lower than 0.01 e-/pixel/frame. The development has many unique features. To obtain high frame rates, multi-output EMCCD gain registers and metal buttressing of row clock lines are used. The baseline device is built in standard silicon. In addition, a split wafer run has enabled two speculative variants to be built; deep depletion silicon devices to improve red response and devices with an electronic shutter to extend use to Rayleigh and Pulsed Laser Guide Star applications. These are all firsts for L3Vision CCDs.

This detector, called CCD220 and subcontracted to *e2v technologies* (UK), is being built as part of the JRA2 activities. This JRA also delivers:

- A detector controller: this is the main deliverable of WP3.
- A cryogenic system (to cool down the detector): this is the main deliverable of WP4. The controller and its cryogenic system are now well known under the name “OCam”.
- A full evaluation of the detector performances in the framework of WFS applications for the second generation of adaptive optics instruments in Europe. This is the main goal of WP5.

For the first time in the world, we demonstrated at the end of FP6 a CCD camera system (using the CCD220 and OCam developed within JRA2) running at 1200 frames/s with 240x240 pixels images and having a read noise lower than 0.5 electrons.

This has never been done before anywhere in the world and is a major achievement of OPTICON.

Progress report

In this document, what is referred to as “Test Camera” and “OCam” is the addition of the WP3 and the WP4 products.

WP1: Management

[13] Lead participant first

[14] Use the same contractor short names and numbers indicated in the table “list of participants” in Annex I of your contract.

[15] AC contractors must include both the total estimated human effort (including permanent staff) and, in brackets, additional staff only.

This year, no formal meeting was organized, however some informal meetings were organized at the SPIE conference “Astronomical Telescopes and Instrumentation” held in Marseille (July 2008). Moreover, weekly teleconferences of the whole JRA2 team were held throughout 2008 (except summer holidays) to organize and follow the activity closely, because this system integration period was extremely critical and we did not want to add any further delay to the activity in order to be able to achieve our main goals. Minutes of these teleconferences were distributed by e-mail to the participants. This was the remedial action we decided to use for recovering the overall delay of the JRA activity that was described in the last annual reports.

WP2: Detector specification and fabrication work package.

All detectors foreseen in the programme have been produced by e2v and have been tested. Science grade detectors will be delivered by e2v technologies to ESO in the first quarter of 2009.

WP3: Detector control and software

Global architecture of OCAM controller

The controller is divided in 4 parts, see the figure below: an acquisition system, an interface, an internal microcontroller that manages the drive electronics and the link with the acquisition system.

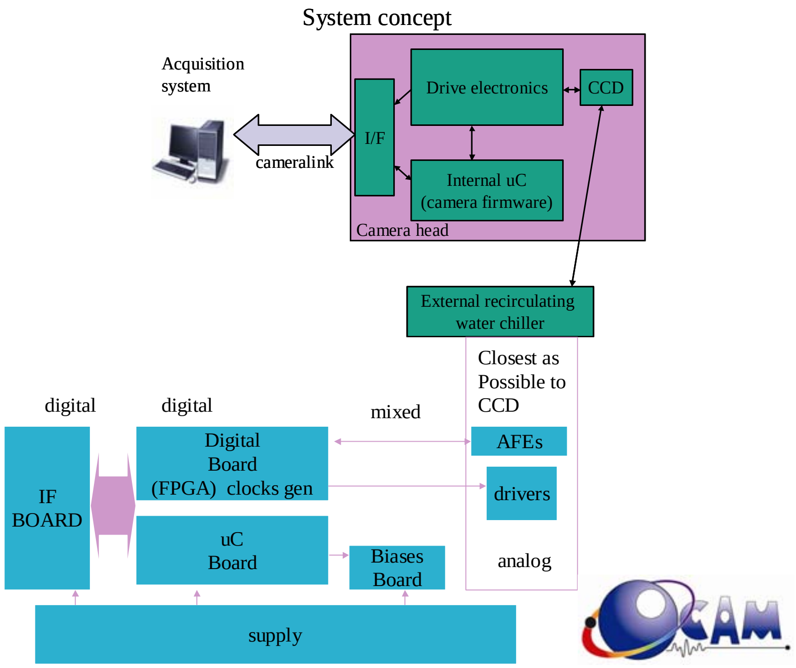


Figure: OCam controller structure. Left: OCam controller global architecture; (right) OCam controller design with a more detailed breakdown structure of the electronics.

This design is also a low noise design. Therefore a particular care has been taken to minimize RF perturbations. The drive electronics are as close as possible to the CCD in order to minimize parasitic inductance and to allow the use of a higher parallel clocking frequency (see figure below). Only a few centimetres separates the CCD die from the video preamplifiers in the OCam design.

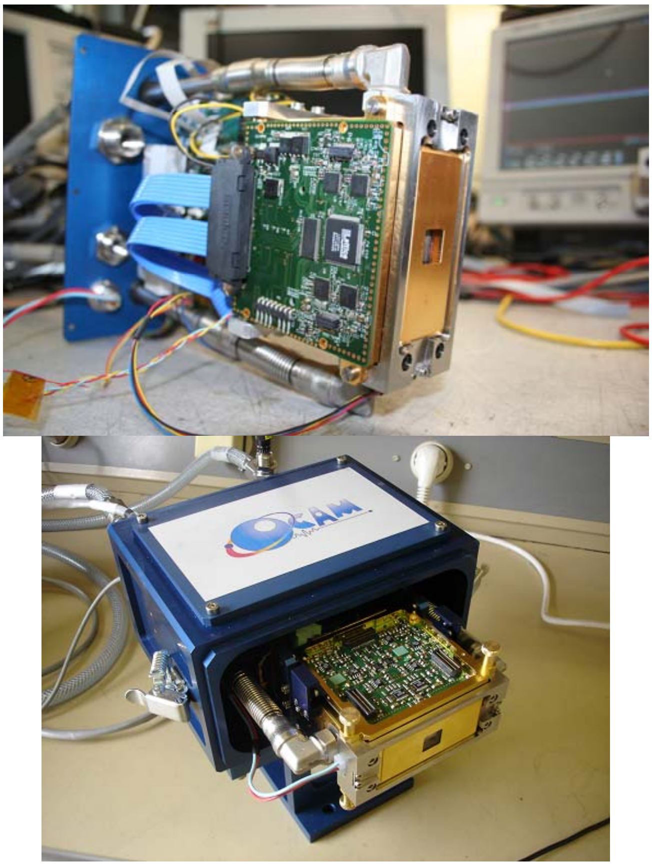


Figure: OCam controller views showing the front end electronics as close as possible to the CCD220.

Main OCam characteristics

The OCam system is capable of driving all the CCD220 family CCDs at their nominal speed (1.5kframes/s) and sending all data through a cameralink full interface. The controller might drive deep depleted variants with multilevel clocking at levels up to 24V with a speed of 10Mlines/s (at a nominal phase load of 1nF). It handles the 8 L3vision outputs with high voltage clocking up to 50v. A major effort has been made to have a good high voltage stability (less that 1mv/hour of drift) to ensure a constant gain over a long period. The system digitizes the CCD signal with correlated double sampling with 14 bits dynamics. Interfacing with the camera is quite simple and the actual acquisition system is a PC computer running windows XP fitted with a cameralink full grabber and proprietary software capable of gathering in real time the astonishing 220Mbytes/s produced by the camera.

Also the team has developed a user friendly timer file editor to manage the sequencer of OCam. The sequencer itself is the heart of the system and has a nominal resolution of 1.5ns and is capable of generating clocks at a frequency of 327MHz. The actual phase jitter was measured at a level of 60ps RMS.

Acquisition software

- Firmware

In order to fully assess the capabilities of OCam and of the CCD220 and its variants, a custom set of software applications was designed.

At the lowest level, OCam runs its firmware on an AVR 8-bit RISC microcontroller, see figure below. The microcontroller is responsible for managing all non-image data input/output of OCam through the serial lines embedded in the CameraLink standard. The firmware works entirely with text commands so that OCam can be operated through any system able to talk through RS-232 serial line protocol.

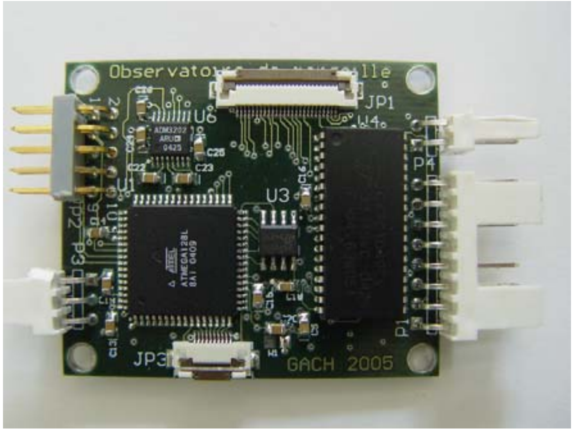


Figure: View of the micro-controller board developed for OCam

- Timer File Editor

OCam's sequencer is fully logic-driven and allows for practically arbitrary clocking of all the phases of the CCD220. In order to ease its operation, a custom timer file editor has been developed to provide a graphical interface over the different clocks used by the detector and to give a powerful tool for the detector testing.

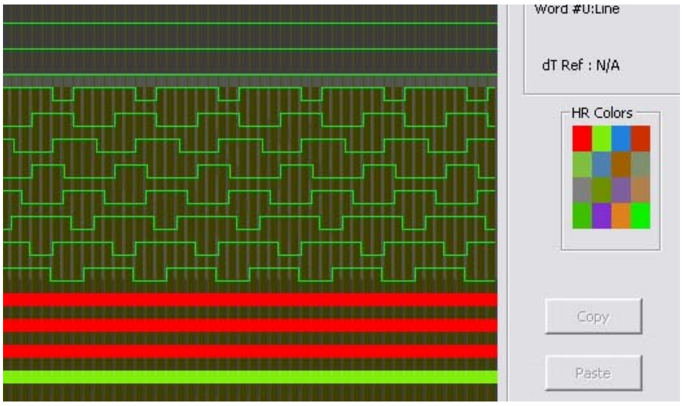


Figure: The OCAM Editor user interface developed for OCam in order to build the clocks necessary to operate the CCD220.

There are 16 General Purpose phases with a time resolution of 9.16ns, 8 High Resolution phases accurate to 1.5ns and 4 High Definition phases that provide up to 16 different levels (with 12-bits precision over the value itself). The Editor is organized hierarchically in letters, words then phrases, each individual item having its own repetition counter. For instance, the exposure time can be set anywhere between 73ns and 237 days (in steps of 73ns). The editor saves its data in text format, so it can be reviewed and or modified by other applications or directly through any text editor.

OCam holds 8 different modes (sequencer files) in a non-volatile memory, 5 "standard" modes and 3 user modes.

* Acquisition Software

The CCD220 and its variants required special acquisition software to cope with its outstanding capabilities, so one was written from the ground up using MS-Visual C++ and the Windows XP operating system.

