2nd 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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1. Progress report

1.1 Summary of the activities and major achievements

The second year of operation of OPTICON has shown the project develop from promise into activity and performance. Progress in all aspects of the activities has been strong, with no significant difficulties or unforeseen problems, even though the project involves some seventy laboratories around Europe.

Highlights of the year include completion and delivery of the two printed books about the `Science Case for an Extremely Large Telescope' NA3), completion of operational prototypes of new InfraRed VPH gratings(JRA6), negotiation and initiation of major contracts for optical elements and electronic systems for next generation adaptive optics facilities (JRA1), contract definition and implementation for two complementary fast detector systems (JRA2; JRA3), completion and submission of a set of detailed proposals for next-generation interferometric capabilities, including enhancement of the ESO VLTI facility (JRA4), and specification and development of next generation mart Focal Plane capabilities (JRA5). All these impressive achievements develop Europe's technical facilities for the future, both enhancing the best of the current generation of telescopes and instruments, and leading towards definition and develop of future Extremely Large Telescopes.

These technical achievements are complemented by the highly successful telescope access programme. The OPTICON access program includes every mid-sized high-quality telescope world-wide with any European ownership, and provides the essential support to make these facilities available to any European who writes the best proposals, unconstrained by nationality. This program, very heavily over-subscribed, is having already an apparent treble benefit: the best scientific ideas are being supported with no national boundary constraints; the European astronomical community is devoting its research efforts to the best modern facilities, thereby strengthening itself; and thirdly, the telescope operators are learning to operate their facilities in a naturally complementary way, improving efficiency and gaining from synergy. This last aspect is proving even more important than anticipated, as the benefits of coordinating facility operation and development are already encouraging facility owners to plan for truly coordinated future joint operations. These developments are occurring naturally inside the telescope directors' forum (NA6).

The third aspect 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. Perhaps the most impressive this year has been developments supporting European intentions to build an Extremely Large Telescope. This plan is 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. The key Technologies network has played a major role here, identifying those technologies most likely to become mature, given reasonable investments.

The Executive carried out a detailed review and analysis of the performance of all OPTICON supported activities, and was able to confirm that all major activities are on track, with most technical developments exceeding expectation. One activity (JRA3) was somewhat reorganised following review, to ensure its highest priority project, development of a super-fast detector system, was fully supported ahead of lower priority desires. OPTICON continues to be an efficient and effective set of activities, naturally complementary, retaining strong internal communications, and ensuring synergy and cross-fertilisation of ideas wherever possible.

1.2 NA1: Management Activity

The primary management activity remains the co-ordination of the six major JRA projects, six complex and multi-activity networking activities, and an 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 formal management meetings were held, one of the OPTICON board, the overarching management body, and two of the smaller executive committee. These are detailed in the table below, with links to the minutes of these meetings. The project office, distributed between contractors nos. 1 and 2, provided support for these meetings, produced and circulated minutes, etc.

The Scientific Co-ordinator undertook long and complicated negotiations with the commission over the precise details of the financial sections of the 1st annual report. This extremely time consuming process included resolving open questions, correcting errors and misunderstandings, obtaining adequate audit certificates and resubmission of the report. Once the final issues regarding the payments for the 2004 spending, and the pre-financing for 2005 were resolved, the management team calculated the correct payments to be made to each contractor, including supplying the contractors with information on how the funds were to be allocated between work packages within each contractor.

Presentations on the overall OPTICON programme and on the trans-national access programme were made at the Joint European National Astronomy Meeting in Leige, Belgium as part of a special session on EC projects in astronomy which was co-organised by the OPTICON project scientist. These presentations (from all the projects) were placed on the OPTICON web page (http://www.astro-opticon.org/download/jenam_papers.html). Special efforts were made to promote the trans-national access programme, including visits by the project scientist to Bulgaria (Meeting Summary) and the national meeting of the Polish Astronomical Society in Wroclaw.

The Project Scientist participated in meetings of N2, N3.5, N4, N6.1, N6.3 and JRA5. He was in teleconference and e-mail contact with the leaders of all the other activities. He also participated in a review of the operations of Network N6.2 which resulted in further improvements to the operation of this already successful and highly regarded activity.

The project office continued to maintain and expand the OPTICON web site. The series of paper handouts were revised and distributed at appropriate events, such as the JENAM meeting mentioned above. Articles on progress with the project have appeared regularly in the newsletter of the European Astronomical Society.

The Project Scientist and Scientific Coordinator were in frequent contact with their

counterparts in RadioNet to share information and discuss common issues.

Participant number[1]	1a	2b	
Participant short name[2]	UCAM - IoA	PPARC - UKATC	**Total**
Person-months[3]	15 (9)	12.2	**27.2 (9)**

Meetings and Workshops

Date	Title/subject of meeting	Location	Number of attendees	Website address
27-28 October 2005	3rd Board meeting	Rome	22	http://www.astro-opticon.org/meetings.html
SB Feb 2005	3rd Executive Committee meeting	Zurich	12	http://www.astro-opticon.org/meetings.html
20 September 2005	2nd Executive Committee meeting	Leiden	11	http://www.astro-opticon.org/meetings.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] 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.

1.3 NETWORKING ACTIVITIES (other than Management)

1.3.1 NA2: Coordination and Integration of ENO facilities

1.3.1.1 Contractors:

Participant number[4]	7	2d	24	
Participant short name[5]	IAC	PPARC	Uni-Graz	
Person-months[6]	54 (12)	12	14 (12)	

The following contractors participated in these activities but are not charging staff effort to the project:

Participant number[7]	27	8f	25	43	17	20a	22	13	1b
Participant short name[8]	IOA-KUL	INAF - TNG	THEMIS	IFAE	KIS	RSAS	Utrecht Univ	NOTSA - NOT	UCAM - CAV
Person-months[9]	0	0	0	0	0	0	0	0	0

Other participants[10]***:***

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

1.3.1.2 Summary of Objectives and progress made:

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

WP1.1.: Dissemination of good practices: Two general NA2 meeting were organized in 2005, following the approval of the implementation plan. Attention was focussed on common setbacks of the different working groups. Basically, how they are managing activities without the corresponding advance payments and how to overcome possible delays with several deliverables/milestones.

In spite of the unfavourable cash flow situation, most of the NA2 activities initially planned for the first 24 months of the contract have been successfully carried out, as explained in this activity report.

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[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.

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

[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

WP1.2.: Laser Traffic Control System (LTCS) for ORM: Significant progress has been made in 2005; a Laser Traffic Control System (LTCS) as initially planned is taking shape.