Starting with a standard CameraLink Full Framegrabber (Dalsa-Coreco X64CL-Full), the acquisition software is responsible for grabbing OCam images at full 1.5KHz speed, providing real-time image analysis tools, saving image data in standard formats (namely FITS and Comma-separated-Values) and of course giving access to all of OCam commands and values. The acquisition software interface is shown in figure below:

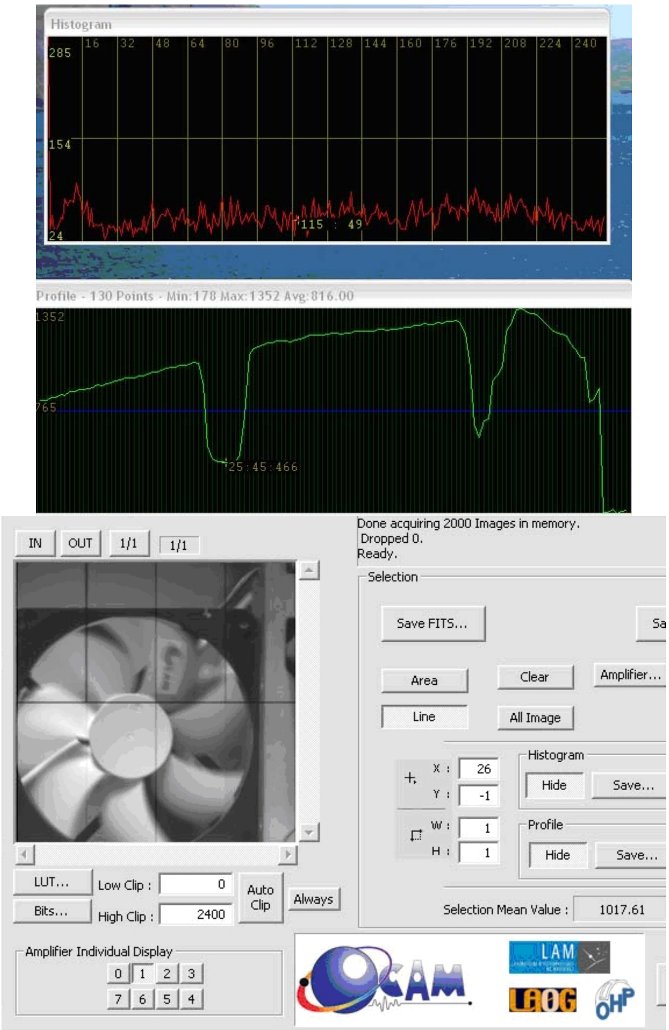


Figure: OCam Acquisition software interface. Left, top to bottom: Image histogram display, Image slice display. Right, main window of the control panel with Image Area showing the combined descrambled 8 outputs (overscan masked) with data saving options and LUT choices.

All voltages can be set using convenient sliders or numerical edit boxes. Precision over the board is below 0.01V. The “IRD ammeter” shows the reset drain current of the whole image with a precision of 10 pA. OCAM image grabbing is always done in real time as well as image analysis. Image display is done at user-selected frequency anywhere between freeze-frame and 60Hz (screen limit). When examination of successive images is required, a memory buffer can store OCAM video outputs and play back at human speed as well as sum and/or average the images grabbed. Note that this is rather memory hungry as 5 seconds of capture takes a Gigabyte of memory. An option is available to save/load the raw data on disk as well using FITS or .csv formats.

WP5: detector testing activity

We started the test by the computation of the conversion gain of the system (in adu/e). This is extracted from the well known photon transfer curve in which the variance of the signal is plotted as a function of the mean signal. This plot is shown in the figure below. From this plot, the system gain and the read noise is extracted for a multiplication gain of 1, see table below.

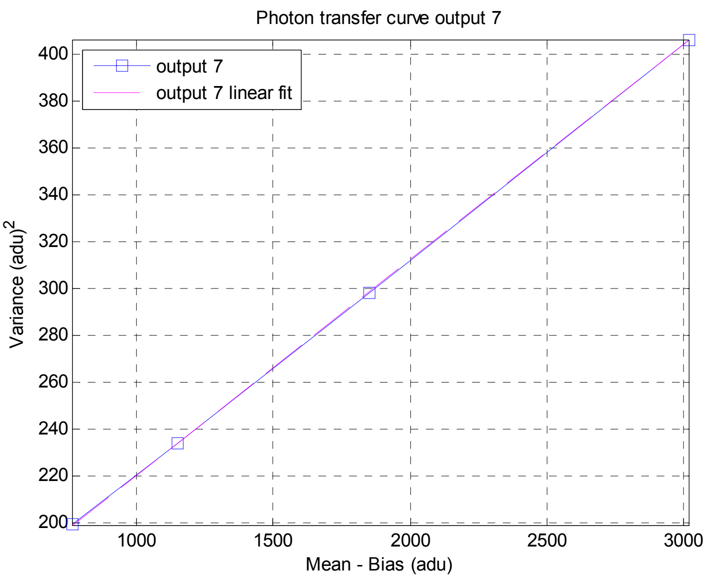


Figure: photon transfer curve of the CCD220 and OCam

Table : noise computation at unity gain, data extracted from photon transfer curve and dark images.

Ouput	System gain (e/adu)	RMS Noise (adu)	RMS Noise (e)
1	11.81	11.52	136.00
2	10.81	8.11	87.75
3	10.45	7.74	80.87
4	11.81	10.54	124.44
5	10.77	12.66	136.36
6	10.17	7.43	75.58
7	11.14	8.32	92.75
8	10.89	11.77	128.08

The way to extract noise data is to accumulate the values of all the pixels of all the images from the 3D file in a single histogram and to fit the histogram with a Gaussian.
Statistics are done on the real image area histogram (HV=41 V, output 1):

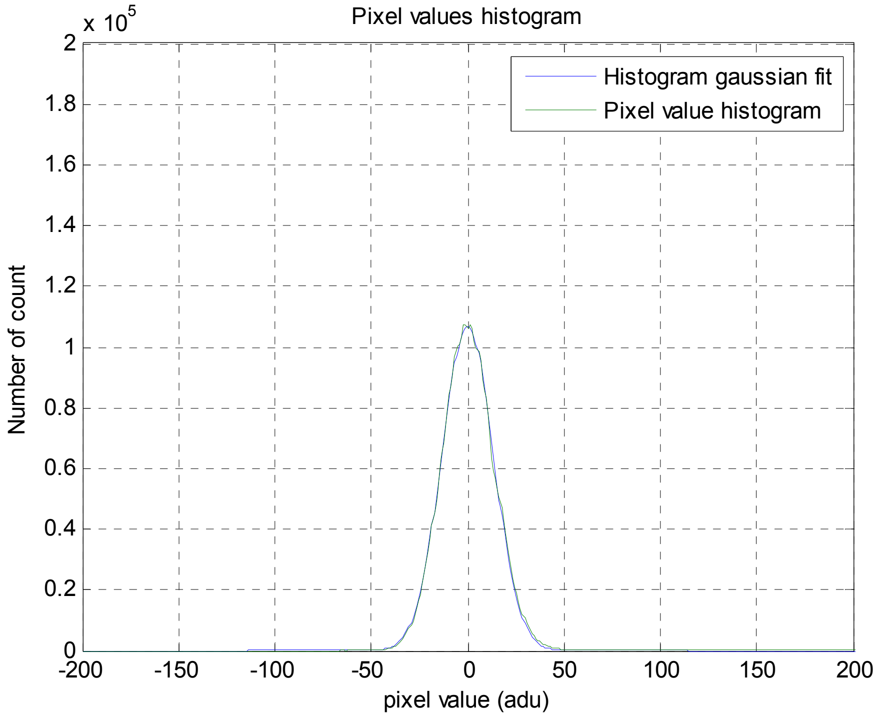


Figure : pixel histogram for HV= 41 V and output 1 of the image area. Also plot is the Gaussian fit of the histogram.

Then we can plot the logarithm of the fraction above threshold as a function of the threshold, which is shown in the figure below. The linear fit, in a least squares sense, of the linear part of this curve is also shown in red. Curve fit options were chosen to work with all outputs at the same time in order to write a Matlab script that computes the dark of all outputs at the same time.
According to the following e2v technical note: “Estimating ultra low levels of dark signal using an L3Vision device”, L3V-TN-635, issue 1, 15th August 2005, the fraction of pixel N_d above a threshold T is given by:

$$N_d(T) = \int_{x=T}^{\infty} \frac{S_{dark}}{G} \exp\left(\frac{-x}{G}\right) dx = S_{dark} \exp\left(\frac{-T}{G}\right)$$

Where S_{dark} is the dark signal and G the multiplication gain.
Plotting $Ln(N_d)$ as function of T makes it possible to extract:
- the dark signal S_{dark} from the intercept with the Y axis which is $Ln(S_{dark})$
- the multiplication gain G which is the inverse of the slope from the linear fit

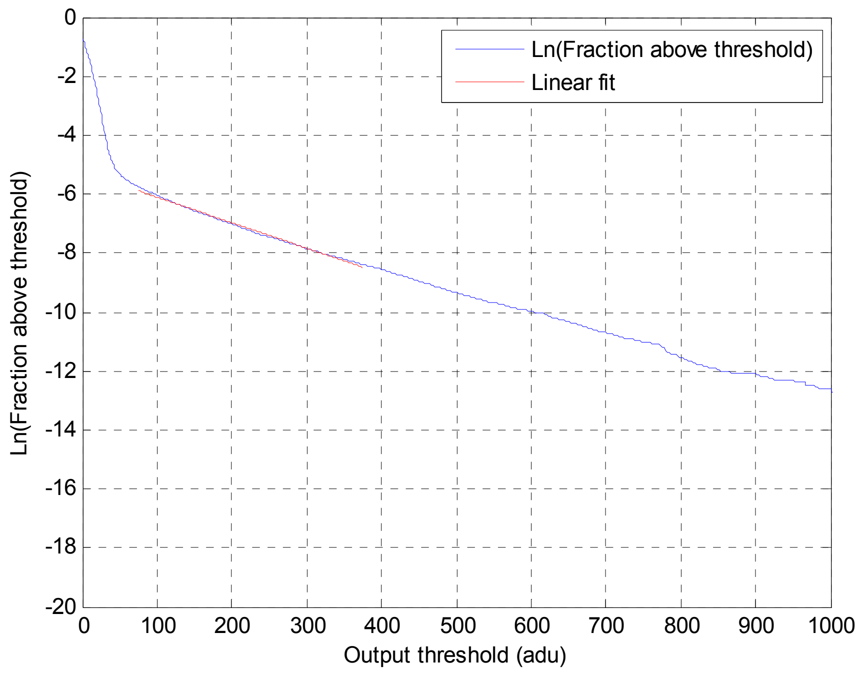


Figure : pixel fraction above a threshold as a function of the threshold (log scale). Also shown in red is the linear fit of the linear part of the curve. Curve fit options were chosen to work with all outputs at the same time.

This makes it possible to obtain the Dark signal (in e/pixel/frame), the multiplication gain, the RMS noise (with gain), the input referred noise and the number of dark events for a 60x120 frame output, see tables below.

Table 1 :Multiplication gain, Dark signal per pixel, fit residual, RMS noise, input referred noise and dark per frame for all outputs and HV=41 V.

Output	Multiplication gain	Dark (e/pixel/frame)	Fit Residual	RMS Noise (e-)	input referred noise (e-)	Dark (e/frame)
0	1248.40	0.004981	0.62	261.34	0.209	36
1	1272.33	0.005328	0.89	146.67	0.115	38
2	639.73	0.002534	2.51	151.63	0.237	18
3	589.18	0.001984	2.56	240.33	0.408	14
4	1093.57	0.003292	0.45	297.37	0.272	24
5	1133.51	0.004103	1.07	141.71	0.125	30
6	555.00	0.004574	1.00	166.76	0.300	33
7	502.41	0.003696	2.04	271.02	0.539	27

Table 2 : Multiplication gain, Dark signal per pixel, fit residual, RMS noise, input referred noise and dark per frame for all outputs and HV=42 V.

Output	Multiplication gain	Dark (e/pixel/frame)	Fit Residual	RMS Noise (e-)	input referred noise (e-)	Dark (e/frame)
0	3359.51	0.023103	0.54	281.23	0.084	166
1	2852.09	0.020928	0.98	157.92	0.055	151
2	2180.71	0.013301	0.97	162.60	0.075	96
3	2024.43	0.014426	0.77	254.46	0.126	104
4	4507.58	0.008548	0.25	307.77	0.068	62
5	3589.27	0.010388	0.52	150.06	0.042	75
6	3407.42	0.013532	0.30	175.44	0.051	97
7	3051.73	0.012289	0.26	281.91	0.092	88

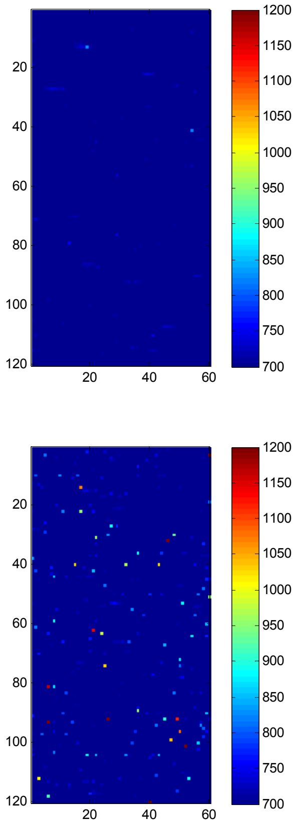


Figure : (left) example of a single image of output 3 with HV=41 V having 14 dark counts in average; (right) single image of same output with HV=42V having 104 dark counts in average.

The figure above shows single images with a multiplication gain of 1200 and 2000. In this figure, we can see individual events (dark counts): when the multiplication gain increases, the number of dark counts increases also: from 14 with a gain of 1200 to 104 with a gain of 2000.

The major result is that the CCD220 and OCam are delivering sub-electron noise 240x240 images at 1200 frames/s: we obtain here ~0.2 e RMS noise for a multiplication gain of ~1200.

Concerning the dark current: the specification of 0.01 e/pixel/frame is easily met with a high voltage clock swing of 41 V (multiplication gain of ~1200) for which the input referred read noise is ~0.2 e. The goal specification was a readout noise lower than one electron, so again, this specification is easily met.

Milestones and Deliverables

During 2008, the major milestone of WP5 was achieved (complete detector tests in laboratory). The last milestones of WP5 were cancelled because the schedule of the whole JRA2 project was optimistic and we probably underestimated the difficulty of the programme. Sub-electron CCDs with 1 kHz frame rate is extremely challenging, the control of this detector was since the beginning identified as a key milestone. Because we were late to deliver WP3 and WP4 and because our main goal is now achieved, we decided to cancel the milestones & deliverable for WP5. However, the last milestones of WP5 (M2 to M4 and D1) were considered as minor compared to what has been achieved in the JRA2. We can consider that we achieved about 95% of the initial goals described in the original OPTICON contract.

Deliverable / Milestone No	**Deliverable/Milestone Name**	**Workpackage /Task No**	**Lead Contractor(s)**	**Planned (in months)**	**Achieved (in months)**
M6	Backside device test	WP2	IAC	54	54
D2	Final detector acceptance report	WP2	IAC	56	56
D1	Controller acceptance report	WP3	IAC	51	51
M1	Complete detector tests in laboratory.	WP5	IAC	60	48
M2	AO wavefront sensor manufactured	WP5	IAC	60	cancelled
M3	Complete detector performances evaluation in an AO system.	WP5	IAC	42	cancelled
M4	Acceptance of the AO wavefront sensor for AO tests	WP5	IAC	42	cancelled
D1	Test report for the results on the AO test bench and/of on sky.	WP5	IAC	60	cancelled

Major meetings and workshops

Date	**Title/subject of meeting /workshop**	**Location**	**Number of attendees**	**Website address**
June 2008	JRA2 progress meeting at SPIE	Marseille, FR	8	--

Conclusion

JRA2 is a major success for OPTICON and has achieved the initial goal of developing a detector fully dedicated to wavefront sensing using the next generation of adaptive optics systems in Europe. For the first time in the world, a 240x240 pixels CCD is running at 1200 frames/s with readout noise lower that 0.5 e and a dark signal lower than 0.001 e/pixel/frame. The detector, called “CCD220”, is now a commercial product from e2v technologies in UK. The test camera, called “OCam” will be used as prototype for the ESO NGC controller dedicated to control of the wavefront sensors detectors. The OCam technology will also be transferred to an industrial partner in Europe.

The CCD220 detector and the OCam camera technology will be used in all European adaptive optics systems of the decade to come.

1.5.4 JRA3: Fast Readout High Performance Optical Detectors

A. Contractors:

Participant number	1	2	4	11d	11e	13	28	37	39	40	
Participant short name	UCAM	STFC	ESO	MPG MPA	MPG MPE	NOTSA	NUIG	LSW	USFD	War	**Total**
Person-months	11	4.12	0	0.5 (0.5)	9(8)	0	7(7)	0	3 (0)	2(0)	**36.62(15.5)**

WP1: Management

Progress of JRA3 during the final reporting period has been as expected. Much of the work, especially that of workpackages 2, 5 and 7, was already completed in previous reporting periods, and has been described in detail in the 2007 Annual Report.

Highlights of activities in 2008

Production of the full-scale (256x512) avalanche-amplified PN-sensor at subcontractor HLL.

Production of the device has been completed with minor delays. A complete test of the device has experienced delays due to lack of qualified manpower. The results of full tests will be assessed in February 2009 by the detector laboratory of contractor ESO. Preliminary tests indicate that the device is the best photon-counting CCD detector ever made. The report (WP3 deliverable D3) is expected to be delivered in the course of the next few months. This will complete the deliverables due for WP3.

Completion and test of fast controllers for L3 CCDs at UCAM and UKATC.

The work completed in 2008 consists of tests needed for completion and verification of the final versions of controllers, camera assemblies and software. Tests under realistic conditions at several astronomical observatories have confirmed the impressions of earlier tests in 2007. The EM (electron multiplied) CCDs and the very high bandwidth controllers developed for them in JRA3 have demonstrated the vastly superior performance of cameras built with these detectors in appliations ranging from diffraction limited imaging with ‘lucky imaging’, capturing high time variability in pulsars, and high-time resolution spectroscopy. On the basis of these tests, it is expected that electron amplified CCDs will become standard detectors at the large astronomical observatories world-wide. The deliverables of workpackages WP2, WP5, and WP7 have been completed.

Contractor USFD has submitted the following executive summary of the joint work of contractors STFC, USFD, and Warwick for work packages WP2,WP5 and WP7:

The potential of electron-multiplying CCDs for high-speed astronomical spectroscopy has been investigated. This involved the specification, procurement and characterisation of a suitable EMCCD, the development of a cooled camera head in which to mount this new device, and the development of a suitable controller to read out the device. The latter was achieved by designing, manufacturing and testing a new high-voltage clock driver board for the commonly-used SDSU CCD controller manufactured by Astronomical Research Cameras Inc. The results of our lab-based and on-sky measurements show that EMCCDs will revolutionise astronomical spectroscopy; the elimination of readout noise can effectively double the diameter of a telescope in terms of the signal-to-noise ratio improvement.

As well as scientifically exploiting this new detector (we have just been awarded 22 nights of science time on the NTT in La Silla), our intention is to now procure a larger-format, multi-output EMCCD for use on the VLT.

Publications resulting from this work are listed under **Use and dissemination of knowledge.**

Other developments in 2008
Success with the development of APD arrays at NUIG has been partial. While small arrays of APD elements have been manufactured and tested successfully, problems with the basic technology used limit their applicability in high time resolution astronomy. The planned fabrication of microlens-fed arrays has correspondingly been suspended, and the corresponding deliverable D2 of WP4 deleted. The effort at NUIG has turned out not to be competitive with APD technology under development elsewhere at large commercial companies.

The deliverable of WP1, a concluding report comparing the relative merits and prospects of the technologies developed in JRA3, is in preparation and will be delivered to OPTICON management shortly in April 2009.

WP2: EMCCD developments
Final on-sky characterisation of the EMCCD on the ESO 3.6m telescope was completed in Jan/Feb 2008. This highlighted problems with the vertical charge transfer at low light levels and high avalanche gains. A lengthy period of lab-based characterisation then followed to eliminate this problem, traced to the vertical clocking rate, and a number of more minor problems (e.g. vertical banding, variable gain). Final system optimisation was also performed during this period: the clock induced charge (CIC) and readout noise were minimised by tweaking the horizontal/vertical clocking rates, gains and ADC times, and running the chip in both inverted and non-inverted mode. CIC was reduced to 0.01 e/pix/frame by this process.

Outstanding milestones and deliverables:

D2: Test report: delivered. The results are available in a publicly accessible report (listed under **Section 3: Use and dissemination of knowledge)**

This completes the requirements of WP2.

WP3: pn-sensor development

The AA-pn-sensor production scheduled for 2008 has been completed successfully with minor delays. The results are 256x512 pixel CCDs designed for high time resolution (>1kHz frame rate) astronomy and adaptive optics applications. Preliminary tests have shown that the device lives up to the expectations based on the single-element test devices produced in previous years. This is to be confirmed with full tests and characterisation by the subcontractor. The test report (final deliverable of WP3) is expected to be delivered within a few months. If the preliminary results hold up, the device will have spectacular performance, making it probably the best CCD with on-chip electron amplification ever made. In a separate contract with ESO, the devices will be characterised independently by the ESO detector laboratory. Tests under realistic application conditions are planned for summer 2009.

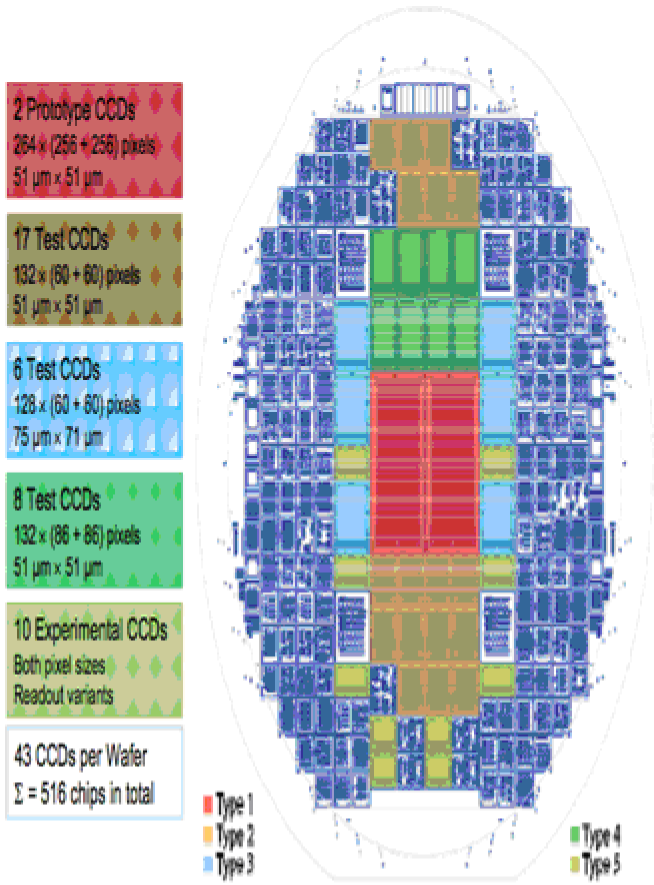


Figure: Layout of the wafer with the different test CCDs manufactured.

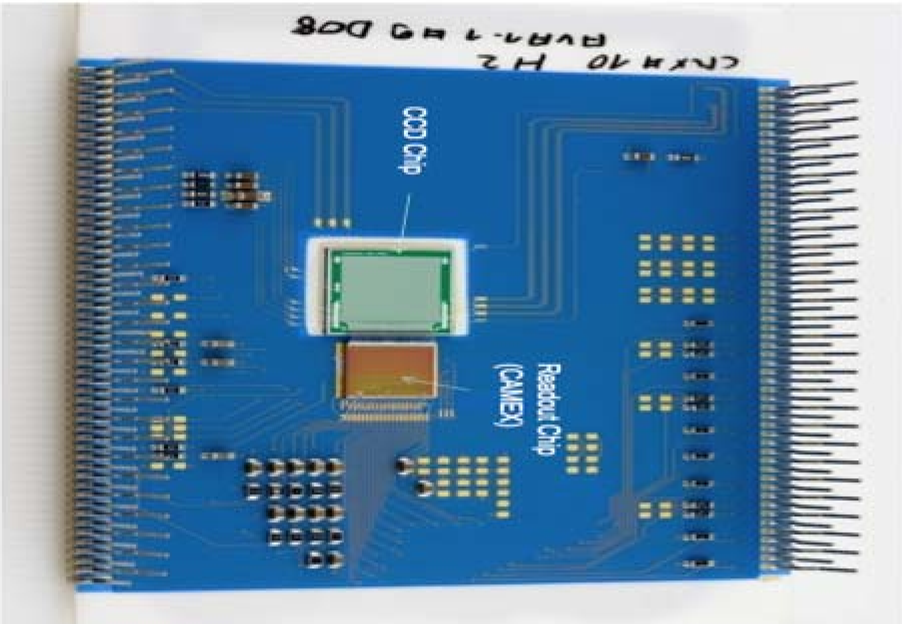


Figure: AApnCCD mounted with readout chip (backside)