Not only will the ORM system be compatible with the Keck/Hawaii system, but also complementary extensions to the software are being implemented, allowing incorporation of the ORM priority rules (these are different from the Hawaii rules). In fact, the implementation will be generalized in such a way that the priority rules can easily be adapted if needed in the future, and will also support multiple laser systems (i.e. WHT and GTC). Furthermore, the Keck system will be extended with a method to deal with non-sidereal motions of telescopes.

At the end of June 2005 the working group organized a coordination meeting in La Palma, where the LTCS was demonstrated, pointing out that the implementation for the ORM would allow different priority rules between telescopes, multiple lasers, non-sidereal tracking, and feature a collision prediction tool.

During the second half of the year, work was focussed in achieving the deliverables D2: Documented model for ORM geometry and D3: Document on site software requirements, as well as the development of several extensions to the software (see next section).

WP2.: Site Characterisation of the Canary Islands' Observatories: Continuous site-testing campaign of night-time properties at the Degollada del Hoyo Verde at the ORM, based on seeing and meteorological characterization.

A new technician has been recruited for the infrastructure needed to carry out a systematic day-time site characterization during the next years.

Meteorological parameters: air temperature and relative humidity at 2m, wind speed and wind direction, barometric pressure, soil and sub-soil temperature have been collected with a sample rate of 1 datapoint/minute. In August 2004 a rain gauge was installed on this site, providing the only pluviometry data at the Observatory.

The automatic procedure developed to derive turbulence profiles from SCIDAR measurements is being tested at the Observatorio del Roque de los Muchachos in La Palma, as a complement to the automated software to derive the velocity of the turbulence layers based on wavelet transforms.

Participation in the following forums: ELT Design Study Workshops at Nice in March 2005, SUCOSIP 2005 at Liverpool in May 2005 and ELT Design Study at Madrid in December 2005.

WP3.: Joint Information System and Transfer of Knowledge:

WP3.1.: Development of a Joint Information System for Solar Physics (JIS): Once the first version of JIS had been presented in a workshop organised at Instituto de Astrofísica de Canarias (April 2005), and after getting feedback and new ideas, the main goal was to present the programme to beta testers who checked the tool for several months. Some improvements were then implemented and a new version was launched and tested from July 2005 onwards.

As a consequence, the Joint Information System is now fully operative and the milestones and deliverables have been achieved. In order to maintain the website during the whole OPTICON project and to promote this tool, the working group will continue its role in this workpackage, focussing efforts on maintenance activities, the announcement to the whole solar physics community and presentation at appropriate forums/meetings.

WP3.2.: Co-ordinated actions on transfer of knowledge and public outreach:

Three meetings were organized in 2005. Among the ongoing actions we emphasize the following ones: Edition and distribution of Joint Brochures for the promotion of facilities at ORM & OT, collection of contents for a joint Public Outreach Website in order to improve the exchange and distribution of information related to the ENO facilities, Participation in the conference about Communicating Astronomy with the Public CAP'05 Munich, Open Days at ORM & OT during the summer, concerted visits in November (European Science Week) and the Airport touring exhibition which started in November 2005.

1.3.1.3. Achievements and their impact resulting from this activity during the reporting period

The general management of the whole NA2 activity, supported by the joint Website, has been properly carried out during 2005, including in such Website the most relevant documents generated during the first two years of the contract (minutes, schedules, working plans, promotional material, etc.).

WP1. Co-ordination of scientific communities at ENO:

WP1.1 Dissemination of good practices: The III NA2 meeting was held in Liverpool (May 2005) where it was informed that the amount of 2,7 M€ had been allocated to the IAC by the Spanish Ministry to carry out improvements of wide-band and high speed communications at ENO. The IAC is investing this financial support, as well as own contribution (1,1 M€), during the period 2005-2007. The wide-band at ORM has been increased from 2 Mbs to 34 Mbs at the beginning of May 2005.

Moreover, international funding opportunities have been identified at European level by request of the Public Outreach working group. Basically, these calls (under the Science & Society Programme) are focussed on the promotion of public scientific and innovation culture, and with the aim of increasing the impact of science and its uses on the daily lives of European citizens.

The IV NA2 meeting was held in La Palma (October 2005), where it was emphasized that special efforts should be made to assess the different workpackages of NA2, in order to guarantee progress of the NA2 activities in spite of delays in the receipt of the advance payments. Particularly, it was decided that the JIS WG (WP. 3.1.) will continue its participation in OPTICON for the promotion and the maintenance of the website until the end of the OPTICON contract.

WP1.2: A co-ordinated Laser Traffic Control System (LTCS) for the ORM: The first deliverable "Document on hardware specifications" was achieved in May 2005 and presented in the III NA2 meeting (Liverpool, May 2005).

The 3D-model of the ORM site has been completed. Accurate coordinates for all telescopes have been measured and verified, and have been incorporated into the software model.
The original version of the LTCS was extended to support non-sidereal observations.
The priority rules between telescopes have been formally agreed by the observatory operations committee. These rules specify that the telescope which is first on target will have priority. For special cases (e.g. targets of opportunity) exceptions can be made.

The original version of LTCS was modified to support the above rule, but also different rules that may evolve in the future. This constitutes a major enhancement of the software over deployment at other sites. The software has also been made robust for the future of the multiple lasers at the ORM. The embedded rules are:

1. The laser will always be shuttered in case of conflict. This is the original implementation.
2. The laser will always be shuttered in case of conflict with a telescope without a laser, but in the case of laser-laser beam collision the telescope first on target has priority.
3. The first telescope on target has priority, independent of whether or not a laser is used. This will be the default implementation at the ORM.
4. A more complex but completely configurable rule which allows setting of specific priorities for each laser and telescope.

The original version of the LTCS was extended to include a simulation tool. This simulation tool gets as an input a target for a telescope and identifies whether there will be a collision with any other the telescope. This tool will be accessible as a web service and resulted from requests from other users in order to allow careful planning to minimize negative impact of the use of lasers.

The original version of the LTCS was extended to include a scheduler tool. This tool gets as input the target coordinates of a laser and of another telescope and together with a given date and time for a planned observation returns whether there will be a collision or not. This scheduler will be implemented as a web service - work is in progress.

ORM Geometry: Satellite picture on which are projected the coordinates measured for each facility at the Observatory.

The error analysis from the original LTCS was improved to better reflect altitude errors. Several other small bugs in the original software were corrected as well.

The web pages of the LTCS have been written to be able to support changes for the new features of the LTCS.

A CORBA server was created for the LTCS. This is the way the LTCS is going to communicate with the system software at the WHT, and in particular will facilitate automatic shutdown of the laser in case of conflict with other telescopes.

The LTCS was modified to run under Linux and to start as a service, using High Availability technology.

A java programme was implemented to get the pointing information from the WHT Telescope Control System and a DRAMA task was implemented to get the pointing information from the INT Telescope Control System.

The Software requirements document has been also delivered at the end of 2005.