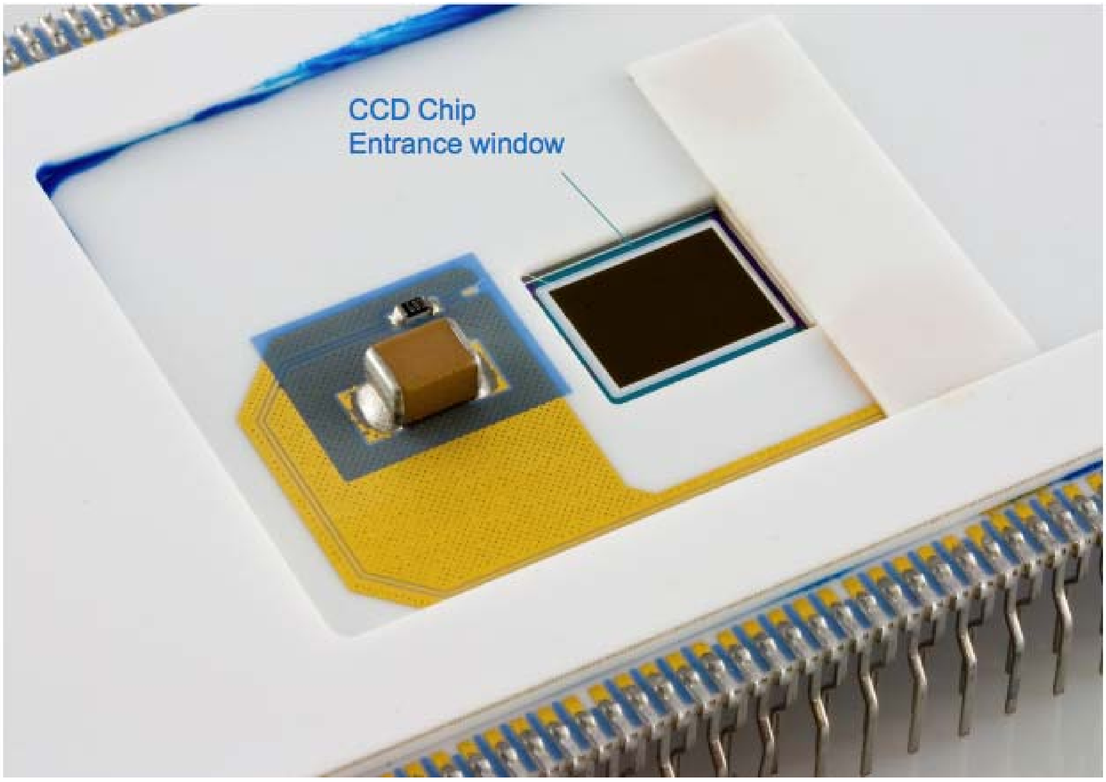


Figure: Mounted CCD seen from the illuminated side.

The first figure shows the arrangement of individual avalanche amplification pn CCDs (AApnCCD) of various sizes on a full wafer. Aside from the full scale prototype detectors we see 41 test units that will be used in the laboratory for the development and adaption of readout electronics. One of these test boards is shown in the third figure (light entrance window of the AApnCCD) and the middle figure the electronics side with the CAMEX ASIC used for signal acquisition and processing.

WP4: APD array development

Work at NUIG finished on 30 June 2008. The small APD detector arrays (D1) were delivered already in the previous reporting period. The planned integration with a lenslet feeding system and subsequent testing under realistic conditions has not been achieved, however. The corresponding deliverable of WP4 has been deleted. As reported in WP1 deliverable 1 (comparison of strengths and weaknesses of the technologies developed under JRA3), the technology pursued at NUIG has turned out not competitive with the other technologies.

WP5: Controller Development

Work done at UCAM
Most of the work done at UCAM was completed in 2007, technical details and results of tests under realistic conditions have been presented in the annual report for 2007. Work in 2008 consisted of the completion and delivery of the highly successful fast timing controller for L3CCDs, deliverable D1 of WP5.

These results have been reported in several publications included in the **Use and dissemination of knowledge** section. This completes the milestones and deliverables of the UCAM effort.

Work done at STFC (UKATC), Sheffield and Warwick

The fourth and final version of high-voltage clock driver board was used successfully during the on-sky tests at the ESO 3.6m telescope in Jan/Feb 2008 and the ensuing, final period of lab-based characterisation.

We also designed and manufactured a time-tagging circuit, driven from the controller, which allows a ramped optical signal to be projected onto the detector. This device provides a direct means of measuring the latency of the system from the controller down to the data storage.

In order to fully utilise the high speed and low latency of the controller, we also re-engineered elements of the low-level controller software to provide higher throughput, lower latency and better reliability. This work went on throughout the year in parallel with the driver board tests, and resulted in much improved system performance. In particular, we have incorporated a new GPS timing system using a Meinberg PCI GPS clock. This system provides better latency (down from > 10 microseconds to 1 microsecond) than the older RS232-connected GPS clock.

With this, the milestones and deliverables of WP5 have been completed

WP6: Common Software Development

As reported in 2006 Annual Report, the development of common software has been found impractical, since the experience delivered by the software developed in the individual work packages (especially WP5) has been found adequate for use in JRA3. The corresponding deliverable of WP6 has been deleted.

WP7: Cooled Camera Head Development
The final version of the cryostat, with an improved thermal contact between the EMCCD and the cold finger, and a more secure and easy-to-adjust mounting for the EMCCD, was successfully tested during the on-sky tests at the ESO 3.6m telescope in Jan/Feb 2008.

Stable EMCCD temperatures of 170 K were maintained for entire duration of the run with twice-daily LN2 refills, even when running at the highest gains at the fastest rates. Alignment of the EMCCD within the cryostat is good to within 10 microns, within the specifications for deliverable D1. This completes the milestones and contractual deliverables of this work package.

WP8: Common Testbed
As reported in 2005 and 2006, the tasks for this workpackage have been transferred to WP1; its deliverables subsumed under the final deliverable of WP1 (report on comparison of relative merits and prospects of the technologies tested).

Milestones and Deliverables

Completed 2008 (contract months 49-60):

Deliverable/ Milestone No	Deliverable/milestone name	Work-package /Task	Lead Contractor(s)	Planned/ revised (in months)	Achieved (in months)
D1	comparison of technologies report	WP1	MPA	60	64
D2	test report	WP2	STFC	48	52
D2	AA-pn-sensor device	WP3	MPE/MPG	60	54
D3	Test report AA-pn-device	WP3	MPE/MPG	60	62
M2	delivery APD array	WP4		12	54
D1	AIT APD array	WP4	NUIG	12	deleted, see text
D1	Fast timing controller L3CCD	WP5	UCAM	45	45
D2	Fast timing controller AA-pn	WP5	MPE/MPG	48	54
D1	Common higher level software	WP6	NOTSA	deleted (see WP1)	
D1	Software testbed	WP8,WP1	LSW/MPA	48	Included in WP1 D1 (see text)
D1	Prototype camera on testbed	WP7	STFC	48	52

Notes to table

Software systems have been developed in the different workpackages for camera controllers, as well as the higher level software for data storage and analysis. This software is available to the partners of JRA3. In view of the continuing rapid evolution of this software, sharing the specific technology developed was found to be faster and more effective than the development of a combined software platform. D1 ‘software testbed’ (WP8, WP1) has been deleted accordingly. The report ‘comparison of technologies’ (D1 of WP1) is in preparation and will be sent to OPTICON management about 4 months after the end of the contract. The deliverable of WP4 has been deleted, as described above in the report on WP1. Deliverable D3 of WP3, the final test report, will be delivered about 2 months after the end of contract. This completes the milestones and deliverables for JRA3.

Meetings

No meetings were held by JRA3, all communication has been effected by electronic means.

1.5.5 JRA4: Integrating optical Interferometry into mainstream astronomy

Participant number	6a	1b	8e	11a	11f	12	21b	30	31	32	
Participant short name	INSU/ CNRS	UCA M/C AV	INA F/O ATo	MPIA	MPIfR	NOV A	ULg	Kon koly Obs	ONE RA	CA UP	
Person-months	3 (0)	0	0	21.4 (19.2)	6(6)	0	12 (6)	0	0	0	
Participant number	33	34	36	38	41						
Participant short name	TECH NION	NCU /UM K	UNI GE	OO	UNIVI E						**Tota l**
Person-months	10 (0)	0.5 (0)	0	0	0						**52.9(25.2)**

WP1.1: Concept to feasibility studies

This work package is complete. In June 2008, the 3 projects Gravity, Matisse and VSI have been approved by ESO for the 2nd generation of VLTI instruments. Gravity and Matisse have begun their phase B: their preliminary design review (PDR) will be held on March and June 2009, respectively. Their first light is scheduled around 2012-2013. VSI will begin its phase B mid 2009, for a PDR in 2010.

Deliverable

WP1.1/D5: Selection of projects by ESO for the second generation of VLTI instruments: scheduled on December 2007, achieved on June 2008

- ***WP1.2: Cophasing and fringe tracking***: WP complete.
- ***WP2: Off-line data reduction software***

WP2.1: General management and user support: WP complete.

WP2.2: Common software: WP complete.

WP2.3 (Model Fitting): WP complete.

Software available at (on request)

- JRA4 Gouttelas version: http://cral.univ-lyon.fr
- JMMC version: http://jmmc.fr/modelfitting

WP2.4 (Astrometry): WP complete.

WP 2.5 (Image reconstruction)

Since the beginning, definite progress has been made in half a dozen research groups throughout EU. The WP2 has reached the goal of providing the VLTI user community with the necessary tools for image reconstruction. Three reconstruction image software packages partly developed within JRA4 are available at:

- http://www.mrao.cam.ac.uk/research/OAS/bsmem.html (Cambridge: BSMEM)
- http://eii-jra4.ujf-grenoble.fr/wizard.html (ONERA: Wizard)
- http://cral.univ-lyon.fr (CRAL: Mira, on request)

These software correspond to the last JRA4 deliverable: **WP2.5/D2**

A summary of the 5 years JRA4 activities from 2004 to 2008 may be found at:

http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-PRE-0000-0003.pdf

The Table below summarized the milestones and deliverables achieved by JRA4 during the year 2008:

Deliverable/ Milestone	**Name**	**Work Package**	**Lead contractor (s)**	**Planned (months)**	**Achieved (months)**
D5	Selection of projects by ESO for the second generation of VLTI instruments: scheduled on December 2007, achieved on June 2008	WP1.1	ESO	48	54
D2	Image reconstruction software WISARD & User manual	WP2.5	UCAM/CAV	60	60

Major meetings and workshops

Date	Title/subject of meeting /workshop	Location	Number of attendees	Website address
10 -11 March 08	EII Meeting including JRA4	CAUP, Porto, PT	22	http://www.mpia-hd.mpg.de/euinterf/

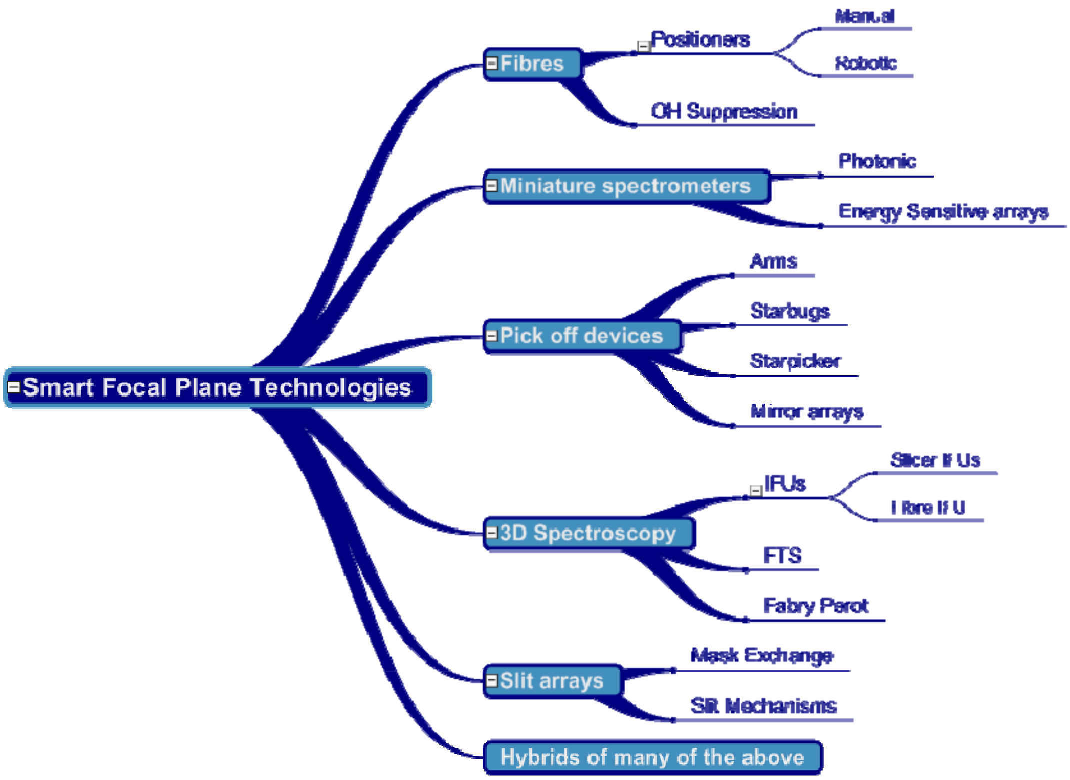
1.5.6 JRA5: Smart Focal Planes

Participating Contractors and Effort Deployed

Participant number	**2b**	**5**	**6d**	**7a**	**8d**
Participant short name	STFC	CSEM SA	LAM	IAC	Padua
Person-months	**3.64**	**0**	**0**	**6(3)**	**0**
Participant number	**10**	**45**	**47a**		
Participant short name	ASTRON	TNO/TPD	AAO		**Total**
Person-months	**15.72**	**1**	**0**		**26.36 (3)**

Introduction

The project goal is the development of technologies to gain maximum scientific benefit from the information dense focal planes of current telescopes and future Extremely Large Telescopes by targeting the objects observed in the most effective manner. The figure below shows the family tree of smart focal plane technologies, most of which have been addressed in this programme.



Family Tree of Smart Focal Plane Technologies

This activity leads on to a programme of active instrument research in the OPTICON FP7 programme, in order to carry forward the developments which the team has carried out on precision cryogenic mechanisms to address the problems of high precision instruments operating in a non-gravity stable environment. We call this ‘Smart Instrument Technologies’, and it will be highly relevant in addressing the significant challenges of building diffraction limited and high spectral resolution instruments for the current and next generation of optical/IR telescopes.

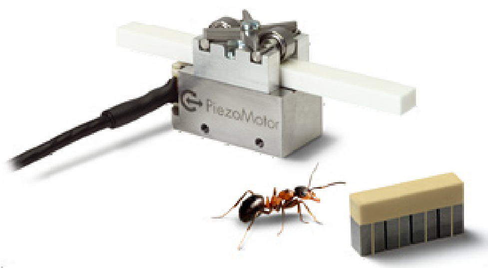
The focus of the final year of the OPTICON Smart Focal Planes JRA has been on evaluation of options for applying smart focal plane technologies to the EAGLE multi-integral field spectrometer, now under Phase A study for the European-ELT. In particular, the system for positioning pick-off mirrors to address many astronomical sources in parallel is based on a modification of the Starpicker concept developed by this JRA. However, there are advantages to two other methods of deploying these mirrors which have generic application for future instruments, so we decided to undertake short studies within the Smart Focal Planes JRA to evaluate commercial robots and micro robotic devices.

The other major activities in this year were the completion of the active cryogenic focal plane stage prototype by ASTRON, and the active mirror prototype by LAM. Meanwhile, the MOEMS slit mirror devices have been taken forward into manufacture of a prototype 20,000 element array by LAM and Institut de Micro-Technologies of University of Neuchatel (Switzerland) (IMT), but without OPTICON funding.

WP 3.2 Cryo Mechanisms: TipTilt Focus cryogenic unit (ASTRON)

This workpackage was aimed at demonstrating a prototype focal plane alignment mechanism at temperatures down to 70K. It is aimed at low-frequency correction for alignment errors, which is especially useful in cryogenic instruments for reducing the number of cool-down cycles needed to commission an instrument. The plan for the first half year of 2008 was to take the design towards final design, produce parts and order the motors, then assemble the unit and close the work package by testing in the May-June period. This was achieved and the unit demonstrated at the SPIE meeting in Marseille in June, with corresponding publication of performance data.

The mechanism is based on an industrial (low-cost) piezo motor (see figure below), selected by evaluation and testing of several motors in previous stages of this workpackage. The piezo material was characterised down to 77K, by measuring dielectric properties and voltage-expansion curves. By modification of the drive electronics it proved possible to produce motor speed and force at low temperatures which equalled room temperature performance.

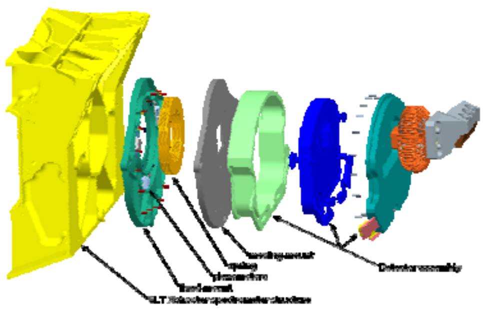


Piezo motor as tested at 70K

Specifications for the mechanism were based on the requirements of the VLT Xshooter NIR detector:

Mechanism Specifications	
Moving mass	1 kg

Speed	0.5 mm/sec
Focus (along z axis) total stroke	± 0.6 mm, res.:2.5 µm
Tip/Tilt stroke	± 1.2 mrad , resolution: 0.1 mrad
Earth quake resistant	4 g without damage
	Self braking system
First natural frequency	> 60 Hz
Orientation	All gravity directions
Environment	293 K, 105 K vacuum, 77 K vacuum



Mechanism design (right)

Mechanism and controller (left)

The mechanism proved to meet specification and is now available for consideration for adoption in new instruments. It is now planned to take this forward into the OPTICON FP7 Smart Instrument Technologies activity, addressing the higher speed requirements needed to fulfil active optics requirements of real-time flexure correction.

WP 3.2 Cryo Mechanisms: Configurable Slit Mask Unit (CSEM)

Work on this unit in JRA5 was completed in 2007 – but it is worth noting that development of this slit mechanism under the OPTICON programme helped CSEM bid successfully to UCLA for the slit mechanism for Keck Telescope MOSFIRE instrument – a rare example of US instrument teams buying European technology.

WP 3.2 Cryo Mechanisms: Configurable Slits and Masks (IAC)

Testing of the first prototype of the EMIR cold slit unit for GTC began this year, with a small level of OPTICON support. This unit is based on the developments in this JRA by CSEM, with manufacture transferred to industry in the Netherlands.

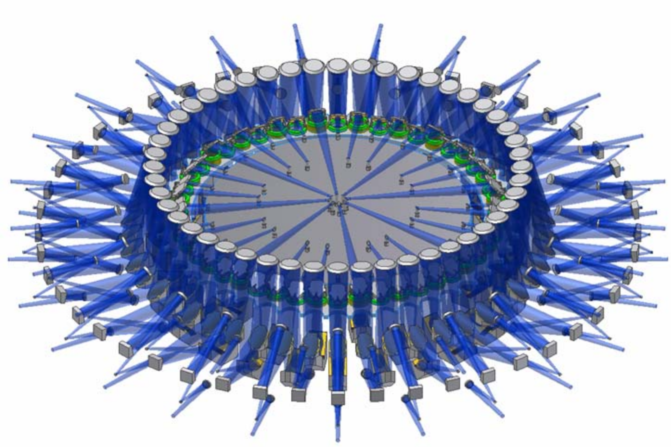
WP 3.3 MOEMS Based Programmable Slit Masks (LAM)

On internal funding, LAM and the IMT (Neuchatel) have continued to develop programme mirror arrays. Working from experience gained from the OPTICON-assisted 5x5 array, the first 20,000 micro-mirror array has been assembled successfully. This first prototype is a proof-of-concept of the device design and assembly method. Characterisation of the mirror surface shows a typical value of 14nm peak-to-valley errors, well within requirements for a NIR slit-based multi-object spectrometer. Rows of mirrors have been actuated, and the next step is to test the line-column addressing to enable individual mirror actuation across the entire array. Such excellent progress, alongside previous successful cryogenic tests of the smaller array, suggests that the device is not far from consideration for future instrument concepts, such as OPTIMOS now being studied for the E-ELT.

WP 5.0 Management and Systems Engineering (STFC)

As noted in previous reports, the Smart Focal Plane systems engineering and management team have attempted to provide a flexible R&D programme which responds to the needs of the European instrument builders, in particular towards the European Extremely Large Telescope instrument requirements. One consequence of this is that during this year we decided to change emphasis in the development programme for the pick and place mechanism for the E-ELT Multi-IFU instrument. Our requirements for the Starpicker robot were based on the needs of the OWL 100m telescope concept. As we have moved to a much more mature design of the instrument EAGLE on the 42m E-ELT, these requirements have changed considerably, most critically in that there is now no need to deal with a strongly curved focal plane, cryogenic operation or operation at a non-gravity stable focus. For this reason, we decided not to continue with cryogenic testing of the Starpicker modules, as previously planned. A further driver against further cryogenic testing was mechanical failure of the gripper mechanism – an event which provided insight into future design improvements. Even if we had wanted to take this system further, we did not have sufficient resource to re-design and re-build the gripper. Therefore, we decided (in consultation with OPTICON management) to concentrate limited remaining resources on two studies aimed at the EAGLE requirements. These were aimed at answering the following questions:

- Commercial robots – as the requirements analysis for EAGLE shows that cryogenic operation is not essential, could commercially available industrial robots be used?
- Micro robotic pick off mirrors – what are the technical issues and potential solutions to positioning the mirrors using small mechanical carriages, potentially communicating by wireless?



EAGLE concept: Pick-off mirrors can be deployed by a pick-and-place robot, or be driven around on self-propelled micro-robots

As part of this workpackage, requirements for future technology developments for Smart Focal Planes have been incorporated into the revised Technology Roadmap developed by the OPTICON Key Technologies Network (N3.5) following a workshop in Edinburgh in November 2008.

WP 6.2 Pick-off Prototype : Pick-and-Place Robots

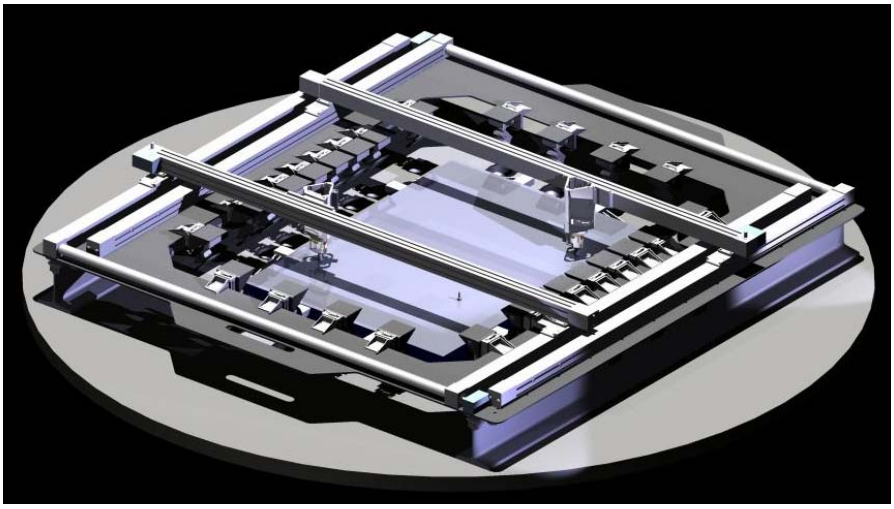
A comparison was carried out between two commercial robots (Mitsubishi RH-12SH535 and OC Robotics Snake Arm) and a custom-design robotic arm similar to the OPTICON Starpicker (see figures below) evaluated against the EAGLE requirements. The conclusion was that the commercial robots had considerable advantages in speed and cost, but offered lower precision and, most importantly, took up too much of the available space, which is constrained by the back-focal distance of the E-ELT.