WP2. Site Characterization at the Canary Islands' Observatories:
WP2.1 Co-ordination of night-time seeing measurements with DIMMs: Continuous site-

testing campaign at the Degollada del Hoyo Verde at the ORM based on seeing and meteorological characterization.

DIMMA will be protected by a clam-shell dome.

New corrected software have been implemented for the SBIG CCD camera.

Cross calibration with instruments providing seeing values at the ORM (IAC DIMM- RoboDIMM and SCIDAR) between October 2004 and June 2005 have been performed and results will soon be published.

The DIMMA is now almost finished and will be delivered during 2006 (installation and testing of elements to be linked in the DIMMA).

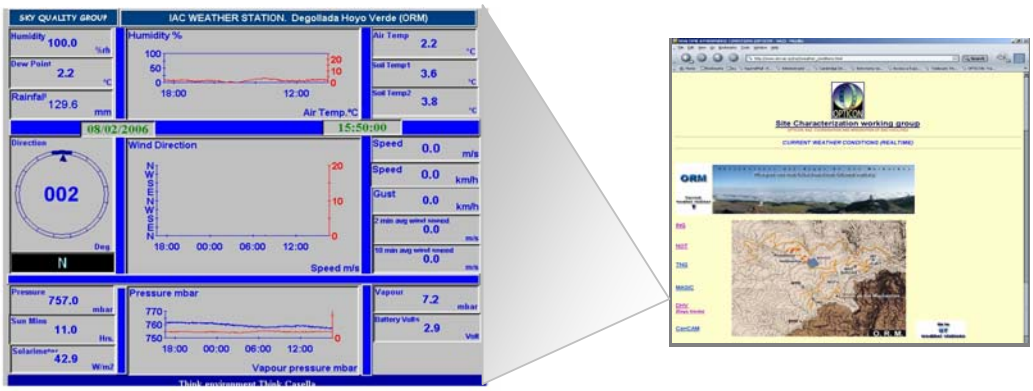
WP2.2 Co-ordination of day-time seeing measurements at Teide Observatory (OT):
A technician was recruited in 2005 to take responsibility for the infrastructure needed to carry out a systematic day-time site characterization. Up to date no statistical data of seeing measurements are available for OT. Current data for OT are based on individual measurements. An S-DIMM and a Scintillometer array are being mounted in order to provide the database presently lacking for OT.

WP2.3 Joint actions for meteorology, dust, extinction and Sky Background:
Meteorological parameters: air temperature and relative humidity at 2m, wind speed and wind direction, barometric pressure, soil and sub-soil temperature have been collected with a sample rate of 1 datapoint/minute.

IAC and TNG dust particle counter data have been compared in a calibration campaign developed at the TNG.

Routine measurements of the sky background at ORM

Based on the pilot experience carried out by the Office for the Protection of the Quality of the Sky (OTPC), the IAC's support astronomers Group(IAC-SA) and the IAC's Sky Quality Group in obtaining monthly data of the sky background at the Teide Observatory (OT) a new working group was set up to apply the same routine programme developed for the OT at the ORM. The data analysis and results will be performed jointly by the IAC-SA, the OTPC and telescope operators at the ORM, and will be also available at: http://www.otri.iac.es/na2/weather_conditions.html. This website is a common platform which provides direct access to current weather conditions (realtime) at the Canary Islands observatories. A total of nine weather stations are included in this new website, the IAC weather station being the most recent to be included in this common online tool.

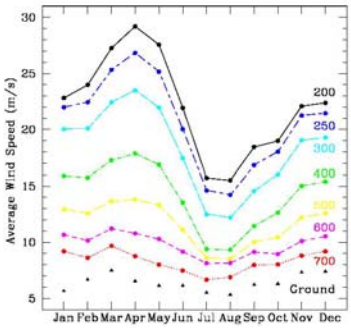


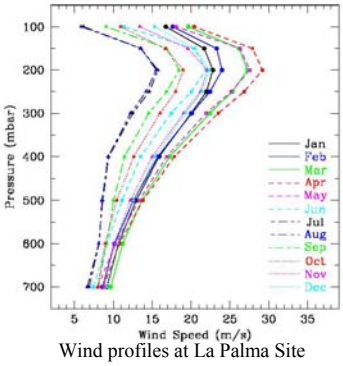
DHV / Hoyo Verde weather

WP2.4 Joint actions for Measurement of turbulence and wind vertical profiles (SCIDAR, GSM & DIMM): Participants in this workpackage are testing the automatic procedure developed to derive turbulence profiles from SCIDAR measurements, at the Observatorio del Roque de los Muchachos in La Palma.

They also have developed new and completely automated software to derive the velocity of the turbulence layers based on wavelet transforms.

Concerning the analysis of the wind vertical profiles, the work was focussed in comparison of several parameters at five sites (La Palma, La Silla, Mauna Kea, Paranal and San Pedro)





Wind profiles at La Palma Site

The main conclusions obtained are the following:

- High level of correlation between high and low altitude winds
- High level correlation between ground and low level winds
- Ground wind roses depends on the topography with different daytime and nightime behaviour
- Clear seasonal behaviour of winds and strong differences in the wind vertical profile behaviour at the five sites.
- If the V* to V200mbar relationship exists elsewhere, it should be similar at Paranal, La Silla, San Pedro Mártir and La Palma
- The V200mbar statistics indicates that La Palma is the most suitable place for AO implementation

WP2.5 Distribution and discussion of results and participation at the scientific forums:
Representatives of the working group have participated in the following forums:

- ELT Design Study Workshops at Nice in March 2005.

Participants: ESO, UNI, IAC.

- SUCOSIP 2005 at Liverpool.

Participants: institutions presented at the ORM.

- ELT Design Study at Madrid in December 2005.

WP3. Joint Information System and Transfer of Knowledge:
WP3.1 Development of a Joint Information System (JIS) on European Solar Physics

Facilities:

The first version of the JIS tool was finished in March 2005. An open workshop was organised at Instituto de Astrofísica de Canarias, a few days after the second coordination meeting of the group, to know the opinion from several solar physicists about the usefulness of this new tool and to improve it accordingly.

Main goal was to present the tool to the other members of this project to get their feedback and new ideas. Some improvements have been already implemented. Other solar physicists, outside this working group, were also invited to participate. Some of them have agreed to cooperate for the validation of this tool to find possible weak points and to give a new point of view concerning the handling of the data.

Progress made under the JIS activity was presented in Liverpool during the NA2 general meeting. May 2005

A JIS brochure was edited and distributed among the European Solar Physics Community. June-September 2005

The JIS tool was launched online with the following URL: http://www.solarJIS.com, being hosted at the IGAM servers.