Mitsubishi RH-12SH535.
Gripper reach - 278 to 850mm
Repeatability - +/-25 μm

Star picker
Gripper reach - 450Ømm
Repeatability - +/-2μm

Pick-and-place Robots (left and right above)

The conclusion of this study was that the most appropriate solution for EAGLE was a combination of commercial linear slide mechanisms with the gripper designed for the Starpicker, as shown in the figure below.



EAGLE Pick-and-place mechanism concept

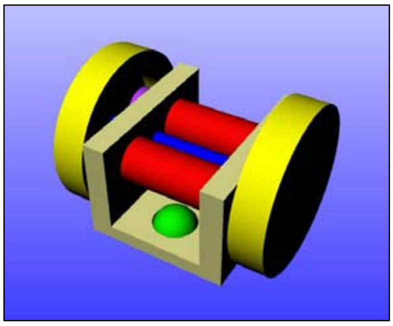
WP 6.2 Pick-off Prototype: Micro Autonomous Positioning System (MAPS)

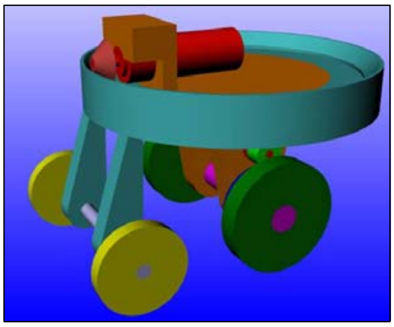
An alternative to mechanical positioning systems for pick-off mirrors is to mount them on autonomous robots. This concept has already been explored in JRA5 via the Starbugs work which showed that the concept of piezo-actuated magnetically-held devices was a practical proposition. The new layout of the E-ELT with a gravity-stable focal plane option opens the option of mechanical driven micro robots driven by electric motors, such as the 'Smoovy' motor (figure below).

'Smoovy' Motor

We have commissioned a design study of drive motor options, carried out as a Master's project (Cyrille Billard) at the Mechanical Engineering department of Heriot-Watt University. This thoroughly evaluated a range of drive topologies, and provided detailed analysis of friction, motor torque requirements and energy supply options. The result was a resulting in the design options shown in the figures below.

The design in the left-hand drawing has two wheels which, though they rotate on a common axis, are independently driven by two Smoovy motors. Steering can be





Chassis designs proposed and analysed in Heriot Watt report

provided by differential driving from the two motors with the aid of a roller ball to provide stability. The other design has one Smoovy motor providing power to the drive wheels and one to control steering.

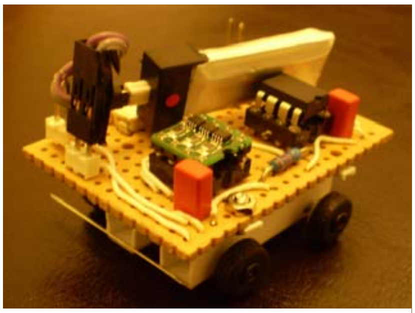
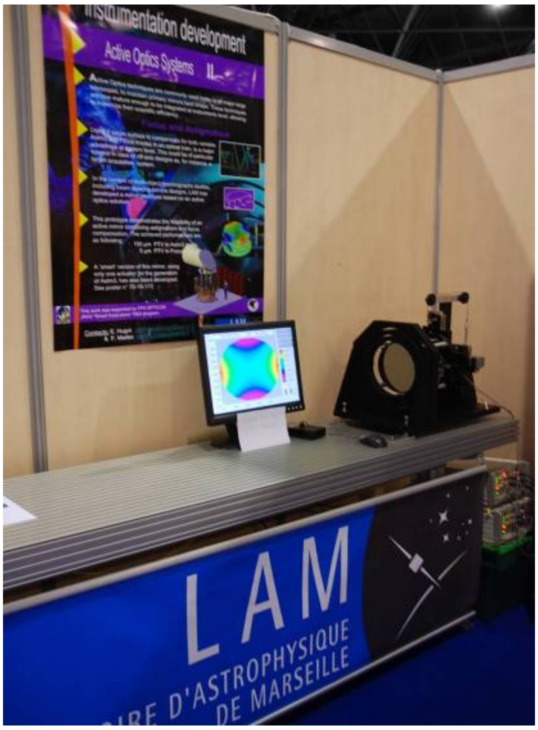


Figure : Experimental robot

In order to evaluate the concepts, simple bread-board has been made using a PIC microcontroller with pre-programmed patterns to control the robot's trajectory. A conclusion of this was that the requirements on wheel and bearing symmetry are quite severe, and precision manufacturing will be required. We are now building a proof of concept prototype utilising existing technologies, and this is being progressed through a PhD project at Edinburgh University (William Taylor). The aim is to show how accurate the x-y drive can be with standard dc motors, using an optical metrology system to track movements. It is being built with rapid prototyping techniques and subcontract electronics in order to achieve fast turn-rounds as the design evolves.

A major issue which has been addressed is how to supply drive power. Battery size and weight are major issues for small scale robot projects, so some work was done to evaluate inductive power coupling. First results suggest a hybrid scheme; with small rechargeable batteries charged from a wireless power source may be the best solution – similar to the system used for electric toothbrushes.

WP 6.3 Beam Manipulator Prototype: Beam Steering Mirror (LAM)



The aim of the final part of this workpackage was to complete the development of an active Beam Steering Mirror, based on the requirements of one of the EAGLE Target Acquisition System concepts. The system is used to generate a fixed pupil (where a Deformable Mirror can be located to enable Multi-Object Adaptive Optics) with the light coming from variable positions of the focal plane selected by pick-off mirrors positioned by the systems described in WP 6.2. The mirror is able to correct the astigmatism and the focusing of the optical path. The mirror is actuated by four amplified piezo actuators, providing up to 200 µm displacement and 500N force. The active mirror and its control and metrology system was completed and tested in time to display at the SPIE meeting in June 2008

Figure : Active Beam Steering Mirror Prototype demonstration at SPIE Marseille

WP 6.3 Beam Manipulator Prototype: Small Deformable Mirrors (TNO)

The aim of this workpackage was to assess the requirements for highly linear cryogenic deformable mirrors in NIR multi-object spectroscopy to enable open-loop Multi Object Adaptive Optics, and for a cryogenic single-conjugate AO system for a Mid-IR ELT instrument. TNO were asked to carry out a survey of technology readiness and develop a roadmap towards meeting the Smart Focal Plane instrument requirements, such as those coming from the EAGLE study. A preliminary report was issued, but this was not pursued to conclusion, mainly due to progress in studies for the E-ELT EAGLE and METIS instruments showing that there was no longer a requirement for cryogenic deformable mirrors.

Smart Focal Plane JRA Outcomes

Now that the Smart Focal Planes programme is complete, we can point to the following outcomes, which can be regarded as a toolkit of available technology solutions, with proven feasibility:

Technology	**Applications**	**Lead Institute(s)**
Robotic pick-and-place mechanism	E-ELT EAGLE, TMT	UK ATC
Micro-robots	E-ELT EAGLE, TMT	UK ATC
Gripper Mechanism	E-ELT EAGLE, TMT	CSEM
Starbugs	E-ELT EAGLE, TMT	AAO
Active Mirrors	EAGLE, TMT	LAM

Active focal plane stage	VLT X-shooter, etc	ASTRON
Slit Mechanisms	E-ELT OPTIMOS, Keck MOSFIRE, GTC EMIR	CSEM, IAC
Replicated IFU Slicers	E-ELT EAGLE, TMT	Durham
MOEMS programmable slits	OPTIMOS, ESA Euclid	LAM

Milestones and Deliverables achieved during the reporting period

Deliverable / Milestone No	Deliverable/Milestone Name	Work package / Task No.	Lead Contractor (s)	Planned (in months)	Achieved (in months)
M2	Tip-Tilt Focal Plane prototype	WP3.2	ASTRON	55	55
D7	Final Report	WP5	UK ATC/IAC	59	59
M2	Pick-off Prototype – Gripper cryogenic testing	WP6.2	CSEM/UK ATC	53	Work discontinued*
M4	Pick-off Prototype – Star-picker cryogenic testing	WP6.2	UK ATC	52	Work discontinued*
New	Commercial Robotic pick-off	WP6.2	UK ATC	55	55
New	Micro robotic pick off mirrors	WP6.2	UK ATC	59	59
D2a	Beam manipulator prototype – active optics	WP6.3	LAM	54	54
M2	MOEMS mirror array prototype	WP6.4	LAM/CSEM	53	54
M1	Integration of Star-Picker and Cryo-Mirrors in Smart Focal Plane Demonstrator	WP6.5	UK ATC/LAM	54	Work discontinued*

* Not worth proceeding due to EAGLE requirements changing

Major Meetings and Workshops organised during the reporting period

No major meetings or workshops held in 2008.

1.5.7 JRA6: Volume Phase Holographic Gratings (VPHG)

Contractors:

Participant number	**4a**	**7a**	**8c**	**21b**	**23**	
Participant short name	ESO - INS	IAC	INAF – Brera	ULg – CSL-AOHL	POLIMI	**Total**
Person-months	1.2(0)	4(4)	8.1(0)	7.5(7.5)	7(0)	**27.8(11.5)**

Summary of Objectives and progress made:

The JRA is organized in 5 main work packages (referred to also as *research lines*) which are:

1. Management
2. IR Volume Phase Holographic gratings development
3. Non-traditional VPHG-based configurations
4. Photochromic Polymers based VPHGs
5. UV Volume Phase Holographic gratings development

The general scheme followed in the JRA toward the final deliverables has followed the following phases

1. Theoretical studies aimed to the definition of a first set of prototypes.
2. Manufacturing of the first set of prototypes
3. Analysis and characterisation of the first set of prototypes
4. Definition of a second advanced set of prototypes and/or of the final devices
5. Manufacturing of the second set of prototypes and/or final devices
6. Characterisation of the second set of prototypes and/or final devices.

The present report describes the activity carried-out in the fifth and last year of the five year project, covering, with the exception detailed in the following sections, the phases 4,5 and 6 described above.

WP 1 – Management

The activity of this Work Package concerned mainly the lead of the interconnection and intercommunication between the Work Packages. This is especially necessary in JRA6 because each of the contractors contributes to more than one Work Package offering its specific expertise to each research line in a transversal way. The coordination activity, e.g. making everyone aware of the expertise, infrastructure and facilities available in the team has been extremely important for the success of the research.

The interconnection and intercommunication has been managed via frequent bilateral conversations with WP leaders and a number of plenary progress meeting (at least one per year)along the project. In the year 2008 we have had no meeting. This because the 2007 plenary meeting was held on October 30 at Merate Observatory (Lecco, Italy - the minutes of the meeting are available on the JRA6 Web-site) and also because most of the results were already available at that meeting and already discussed in the group.

The management activity also concerned the link between the JRA and the OPTICON Management, the board and the executive board. This has been done via participation of the JRA leader to the relevant meetings and by assuring the preparation and delivery of the technical document in a timely manner.

WP1 also takes care of the dissemination of the JRA6 results. This is done via encouraging and coordinating the participation of the team members to congresses, conferences etc. The texts of the most relevant publications are available on the JRA6 web-site.

Furthermore the JRA6 is represented in the N3.5 Key Technology Network (see corresponding section in this report) by the JRA leader. JRA6 contributed in this way to the roadmapping meeting held in Edinburgh in November 2008 and the Cryogenic Material Workshop organized in Merate in December 2008.

WP 2 – IR VPHGs

The goal of WP2 in JRA6 was to demonstrate the usability of VPHG's in cryogenic enviroments such as those normally in use in infrared astronomical instrumentation. Detailed performance analysis has been carried out regarding.

- Diffraction efficiency
- Wavelength coverage
- Transmitted wavefront
- Fragility and durability.

A set of prototypes covering the usual NIR Astronomical bands (J,H,K) has been thouroughly studied and characterized yielding positive results. The conclusion of the activity in WP 2 is that instrument designer can count on VPHG technology in their designs.

In order to test the properties of these cryogenic devices a new set of gratings was ordered from the manufacturer associated with the JRA. Substrates have been purchased, characterized and delivered. The difficulties at manufacturer described in earlier reports made it impossible to receive the new set in time to characterize it. Nevertheless, and in spite of this delay, the original goal of WP2 can be considered accomplished as extensively explained in the technical annex of this report available on the JRA6 Website.