During summer work was focussed in the following tasks:

- Contact and collaboration with beta-testers.
- Introduction of the use by means of a handbook.
- Update of the JIS website layout.
- Announcement to the whole solar physics community and presentations at appropriate forums and meetings.
- Sending the brochures to European solar physics institutes.

WP3.2: Co-ordinated actions on transfer of knowledge and public outreach: Three coordination meetings were organized in 2005 (*Feb. [La Palma], May [La Laguna] and Nov. [La Palma]*) by this working group.

5th Coordination Meeting Public Outreach. November 2005

A diverse set of public outreach activities has been proposed by member of the working group with the aim of strengthening the scope of this activity. In this way, a long-term plan for public outreach activities has starting to take shape in 2005 and will be developed during 2006.

The following activities planned for 2005 were successfully accomplished:

(1) Installation of a permanent panel at the OT in order to display detailed info of the observatory facilities. (The corresponding one at the ORM will be installed shortly)
(2) Edition and distribution of Joint Brochures for the promotion of facilities at ORM & OT (3000 copies of 21 double-pages in English and Spanish version)
(3) Collection of contents for a joint Public Outreach Website in order to improve the exchange and distribution of information related to the ENO facilities.

(4) Participation in the conference about Communicating Astronomy with the Public (CAP'05), Munich, Jun'05

(5) Promotion of the Deep Impact mission through out the Radio Programme Canarias Innova (www.canariasinnova.es), organization of talks in the Science Museum of Tenerife and publication of latest news on the NA2 website.

(6) Open Days at Teide Observatory focussed in solar physics in July 22nd and 23rd .

(7) Open Days at the Roque de los Muchachos Observatory during the month of July 05. It was planned four days of visits were planned, each Saturday of July except the 16th.

(8) Thematic visit to the ORM, focussed on the scientific output and the "hot topics" as part of the collaboration with the Environmental University of La Palma which will organize a course of Astronomy (25th –31st July 2005). Also, concerted visits under the European Science week in November 2005.

(9) Organization of a touring exhibition, inaugurated in La Palma airport, with 13 astronomical images as well as a poster with general description of the Canary Islands' Astronomical Observatories (OT and ORM). November 2005.

(10) TO BE DISTRIBUTED DURING 2006: Edition of an Outreach Bulletin, planned as a 15-page journal-style handout of "news and articles" about astronomy and astrophysics related to the ENO facilities. The idea is to foster the dissemination of the science carried out at ENO among the general public.

1.3.1.4 Deviations from the work planned in the last detailed implementation plan.

Deviations associated with specific work-packages:

WP2. Site Characterization at the Canary Islands' Observatories:
WP2.1: Co-ordination of night-time seeing measurements with DIMMs: Almost all of the activities initially planned in this workpackage have been carried out during 2005. An anticipated campaign using a Generalized Seeing Monitor (GSM) at the ORM was not carried out, given that it was impossible to bring this instrument from the Nice University (GSM's owner). Since this facility is unique, and required elsewhere world-wide for other site surveys, the working group decided to withdraw this (non-essential) deliverable.

Concerning the DIMMA, and due to the late arrival of OPTICON funds, it was possible to carry out this urgent development by optimised cash-management of the IAC's whole Opticon budget (139000 EUR). This prevented any postponement of the whole activity.

Some other planned activities which are less time-critical will be re-phased. This will be reported accordingly in the future.

WP2.3 Joint actions for meteorology, dust, extinction and Sky Background: The installation of the Automatic Weather Station (AWS) depends on the time required to pass the administrative proceedings. It is expected that this Milestone will be achieved in the first four months of 2006. The Automatic Weather Station (AWS) already tested by the working group is pending local government planning authorization to install it at the proposed site.

The METEO and WEB network planned as a deliverable for month 22 has not been set up as initially expected. In spite of sharing data to use a common database, institutions (NOT, ING, TNG, Mercator) agreed on the development of a joint platform (website) providing information about their stations, with direct access to the several database available: http://www.otri.iac.es/na2/weather_observatories.html

1.3.1.5. Milestones and Deliverables achieved:

Name of deliverable/milestone	Activity (NAx; JRAy)	Work-package /Task	Delivered by Contractor(s)	Planned (in months)	Achieved (in months)
D1. Updated Progress report and revised roadmap	NA2	WP1.1 Dissemination of good practices.	IAC	24	24
M1: Regular ENO meetings	NA2	WP1.1 Dissemination of good practices.	IAC, IOA-KUL, INAF, THEMIS, IFAE, UCAM, Jodrell Bank.	16	17
M1: Regular ENO meetings	NA2	WP1.1 Dissemination of good practices.	IAC, IOA-KUL, INAF, THEMIS, IFAE, UCAM, Jodrell Bank.	22	22
M2: Meetings among telescope operators	NA2	WP1.2: A co-ordinated Laser Traffic Control System (LTCS) for the ORM	PPARC, IAC, IOA-KUL, IFAE, NOTSA, INAF	14	18

D1: Document on hardware specifications	NA2	WP1.2: A co-ordinated Laser Traffic Control System (LTCS) for the ORM	PPARC	14	17
D2: Documented model for ORM geometry	NA2	WP1.2: A co-ordinated Laser Traffic Control System (LTCS) for the ORM	PPARC	14	20
D3: Document on site software requirements	NA2	WP1.2: A co-ordinated Laser Traffic Control System (LTCS) for the ORM	PPARC	20	23
M1 Automate monitor DA/IAC	NA2	WP2.1: Co-ordination of night-time seeing measurements with DIMMs	IAC	12>>	12>>
D1. Report: Systematic measurements of seeing & meteorology	NA2	WP2.1: Co-ordination of night-time seeing measurements with DIMMs	IAC, INAF, PPARC, NOTSA	24	25
M1 Systematic measurements using a DIMM	NA2	WP2.2 Co-ordination of day-time seeing measurements at Teide Observatory (OT)	IAC	16>>	18>>
M1 Scintillation measurements	NA2	WP2.2 Co-ordination of day-time seeing measurements at Teide Observatory (OT)	IAC	16>>	18>>
D1: Annual report on measurements of extinction and dust	NA2	WP2.3 Joint actions for meteorology, dust, extinction and Sky Background	IAC	24	24
D2: Annual report on stations already existing	NA2	WP2.3 Joint actions for meteorology, dust, extinction and Sky Background	IAC	18	20
D1. Report on techniques to get wind profiles	NA2	WP2.4 Joint actions for Measurement of turbulence and wind vertical profiles (SCIDAR, GSM & DIMM)	IAC	24	24
D1. Annual report on discussion forums for site-selection	NA2	WP2.5 Distribution and discussion of results and participation in the scientific forums	IAC	24	24
D1: Draft proposal for design and contents of Central Site	NA2	WP.3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities.	IGAM, IAC,	14	14
D2: Final prototype/version of the tool	NA2	WP.3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities.	IGAM, IAC,	18	19
D3:Report on new institutions interested in JIS	NA2	WP.3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities.	IGAM, IAC,	22	22

D4: System fully operative	NA2	WP.3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities.	IGAM, IAC,	20	22
D5: FINAL REPORT: JIS	NA2	WP.3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities.	IGAM, IAC,	24	24
M3: Workshop	NA2	WP.3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities.	IGAM, IAC,	16	16
M4: Open Announcement	NA2	WP.3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities.	IGAM, IAC,	20	21
M1: Open-doors days at OT and ORM	NA2	WP3.2: Co-ordinated actions on transfer of knowledge and public outreach.	IAC, PPARC, INAF, IOA-KUL, IFAE	20	20
M2: Distribution of new editions	NA2	WP3.2: Co-ordinated actions on transfer of knowledge and public outreach.	IAC, PPARC, INAF, IOA-KUL, IFAE	18	18
D1: New editions of outreach material	NA2	WP3.2: Co-ordinated actions on transfer of knowledge and public outreach.	IAC, PPARC, INAF, IOA-KUL, IFAE	16	17, 20
D2: ENO website. Final design operative	NA2	WP3.2: Co-ordinated actions on transfer of knowledge and public outreach.	IAC, PPARC, INAF, IOA-KUL, IFAE	17	24
D3: Annual report on ENO website and public outreach	NA2	WP3.2: Co-ordinated actions on transfer of knowledge and public outreach.	IAC, PPARC, INAF, IOA-KUL, IFAE	24	24
D4: Programme of activities for the next event	NA2	WP3.2: Co-ordinated actions on transfer of knowledge and public outreach.	IAC, PPARC, INAF, IOA-KUL, IFAE	16	23
D5: Exhibition elements and educational material	NA2	WP3.2: Co-ordinated actions on transfer of knowledge and public outreach.	IAC, PPARC, INAF, IOA-KUL, IFAE	18	23

1.3.1.6. Meetings and Workshops table

WP1.1 Dissemination of good practices

Name of Meeting	Date and Location	Web address
Third ENO meeting	Liverpool, 26th May 2005	http://www.otri.iac.es/na2/
Fourth ENO meeting	La Palma, 5th October 2005	http://www.otri.iac.es/na2/

WP1.2 A co-ordinated Laser Traffic Control System (LTCS) for the ORM

Name of Meeting	Date and Location	Web address
Coordination meeting	La Palma, 23th June 2005	http://www.otri.iac.es/na2/
OSC meeting	La Palma, September 2005	http://www.otri.iac.es/na2/

WP2 Site Characterisation of the Canaries Observatories

Name of Meeting	Date and Location	Web address
SUCOSIP Meeting	Liverpool, 26th May 2005	http://www.otri.iac.es/na2/ http://www.iac.es/gabinete/cci/index.html
XI National Conference of Teledetección	Tenerife, 21-23rd September 2005,	http://www.xicongtel.ull.es/
ELT Design Study	Niza 29-March 2005	http://www.otri.iac.es/na2/
ORM - MASS meeting	Tenerife, June 2005	http://www.otri.iac.es/na2/
WP12000 Progress Meeting,	Madrid, 1-December-2005	http://www.otri.iac.es/na2/

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

Name of Meeting	**Date and Location**	**Web address**
Coordination meeting	Tenerife, 25th April 2005,	http://www.otri.iac.es/na2/
Solar Physics Section of European Phys. Society, SPM 11	Leuven, 11-16 Sep. 2005	http://wis.kuleuven.be/cpa/finalannouncement.php?
Seminar	France, Univ Toulouse/Tarbes, 26.9.2005	http://www.omp.obs-mip.fr/omp/Pic/
Seminar, Coordination, Central European Solar Archive	Hvar Observatory/Univ of Zagreb, 12.19.8. 2005	http://www.geof.hr/oh/
Seminar	Univ Zagreb, 2.12.	http://www.geof.hr/oh/
Name of Workshop	Date and Location	Web address
Testing the JIS	Tenerife, 28th April 2005,	http://www.otri.iac.es/na2/

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

Name of Meeting	**Date and Location**	**Web address**
III Coordination meeting	La Palma, 5th February, 2005	http://www.otri.iac.es/na2/
IV Coordination meeting	Tenerife, 16th May, 2005	http://www.otri.iac.es/na2/
V Coordination meeting	Tenerife, 15th November, 2005	http://www.otri.iac.es/na2/

1.3.2 NA3: Structuring European Astronomy

Participant number	2	
Participant short name	PPARC	**Total**
Person-months	4.74	4.74

Considerable efforts have been put into these activities by many contractors and other persons, however, only two individuals are charging effort to the project.

WP1: ELT

The objective of N3.1 is to develop the science case for an Extremely Large Telescope (ELT). The network involves over 100 astronomers from around Europe. Since the 2004 annual report the following activities have been carried out or are underway.

Production of a top-level brochure (24 pages) summarising the science case for a 50-100m ELT. The Brochure was printed and released in February 2005. It has been widely distributed

A small sub-meeting to develop the "Galaxies and Cosmology" section of the science case. This was a one-day meeting held in Munich on 13April 2005, involving 8 members of the OPTICON ELT Science Working Group.

Production of a full ELT science case document (about 150 pages). 3000 copies were printed and 3000 CDs were made. This was released as hardcopy in July 2005 at the EU Astronomy press day in Dwingeloo, NL and is also available for download on the web site. This document corresponds to WP1 D2.

A summary article was written for the ESO messenger based on the above documents. This appeared in the September issue (vol 121 p2-10).

Planning of and attendance at the IAU symposium on Scientific requirements for ELTs, held in Cape Town, November 2005 (see http://www.saao.ac.za/IAUS232/). Many members (over 20) of the OPTICON science group attended, (not all charging costs to the network) and this replaced the European ELT science case meeting for 2005 (WP1 M1). It provided an opportunity to exchange ideas and results with those working on other ELT projects around the World and it was an extremely interesting and productive meeting. The proceedings will be published by Cambridge University Press (CUP) in print and on-line.

Continued close interaction with the European ELT Design Study. Six Members of the OPTICON ELT working group (in addition to the Design Study Project Scientists) attended a meeting on Adaptive Optics requirements for ELTs in Florence, May 2005.

The web site for the OPTICON ELT Science WG, is (http://www-astro.physics.ox.ac.uk/%7Eimh/ELT/) where details of the meetings and draft science cases can be found.

WP2: Network for UV Astronomy (NUVA)

The objectives for the Network for UltraViolet Astronomy are:

- 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.

WP1: An instrumentation meeting was held in Madrid, 17-18 November, to discuss/summarize the characteristics of the instrumentation required from the science case articles. Two aspects were analyzed in detail:

1. The target spectral features. This is required to tune the instruments sensitivity to them and guarantee the optimal detection conditions for them. Also a first set of target lines for narrow band imaging were identified.