WP 3 – Non Traditional VPHG-based configurations

WP3 is dedicated to the study and realisation of non-traditional configuration making use of VPHGs. The reason for having this research line comes from the consideration that the use of existing VPHGs has not been pushed at the maximum. As a matter of fact, they have only be used up to now as replacement of grisms in straight-through geometry spectrographs, with few remarkable exceptions.

After a trade-off phase dedicated to the selection of a representative prototype a VPHG tunable filter was selected as the one to produce and characterize. During the year 2008 such a prototype was manufactured and characterized.

A description of the prototype and its characterization are reported in the technical annex to this report available in the JRA6 website.

WP 4 – Polymer based VPHGs

In the context of OPTICON-JRA6 activity the WP 4 is meant to investigate possible alternatives to DCG as photosensitive layer in the fabrication of VPHGs.

Due to limited resources that did not allow us to investigate all possible DCG alternatives, attention has been concentrated on a class of polymers, purposely synthesised in our laboratories, with linear and non-linear optical properties of already proven interest for astronomical instrumentation. These polymers are referred to in general as photochromic polymers, although many different species can be used for our purposes.

Numerous polymer species have been synthesized and used in tests for the fabrication of graings. A first ronchi grating replica was obtained earlier during the study. In 2008 the first holographic grating was successfully grooved in a polymer film, demonstrating the feasibility if the approach and accomplishing the goals of this WP.

The process of fabrication and characterization is described extensively in the technical annex to this report available in the JRA6 website.

WP 5 – UV VPHGs

The goal of WP5 within JRA6 is to enable the technology needed to manufacture science grade VPHGs working at UV wavelengths with special attention to their use as cross dispersers in high resolution spectroscopy.

Particular attention had to be given to
- Diffraction efficiency (specially at extreme UV wavelength)
- Transmitted wavefront
- Control of the transmitted zeroth order for use in double pass

All the above has been tested through a number of prototypes and a specific mounting configuration that proved the possibility of using VPHGs at UV wavelength at the limit of the transmission of the Dicromated Gelatine. Having reached the limit of the central component of the VPHGs technology, WP5 was stopped and merged into WP4 for the search of DCG replacements.

No new activity has been carried out in this WP during the reporting period.

Milestones and Deliverables achieved

JRA6 acieved the original goals in all the Work Packages. The structure of milestones has been maintained according to schedule well within the project development and close to his final phase. The final milestones, although largely achieved in terms of new knowledge do not precisely follow the description given in the original plan, e.g. a new set of prototype could not be analyzed (WP2 case) or was not ordered because it was no longer of value (WP5 case).

Significant achievements and their impact resulting from this activity during the reporting period include:

4. Full cryogenic characterization of J,H and K VPHGs
5. First working non-traditional configuration based on VPHGs
6. First working holographic grating obtained on a film of photocromic polymer specifically studies as DCG replacement.

Milestones and Deliverables achieved for JRA6 in 2008

Deliverable / Milestone No	Deliverable/Milestone Name	Work package / Task No.	Lead Contractor (s)	Planned (in months)	Achieved (in months)
D1	"OPTICON JRA 6 – Volume Phase Holografic Gratings: Report of the activity carried out during the year 2008, Analysis of the Results Achieved during the Whole Project"	WP2	ALL	60	60

Meetings and Workshop Table for JRA6

Date	Title/subject of meeting /workshop	Location	Number of attendees	Website address
13th/14th November 2008	JRA6 representation at NA3.5 Roadmap Update Workshop	Edinburgh, UK	12	https://forge.roe.ac.uk/twiki/bin/view/Optikeytec/RoadmapDocument
4th/5th December 2008	JRA6 representation at NA3.5 Material Property Measurements for Cryogenic Instruments Workshop	Merate, Milan, IT	18	http://www.astro-golem.it/opticon/workshop_merate/

List of deliverables

Activity	Deliver--able No	Deliverable Name	Workpackage /Task No	Delivered by Contractor(s)	Planned (in months)	Achieved (in months)
NA1	M19	Executive meeting. Garching	WP1	UCAM, STFC	49	49
NA1	M20	Complete Annual report to EU	WP1	UCAM, STFC	50	50
NA1	M16	Executive meeting	WP1	UCAM, STFC	54	55
NA1	M18	OPTICON Board meeting	WP1	UCAM, STFC	54	59
NA2	D1	Updated Progress report	WP1.1	IAC	60	60
NA2	M1	Regular ENO meetings	WP1.1	IAC, IOA-KUL, INAF, NOTSA, THEMIS, IFAE, UCAM, Jodrell Bank.	58	58
NA2	M4	Dissemination of results	WP2.1	IAC	58	60
NA2	D1	Measurements of extinction and dust	WP2.3	IAC	58	60
NA2	M1	Campaigns at OT & ORM	WP2.4	IAC	58	58
NA2	D1	Annual Report on discussion forums for site-selection	WP2.5	IAC	58	60
NA2	M1	Workshop	WP2.5	IAC	56	Did not take place
NA2	D3	Compendium and Publication of results	WP2.5	IAC	60	60
NA2	D6	Annual Report with the maintenance activities carried out	WP3.1	IAC	60	60
NA2	D7	Report of the promotional activities related to JIS	WP3.1	IAC	59	60
NA2	M1	Open-doors days at OT and ORM	WP3.2	IAC, STFC, INAF, IOA-KUL, IFAE	54 -55	54 -55
NA2	D1	New editions of outreach material	WP3.2	IAC, STFC, INAF, IOA-KUL, IFAE	58	55-60
NA2	D3	ENO website. Updated version	WP3.2.	IAC, STFC, INAF, IOA-KUL, IFAE	60	60
NA2	D5	Exhibition elements and educational material	WP3.2	IAC, STFC, INAF, IOA-KUL, IFAE	54	54
NA3	M1	ELT Conference	WP1	STFC	57	57
NA3	D2	Final Science Case Book	WP1	STFC	60	61
NA3	M4	NUVA Board Meeting, Madrid	WP2	STFC	51	51
NA3	D3	Final Report + Roadmap	WP5	SFTC	58	60
NA3	M3b	Draft of interfaces required	WP6	ESO	51	51
NA3	M3c	Detailed list of interfaces required	WP6	ESO	57	54
NA3	M5	Architectural concept document	WP6	ESO	57	60
NA3	M6	Final report	WP6	ESO	60	60
NA6	M3B	Peer review of Aristarchos Telescopes	WP1	STFC	53	Not complete
NA6	M2	Annual Directors Meeting	WP1	STFC	53	54 + 57
NA6	M2	5th Report to Directors forum	WP2	IAC	56	56
NA6	D3	Report on Scientific Output.	WP2	IAC	58	60
NA6	M3	IFU workshop, Potsdam	WP3	CNRS, IAP	53	53
NA6	M4	NEON School	WP3	CNRS, IAP	54	54
NA6	M5	ESO Archive School	WP3	CNRS, IAP	57	56
NA6	M2	Enhancement Working Group Meeting	WP3	CNRS, IAP	57	>60
JRA1	M1	JRA1 General Meeting 6	WP1	ESO	57	59
JRA1	M1	Delivery of the curvature wavefront sensor for GTC	WP2.3	GTC	51	57

JRA1	M2	Delivery of the multi objects wavefront sensor opto-mechanics without translation stages and base plate.	WP2.3	GTC	55	60
JRA1	D1	Test report on component and sub-unit tests of the multi object wavefront sensor	WP2.4	MPIA	58	58
JRA1	M1	Complete development of the deformable mirror drive electronics and testing	WP3.4	ESO	51	51
JRA1	M2	Manufacturing of a convex glass shell prototype for an adaptive secondary	WP3.6	INSU/ESO	60	60
JRA1	M6	Delivery and testing of a 50x50 actuator mini piezo deformable mirror	WP3.7	INSU/ESO	57	60
JRA1	M7	Delivery and testing of a 11x11 actuator electromagnetic deformable mirror	WP3.7	INSU/ESO	57	59
JRA1	D1	High order Test bench test report	WP3.8	ESO	57	57
JRA2	M6	Backside device test	WP2	IAC	54	54
JRA2	D2	Final detector acceptance report	WP2	IAC	56	56
JRA2	D1	Controller acceptance report	WP3	IAC	51	51
JRA2	M1	Complete detector tests in laboratory.	WP5	IAC	60	48
JRA2	M2	AO wavefront sensor manufactured	WP5	IAC	60	cancelled
JRA2	M3	Complete detector performances evaluation in an AO system.	WP5	IAC	42	cancelled
JRA2	M4	Acceptance of the AO wavefront sensor for AO tests	WP5	IAC	42	cancelled
JRA2	D1	Test report for the results on the AO test bench and/of on sky.	WP5	IAC	60	Cancelled
JRA3	D1	comparison of technologies report	WP1	MPA	60	>60
JRA3	D2	Test report	WP2	STFC	48	52
JRA3	D2	AA-pn-sensor device	WP3	MPE/MPG	60	54
JRA3	D3	Test report AA-pn-device	WP3	MPE/MPG	60	>60
JRA3	M2	Delivery APD array	WP4	NUIG	12	NUIG
JRA3	D1	AIT APD array	WP4		12	deleted, see text
JRA3	D1	Fast timing controller L3CCD	WP5	UCAM	45	45
JRA3	D2	Fast timing controller AA-pn	WP5	MPE/MPG	48	54
JRA3	D1	Common higher level software	WP6	NOTSA	deleted (see WP1)	
JRA3	D1	Software testbed	WP8, WP1	LSW/MPA	48	Included in WP1 D1 (see text)
JRA3	D1	Prototype camera on testbed	WP7	STFC	48	52
JRA4	D2	Image reconstruction software WISARD & User manual – This was in last year's 18-mo projection	WP2.5	UCAM	60	60
JRA5	M2	Tip-Tilt Focal Plane prototype	WP3.2	ASTRON	55	55
JRA5	D7	Final Report	WP5	UK ATC/IAC	59	59
JRA5	M2	Pick-off Prototype – Gripper cryogenic testing	WP6.2	CSEM/UK ATC	53	Work discontinued
JRA5	M4	Pick-off Prototype – Star-picker cryogenic testing	WP6.2	UK ATC	52	Work discontinued
JRA5	New	Commercial Robotic pick-off	WP6.2	UK ATC	55	55
JRA5	New	Micro robotic pick off mirrors	WP6.2	UK ATC	59	59
JRA5	D2a	Beam manipulator prototype – active optics	WP6.3	LAM	54	54
JRA5	M2	MOEMS mirror array prototype	WP6.4	LAM/CSEM	53	54

JRA5	M1	Integration of Star-Picker and Cryo-Mirrors in Smart Focal Plane Demonstrator	WP6.5	UK ATC/LAM	54	Work discontinued
JRA6	D1	"OPTICON JRA 6 – Volume Phase Holografic Gratings: Report of the activity carried out during the year 2008, Analysis of the Results Achieved during the Whole Project"	WP1-5	ESO, IAC, INAF – Brera, ULg – CSL-AOHL, POLIMI	60	60

[In addition to being described in the Activity Report, achieved deliverables, if not yet provided to the Commission services, will be gathered in a CD-ROM in ***Annex 7****. When the deliverable is not a report provide any available supporting material that can document it (e.g. photographs of a prototype).]*

Use and dissemination of knowledge

NA 1. Management

JENAM, Vienna, Austria, September 2008
ECRI, Versailles, France, December 2008

NA2: Coordination and Integration of ENO facilities

WP1.2 Laser Traffic Control System (LTCS) for ORM

The complete final report can be downloaded as paper 06/07 at the following Web address: http://www.otri.iac.es/na2/ver_meeting.php?id=27&id_proyecto=1

WP2: Site Characterisation of the Canary Islands' Observatories

The bibliography has been improved with 'Referred Papers' and 'Conference-Proceedings' which deal about the history of the sky characterization of the Canary Islands' Astronomical observatories. It will include a series of new contributions developed for the 'Optical Turbulence Astronomy meets Meteorology 08' (OTAM) with the presentations and reports of the group.

WP2.1.1 IACDIMM and MASS-DIMM calibration.