2. Time resolution - requirements to track flares and outburst.

The major conclusion is that the most needed UV capability is high resolution spectroscopy ($\Delta/\Delta\lambda = 50{,}000$) in the 950-3200 Angstrom range.

The article summarizing the results of the meeting is being prepared under the coordination of Norbert Kappelmann (IAAT, Tuebingen) and will be included in the White book of UV astronomy. Attendees: Norbert Kappelmann, Martin Bartsow, Isabella Pagano, Noah Brosch, Francisco Najarro, Rosa Gonzalez and Ana I Gomez de Castro

WP2: The UV science case book is, in press. The book will be entitled: "Fundamental problems in astrophysics: Guideline for future UV observatories" and be published by Astrophysics & Space Science/Kluwer-Springer (Vol 302). This book represents the draft of the "White book" for UV astronomy.

WP3 D2: NUVA web site has been established (www.ucm.es/info/nuva) . The web is handled by a contents manager so it works as an instrument for publication/interaction among the disperse UV community.

WP3: High Time Resolution Astrophysics (HTRA)

No expenses have been reported in 2005, since most of the communication related to WP3 has taken place by e-mail and direct contacts in conjunction with activities in JRA3.

The HTRA working group met at NUI Galway in October 2005. The plans for the HTRA network activities were presented at this meeting. The main activity was a discussion for the preparation of a 'white book' on HTRA in June 2006. This has provisionally been titled 'Astrophysics in the 4th dimension', with a proposed selection of about 20 reviews, prepared in the course of a meeting of invited experts. Different subject and topic headings were discussed at the meeting, along with suggestions for invited speakers.

WP4: Astrophysical Virtual Observatory (AVO)

This was the final year of the Astrophysical Virtual Observatory (AVO) project. The third and last AVO demonstration was held on January 25 - 26, 2005, at the European Space Astronomy Centre (ESAC; previously known as VILSPA), near Madrid, concurrent with a

meeting of the AVO Science Working Group (SWG) (full details available at http://www.euro-vo.org/twiki/bin/view/Avo/AvoDemo2005). The demonstration dealt with an extragalactic case on star formation histories in galaxies and with a Galactic scenario on the Asymptotic Giant Branch (AGN) to Planetary Nebulae (PN) transition. Both cases, and in particular the stellar one, were put together with input from the AVO Science Working Group (SWG). This year the stellar case was the strongest one on the science side, and lead to the discovery of nearly 100 candidates in the post-AGN - young PN transition, increasing by about 50% the number of already known such (rare) sources. A paper describing these results is being written (Bayo, Garcia-Lario, Sierra, et al.).

New features, compared to last year's demonstration, included: the ability to run galaxy evolution models in a VO context, building of a Spectral Energy Distribution (SED) on-the-fly (VOSpec [ESAC]), various improvement to the AVO prototype [CDS], including multi-image/multi-wavelength display, an image cut-out service, direct SIMBAD and Vizier queries, and a new version of SpecView [STScI]. The concepts of MySpace (management of user's own space in the VO) and workflows (the possibility of running time-consuming processes remotely and using scripts; ASTROGRID) were also demonstrated, as well the usage of new IVOA standards on registries (high-level directories of astronomical catalogues, data archives, data-providing organizations, and computational services) and Web services (which allow any astronomical software to be "wrapped" and accessed through the VO).

The AVO project is now formally concluded. Links to various documents and to the software download page can be found at http://www.euro-vo.org/twiki/bin/view/Avo/. The AVO successor is the EURO-VO project, which will build the Virtual Observatory in Europe.

WP5 : Key Technologies Network

No time was booked to the Key Technologies Network by the participants apart from PPARC in their role as the Key Technologies Network administrator. Travel and subsistence costs were claimed by some of the participants.

Network Overview

The principal objectives of the Key Technology Network (KTN) are to identify key technology needs, look for opportunities which technology developments in other sectors provide for astronomy, encourage European collaborative technology development projects, and provide a forum for discussing potential routes for further development.

The scope of the Key Technology Network:

- The focus of the KTN activities will be *enabling* technologies
- The KTN will support the development of facilities (telescopes) as well as instruments
- The core activity of the KTN will be in the wavelength region 300 nm to 35 μm.
- The KTN will support a balanced portfolio of low risk and high risk technology developments
- The KTN should support the integration of telescope and instrument test facilities.

The following astronomy technologists have agreed to support the core KTN team of 14 by becoming associate members of the OPTICON key technologies network.

Participant	Organisation	Participant	Organisation
Eli Atad Ettedgui	UKATC	Derek Ives	UKATC
Roger Haynes	AAO	Fabio Bortoletto	Univ Padua
Gert Finger	ESO	Norbert Kappelmann	Univ. Tubingen
Graham Peggs	NPL	Michael Redfern	Univ. Galway
Jeremy Allington Smith	Univ Durham	Christian Erd	ESA/ESTEC
Michael Andersen	Max Planck	Gunther Wiederman	Univ. Hamburg
Pierre Kern	LAOG	Lars Venema	Univ Leiden
Klaus Strassmeier	Univ Innsbruck	Peter Hastings	UKATC
Remko Stuik	Univ Leiden	Roland Lemke	Ruhr University
Lorenzo Zago	CSEM	David Walker	Zeeko / UCL
Eric Prieto	LAM	David Robertson	Univ. Durham
Jean Gabriel Cuby	LAM	Roland Bacon	CRAL
Enzo Brunetto	ESO	Nick Waltham	RAL

The first overview KTN roadmap resulting from activities in 2004 has been completed and posted on the open TWIKI website. This covers areas of detectors, adaptive optics, cryogenics and general instrument technology.

A major industry workshop was held in Rome on 20/21st October 2005 on the Challenges for Optics posed by Extremely Large Telescopes. With 25 participants from companies and universities throughout Europe, the meeting was split into four sessions – large optics, metrology, new materials and innovative properties, and smart focal planes. The major conclusion from the meeting was that improved metrological systems are required in order to take advantage of new ways of manufacturing free form optics. Roadmaps for the 4 sessions are available alongside presentations on the TWIKI. A combined paper covering the meeting is in the process of being written.

WP6: Future Software

Contractors:
Although the Working Group has been very active, all work has been done on a volunteer basis and no effort has been charged to OPTICON. The following contractors have all contributed effort to this work package: ESO, PPARC, ESA, RDS, NOVA, INSU/CNRS, NOTSA, INAF.

Summary of Objectives and progress made:

Scope and objectives for WP 6 were defined in 2004 and are available on the Twiki based Web site at URL: http://archive.eso.org/opticon/twiki/bin/view/Main which is also used for exchange of ideas and proposals. Monthly phone meetings were held to ensure that all members are updated on discussions (minutes are on the Twiki). Detailed high-level requirements were drafted and discussed at the Second Face-to-face meeting held at ESO,

June 2005. This resulted in a list of around 185 explicit requirements for a future astronomical software environment (see Twiki) An architectural concept was also brought forwards and accepted as the basis for further work. This includes overall structure of and parsing of information within the environment. For a future environment to succeed, it is essential that not only a European consensus is achieved but also a community wide agreement is reached. Thus the Third Face-to-face meeting was arranged just before ADASS 2005 conference in Madrid, Spain, to enable representatives for major non-European organization to join. During this meeting ideas were exchanged with other groups such as NRAO, ALMA, STScI, Gemini, and NVO. General agreement was reached on the drafts of both requirements and architectural concept.

The architecture was presented as a poster at ADASS 2005. Also a Bird-of-Feather session was arranged in which more than 70 people participated. There were significant interest and the importance of defining a future software environment for astronomical data analysis was generally recognized especially considering the recent reduction of support for important legacy system like IRAF and Starlink.

The milestone M2 was achieved as a result of detailed discussions of the draft high-level requirements at the Second Face-to-face meeting. They are posted on the URL: http://archive.eso.org/opticon/twiki/bin/view/Main/DetailedHighLevelRequirements

A draft of high-level requirements was agreed on after intensive discussions both within the Network and with representatives for major North-American organizations (e.g. NRAO, STSci, Gemini, NVO).
The work done by the Network on architecture was presented at the ADASS 2005 meeting (both as a poster and in a Bird-of-Feather session) for a wide group of people in the area of astronomical software development. This significantly increased the awareness in the community of the work done by the Network. The need for defining a future astronomical software environment was conceived as very important for the community.

Milestones And Deliverables Achieved During The Reporting Period

Activity	Deliverable/ Milestone No	Deliverable/Milestone Name	Work-package /Task No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
NA3	M1	ELT Science Meeting (Cape Town)	WP1	PPARC	23	23
NA3	D2	Science Case Document	WP1	PPARC	30	18
NA3	M4a	Conference Planning Meeting	WP3	NUIG (was MPG)	21	22
NA3	M1	Circulate Technology Roadmap	WP5.1	UKATC	18	20
NA3	M3	Hold Industry Workshop	WP5.2	UKATC	18	22
NA3	D1	Progress Report	WP5.1	UK ATC	24	24
NA3	M2	Draft High level Requirements	WP6	ESO, PPARC, ESA, RDS, NOVA, INSU/CNRS, NOTSA, INAF	18	18

Major Meetings And Workshops Organised During The Reporting Period

Date	Title/subject of meeting /workshop	Location	No. of attendees	Website address
13/04/05	Galaxies and Cosmology WG	Munich, Germany	8	See details in text
May 2005	ELT Design Study Meeting on Adaptive Optics	Florence, Italy	6	See details in text
14 - 18/11/04	WP1 OPTICON ELT Science meeting at IAu symposium	Cape Town, SA	20	http://www-astro.physics.ox.ac.uk/~imh/ELT/
17 – 18/11/05	WP2 NUVA Meeting	Madrid	7	See details in text
20/10/05	HTRA Network Meeting	Galway, EI	9	See details in text
25 – 26/1/05	WP4 AVO Demo	ESAC, Madrid	60	http://www.euro-vo.org/twiki/bin/view/Avo/AvoDemo2005
24 – 28/5/04	WP4 Interoperability Meeting	Boston, USA	74	http://www.ivoa.net/twiki/bin/view/IVOA/InterOpMay2004
27 – 29/9/04	WP4 Interoperability Meeting	Pune, India	85	http://www.ivoa.net/twiki/bin/view/IVOA/InterOpSep2004
20 – 21/10/05	Optics for ELTs	Rome	30	https://ssl.roe.ac.uk/twiki/bin/view/Optikeytec/MeetingPresentations
23/06/05	Second face-to-face meeting	ESO, Garching, Germany	9 + (6 external)	http://archive.eso.org/opticon/twiki/bin/view/Main/FaceToFaceMeeting20050623
29/09/05	Third face-to-face meeting	Madrid, Spain	8 + (9 external)	http://archive.eso.org/opticon/twiki/bin/view/Main/FaceToFaceMeeting2005930

1.3.3 NA4: Mechanisms for synergy in space-ground coordination

OPTICON network N4 was set up to develop proposals to enhance synergies between space and ground-based astronomy. Under this umbrella, two activities are currently underway:

- **Scientific Support**: to analyze the situation regarding scientific support for exploitation of European space- and/or ground-based astronomical infrastructures, and to propose mechanisms to improve situation by (a) reinforcing competitiveness of the European astronomical community in front of the international competition and (b) supporting groups carrying out "key" programmes.
- **Test Facilities**: to make a census of the unique test facilities developed by European institutes and laboratories for astronomical space and ground instruments/experiments and to identify facilities/capabilities that need to be developed to support the test and calibration of the next generation of instruments.

It has been decided to drop the "Elite Fellowships" idea that was part of the original discussions for this network. As necessary, additional initiatives relevant to space-ground synergy can be started.

After the general meetings held in early 2005, coordinators met with a few key persons to discuss in details if European networks could effectively help with the questions raised and what could be the structure and organization of two networks to be proposed within the framework of the FP7 to fulfill the goals outlined above.

These meetings were held in ESTEC on November 23-24th 2005. It was concluded in both cases that proposals for two networks should be prepared. The basic content was outlined in the meetings and a schedule for drafting white papers detailing the rational and structure of these networks was set.

The drafts were written and circulated.

Meetings and workshops

	Date	Title/subject of meeting /workshop	Location	No of attendees	Website address
1	23/11/2005	Synergy meeting	Nordwick, NL	5	N/A
2	24/11/2005	Test Facilities meeting	Nordwick, NL	5	N/A

1.3.4 NA5: Interferometry forum

Participant number[11]	Participant short name	Person-months[12]
12	NOVA	1 (0.5)
21b	ULg	1 (0.5)
34	NCU/UMK	0.5

Although the group has been very active, limited staff efforts (Table N5.1) have been charged to the project. Mostly travel and material cost have been charged to the project.

The European Interferometry Interferometry Web-site that contains the most up to date information about the European Interferometry Initiative (EII) activities and the Network Activities (www.strw.leidenuniv.nl/~eurinterf) has constantly been updated.

1.5.1.1 Fizeau exchange visitors programme

New announcements of the Fizeau Exchange Visitors Programme have been widely distributed through relevant mailing lists, web-pages (http://www.strw.leidenuniv.nl/~eurinterf), and direct mailing. A poster with the announcement was printed and has been mailed to a long list of astronomical institutions in Europe.