The complete technical information is available at: Doc Nº. ELT-PLA-IAC-12200-0009
Issue 1.2 – DRAFT 24th March 2008

WP2.3.2 Atmospheric extinction

The results have been published in press: "Astronomical site selection: On the use of satellite data for aerosol content monitoring", A.M. Varela et al. at M.N.R.A.S.

WP 2.4 Joint actions for Measurement of turbulence and wind vertical profiles

The paper entitled: "Correction of the dome seeing contribution from generalized-SCIDAR data using evenness properties with Fourier analysis" (Fuensalida, García-Lorenzo and Högemann) has published in Monthly Notices of the Royal Astronomical Society (MNRAS) Main Journal (vol. 389, p.731, 2008).

The followings proceedings, where we have analysed different aspects of the Canary Islands turbulence and wind regime over the astronomical sites, have been presented in the International meeting "Optical Turbulence: Astronomy meets Meteorology" held in Alghero (Sardegna-Italy) the past 15-18 September 2008, organized by the Osservatorio Astrofisico di Arcetri (INAF):

-"Vertical turbulence profiles at Canary Islands Astronomical Sites" (B. García-Lorenzo, J.J. Fuensalida, J.A.Castro-Almazán and M. Rodriguez-Hernández).
-"Turbulence structure and meteorological conditions at Teide and Roque de los Muchachos observatories (Canary Islands) (J.A.Castro-Almazán, B. García-Lorenzo and J.J. Fuensalida).
-"Studying the relationship between the average velocity of the turbulence (v0) and the high altitude winds (v200) at the Teide Observatory" (B. Garcia-Lorenzo, C. Del Giorgio-Castiglione, J.J. Fuensalida)

NA3: Structuring European Astronomy

WP1: ELT

A final report on the science case as it stands at the end of OPTICON FP6 has been produced (deliverable N3.1 D2):

"The Science Case for the European ELT", I. Hook, in proceedings of "Science with the VLT in the ELT Era", Astrophysics and Space Science Proceedings, Volume . ISBN 978-1-4020-9189-6. Springer Netherlands, 2009, p. 225

The SWG web site has now been integrated into the E-ELT project web pages hosted at ESO: http://www.eso.org/sci/facilities/eelt/science/

The E-ELT Science Case Development presentation given at the OPTICON Board Meeting #6, 10 - 11 November, Porto (I Hook):
http://www.astro-opticon.org/agendas_minutes/porto_presentations/Hook.ppt

The OPTICON ELT mailing list continues to be maintained and has been used to distribute various ELT announcements.

ELT science session at JENAM 2008 on status of project, science and instrumentation: http://www.eso.org/sci/facilities/eelt/science/meetings/jenam08/ and summary article by G. Monnet, in The Messenger (ESO):
http://www.eso.org/sci/publications/messenger/archive/no.133-sep08/messenger-no133-2.pdf

WP2: Network for UV Astronomy (NUVA)

Space Astronomy: the UV window to the Universe (eds. Ana I. Gómez de Castro Noah Brosch), published by Springer (and ApSS) in 2008; the book is coming in March 2009

Hot plasma around young pre-main sequence stars by Gómez de Castro (Proc of the FUSE conference on Future directions on UV spectroscopy held in Annapolis, U.S.A. in October 19-22, 2008)

The WSO-UV, a UV mission for the future by Shustov et al. (Proc of the FUSE conference on Future directions on UV spectroscopy held in Annapolis, U.S.A. in October 19-22, 2008)

UV instrumentation demanded by the UV community, results from the NUVA on-line questionnaire published in the EAS bulletin and in the NUVA web site (www.ucm.es/info/nuva).

WP3: High Time Resolution Astrophysics (HTRA)
No activity in this period.

WP5: Key Technologies Network

Documents Produced
Dave Mellotte and Robert Pfab, *OPTICON Key Technologies Roadmap 2008*

Publications
Colin Cunningham, *Future technologies for optical and infrared telescopes and instruments:* Experimental Astronomy (in press)

NA5: Interferometry forum

Activity updates can be found at the EII website:
http://www.mpia-hd.mpg.de/euinterf//Activities/OPTICON-NA/

NA6: OPTICON Telescope Network

WP2: Operation of the Trans-national Access Office

This is described in detail in **Section 1.4.1.1 Description of the publicity concerning the new opportunities for access** and **Section 1.4.1.4 Scientific output of the users at the facilities**

WP3: Enhancement

Websites kept up-to-date with information on this Activity:

http://eas.iap.fr/neon2008.html

http://opticon.3d-school.aip.de/

http://www.eso.org/sci/meetings/neon-2008/

A description of the 2008 NEON schools was posted in the ESO Messenger issue of December 2007 and information is on the Observatories websites: http://www.ing.iac.es and http://www.not.iac.es

JRA1: Adaptive Optics

WP2.4: Multiple FOV System with NGS

List of delivered documents:

LN-INAFB-MAN-AO-001.pdf: MHWS hardware manual

LN-INAFB-VER-AO-001.pdf: MHWS verification document

LN-INAFP-MAN-AO-002.pdf: K-mirror assembly manual

LN-INAFP-VER-AO-002.pdf: K-mirror company verification

LN-MPIA-MAN-AO-001.pdf : GWS support structure transport

LN-MPIA-TN-AIT-026.pdf : GWS bearing tests

LN-MPIA-TN-AIT-032.pdf: Alignment and verification of the K-mirror unit

LN_MPIA_VER_AO_002.pdf: LN-DM-2 surface flattening procedures and results

LN-MPIA-VER-OPT-002.pdf: FP20 Filter - Verification and Acceptance Report

LN-MPIA-VER-OPT-003.pdf: FP20 verification and acceptance tests

Two reports have been submitted for WP3.7, a final design and test report (JRA1-TRE-ALP-0005) and a perspective report (JRA1-TRE-ALP-0006).

Published papers:

- "Integration of the mid-high wavefront sensor to the LINC-NIRVANA post-focal relay" Schreiber L., et.al.; Proceedings of the SPIE, Volume 7015, pp. 70155A-70155A-11 (2008)
- "LINC-NIRVANA: achieving 10 mas imagery on the Large Binocular Telescope"; Herbst T. M., et.al.; Proceedings of the SPIE, Volume 7014, pp. 70141A-70141A-6 (2008)
- "The Multiple Field of View Layer Oriented wavefront sensing system of LINC-NIRVANA: two arcminutes of corrected field using solely Natural Guide Stars" Farinato J., et.al.; Proceedings of the SPIE, Volume 7015, pp. 70155J-70155J-11 (2008).

JRA2: Fast detectors for AO

JRA2 was represented at SPIE 2008 Astronomical Instrumentation conference in Marseille and the activity was presented in the detector session of the conference:

"The L3Vision CCD220 with its OCam test camera for AO applications in Europe" , Author(s): Philippe Feautrier; Jean-Luc Gach; Philippe Balard; Christian Guillaume; Mark Downing; Eric Stadler; Yves Magnard; Sandy Denney; Wolfgang Suske; Paul Jorden; Patrick Wheeler; Michael Skegg; Peter Pool; Ray Bell; David Burt; Javier Reyes; Manfred Meyer; Norbert Hubin; Dietrich Baade; Markus Kasper; Robin Arsenault; Thierry Fusco; Jose Javier Diaz Garcia High Energy, Optical, and Infrared Detectors for Astronomy III, Proceedings Vol. 7021, 2008

JRA3 : High Time Resolution Astronomy

WP1: Management
Publications resulting from this work:

Dhillon, V. S., Marsh, T. R., Copperwheat, C., Bezawada, N., Ives, D., Vick, A., O'Brien, K., 2008, High-speed spectroscopy with zero readout noise, AIP Conference Proceedings, Volume 984, 132

Marsh, T. R., 2008, High-Speed Optical Spectroscopy, Astrophysics and Space Science Library, Volume 351, 75

Dhillon, V. S., Marsh, T. R., Copperwheat, C., Bezawada, N., Ives, D., Vick, A., O'Brien, K., 2007, ESO Messenger, Volume 127, 41

WP2: EMCCD developments

D2: Test report: delivered. The results are available the following publicly accessible report:

Dhillon, V. S., Marsh, T. R., Copperwheat, C., Bezawada, N., Ives, D., Vick, A., O'Brien, K., 2008, High-speed spectroscopy with zero readout noise, AIP Conference Proceedings, Volume 984, pp. 132-139.

WP5: Controller Development
Work in 2008 consists of the completion and delivery of the highly successful fast timing controller for L3CCDs, deliverable D1 of WP5. These results have been reported in several

publications, including:

C.D. Mackay, J. Baldwin, N. Law, P. Warner (2004) “High resolution imaging in the visible from the ground without adaptive optics: new techniques and results”, SPIE vol 5492, 128, Glasgow, June 2004.

Craig Mackay, Nick Law and Timothy D Stayley, "Diffraction Limited Imaging in the Visible from Large Ground-Based Telescopes: New Methods for Future Instruments and Telescopes", (2008), SPIE 7014, Marseille June 2008.

C. Mackay, “High Resolution Imaging on the VLT”, (2009) Astrophs & Space Science Proc: Science with the VLT in the ELT era, p449-453.

JRA4: Interferometry

Web pages : Information and documentation and publications can be found at

VSI: http://www-laog.obs.ujf-grenoble.fr/twiki/bin/view/Laog/Projets/VSI/WebHome
MATISSE: http://www.obs-nice.fr/matisse

JRA5: Smart Focal Planes

Publications:

Colin Cunningham and Chris Evans *Smart Focal Plane Technologies for VLT instruments*. In Alan Moorwood (ed), Science with the VLT in the ELT era, Springer 2009

Fabrice Madec, Emmanuel Hugot, Jean-Luc Gimenez, Fanny Tracol, Marc Ferrari, Pascal Vola, Sébastien Vivès, Kacem El Hadi, Gabriel Moreaux, Eric Prieto, and Jean-Gabriel Cuby *An active optics concept for the multi-object spectrograph EAGLE.* Proc. SPIE 7018, 70182K (2008)

Johan H. Pragt, Raymond van den Brink, Gabby Kroes, Niels Tromp, and Jean-Baptiste Ochs *Piezo-driven adjustment of a cryogenic detector.* Proc. SPIE 7018, 70184N (2008)

M. Teuwen, H. Janssen, R. Geurink, M. Boots, and F. Garzón López
GTC-EMIR configurable slit unit development details. Proc. SPIE 7018, 70180K (2008)

Severin Waldis, Frederic Zamkotsian, Pierre-Andre Clerc, Wilfried Noell, Michael Zickar, Patrick Lanzoni, and Nico de Rooij *Uniform tilt-angle micromirror array for multiobject spectroscop.y* J. Micro/Nanolith. MEMS MOEMS 7, 021014 (2008)

Severin Waldis, Frederic Zamkotsian, Patrick Lanzoni, Wilfried Noell, and Nico de Rooij *Micromirrors for multiobject spectroscopy: optical and cryogenic characterization.* Proc. SPIE 6887, 68870B (2008)

Severin Waldis, Frederic Zamkotsian, Patrick Lanzoni, Wilfried Noell, and Nico de Rooij *Micromirror array for multiobject spectroscopy in ground-based and space telescopes.* Proc. SPIE 7018, 70182S (2008)

Martyn Wells, Sébastien Vives, Eric Prieto, Philippe Laporte, Peter R. Hastings, Chris Evans,

Robert Content, and Fanny Chemla *Optical solutions for the multi-IFU instrument EAGLE for the European ELT.* Proc. SPIE 7014, 70141L (2008)

Frederic Zamkotsian, Emmanuel Grassi, Severin Waldis, Rudy Barette, Patrick Lanzoni, Christophe Fabron, Wilfried Noell, and Nico de Rooij *Interferometric characterization of MOEMS devices in cryogenic environment for astronomical instrumentation.* Proc. SPIE 6884, 68840D (2008)

JRA6: Volume Phase Holographic Gratings

Technical Annex to Annual Report for the whole JRA6: "OPTICON JRA 6 – Volume Phase Holografic Gratings: Report of the activity carried out during the year 2008, Analysis of the Results Achieved during the Whole Project" - OPT-JRA6-MAN-OAB-0001(2009) dated Feb 01, 2009.

The dissemination of the JRA-6 results and the texts of the most relevant publications are available on the JR6 web-site (http://golem.merate.mi.astro.it/projects/jra6/)