On 15 March (call 2005A) and 15 September (call 2005B) 2005 two new application rounds for the Fizeau Exchange Visitors Programme were closed. The applications were reviewed by the Network Board and suitable candidates were identified. This has resulted in two series of exchange visits (Table N5.2).

Applicants name		**Home country**	**Host country**	**Host city**
First	**Last**			
2005A				
Olivier	Absil	Belgium	France	Paris
Emmanuel	di Folco	France	France	Bordeaux
Davide	Fedele	Italy	Germany	Garching
Lucas	Lara	Spain	UK	Cambridge
Martin	Netolicky	Czech Republic	France	Nice
Poncelet	Anne	France	Netherlands	Leiden
2005B				
Askari	Ghasempour	Portugal	France	Limoges
Mario	Gai	Italy	Israel	Haifa
Tomasz	Laczkowski	Poland	France	Nice

[11] Lead participant first

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

WP2 Strategic Coordination

Three working groups had been established in 2004. These were: "Interferometric scientific council", "Radiative transfer", and "Atmospheric modelling". Each of these working groups was convened at least once during the year 2005. The latter two groups were merged by request of the group members because of a large overlap in their scientific scope. A new working group on "Interferometry and asteroseismology" was established in 2005 and met for the first time in November in Porto.

Scientific Council

The "Scientific Council" met on 04 April 2005 in Garching and on 09 Sep 2005 in Prague. The representatives (one for each participating country and the two international organisations ESO and ESA), who were elected in 2004, continued to serve on the Scientific Council.
Minutes of the meetings have been compiled and distributed.

Country	Member	Status
Austria	Josef Hron	
Belgium	Jean Surdej	
Switzerland	Didier Queloz	
Czech Republic	Pavel Koubsky	
Germany	Thomas Henning	President
Spain	Carlos Eiroa	
France	Christian Perrier	
United Kingdom	David Buscher	
Hungary	Lajos Balazs	
Italy	Mario Gai	
Israel	Erez Ribak	
Netherlands	Eric J. Bakker	Deputy-president
Poland	Andrzej Niedzielski	
Portugal	Paulo Garcia	
ESO	Guy Monnet	
ESA	Malcolm Fridlund	Observer

Table: N5.3: participants of working group "EII scientific council".

The "radiative transfer" and "atmospheric modelling" working group met a few times by teleconference. It was decided to merge these two groups because of the large overlap in scientific interests. Members of this working group are listed in Table N5.4.

Participant	Home country	Home city
Romain Petrov	France	Nice
France Allard	France	Lyon
Renaud Foy	France	Lyon
Frederic Thevenin	France	Nice
Thomas Beckert	Germany	Bonn
Jo Bruls	Germany	Freiburg
Armando Domiciano	Germany	Bonn
SebastianWolf	Germany	Heidelberg
Philippe Stee	France	Nice
Krzystof Gesicki		
Andreas Quirrenbach	Netherlands	Leiden

Paulo Garcia	Portugal	Porto
Margarida Cunha		
Berhard Aringer		

Table: N5.4: participants of working group "Radiative transfer" and "Atmospheric modelling".

1.5.1.3 Next-generation interferometric infrastructure

The proceedings of the first workshop on next-generation interferometers, which had taken place in Liège in 2004, appeared in print ("Science cases for Next Generation Optical/Infrared Interferometric Facilities", edited by J. Surdej, D. Caro, & A. Detal). The second study group meeting took place on 04 to 08 July 2005 in Liège, in connection with the JENAM conference. Building on the discussions of the science case for a next generation interferometric facility, which had taken place in 2004, the 2005 meeting was devoted to the identification of the most important technical issues. In total, some 50 participants were actively involved during the Liège workshop. The workshop consisted of general presentations summarizing concepts for future interferometric facilities and specific technology needs. Contributed talks and posters were part of the programme. The main topics discussed during the Liège workshop were:

- Perspectives for next generation ground- and space-based interferometers (O. Absil & D. Mawet)
- Complementarity between space and ground-based interferometry (V. Coudé du Foresto & S. Ridgway)
- Scientific requirements for space interferometric missions (M. Fridlund)
- A high-level technical overview of prototype and first-generation optical arrays (D. Buscher)
- Cophasing and Fringe Tracking for future interferometers (M. Gai, D. Bonino, L. Corcione, D. Gardiol, M.G. Lattanzi, D. Loreggia, G. Massone, S. Menardi, E. Ribak)
- Long baseline beam transport (G. Perrin)
- Concept of a pupil densification assembly using optical fibers (F. Patru, D. Mourard, O. Lardière, A. Spang, J.M. Clausse, P. Antonelli, Y. Bresson, S. Lagarde)
- Single mode beam combination for interferometry (P. Kern)
- Algol-CPNG: The new generation photon counting cameras for visible interferometry (A. Blazit, E. Thiébaut, F. Vakili, L. Abe, A. Spang, J.-M. Clausse, D. Mourard, X. Rondeau)
- Arrays with a wide field of view combination (A. Quirrenbach)
- Reconfiguration of 8m class telescopes (M. Kraus)
- Synergies between interfacing a future generation interferometer and ELTs (F. Delplancke)
- Using interferometry to achieve high dynamic range imaging (S. Lacour & G. Perrin)
- The Large Binocular Telescope Model Extrapolated to ELTs (T. Herbst)
- Future optical very long baseline interferometers : the OVLA model – a well-populated array (F. Vakili)
- Arrays without delay lines (V. Borkowski)
- Direct imaging: the natural choice for cophased interferometry (F. Martinache & O. Lardiere)
- Site considerations for the next generation of optical arrrays: Mid-latitude sites versus Antarctica (M. Sarazin)
- Perspective of Interferometry in Antarctica (B. Lopez, F.X. Schmider, F. Vakili, E. Aristidi)
- AT telescopes at Dome C (O. Pirnay)
- Aladdin on the road to Darwin (V. Coudé du Foresto)
- EC proposal for FP7 and research infrastructures in astronomy (P. Moschopoulos)
- General conclusions (A. Quirrenbach)

Conference proceedings, including a final and detailed report summarizing the main conclusions of this workshop are in press.

A web-site is maintained for the workshop: http://www.eso.org/gen-fac/meetings/vltiws05/

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	13	15&21
M3	Collate list of applicants	1	NCU	14	16&22
M4	Selection of exchange visitors	1	NCU	16	16&22
D1	Report from participants	1	NCU	24	24

Table N5.5: milestones and deliverables for interferometry forum during 2005

Milestone WP1.M2, WP1.M3, and WP1.M4 occur twice in the year 2005 since applications for the Fizeau Exchange Visitors Programme were accepted every 6 months.

Meetings and workshops

	Date	Title/subject of meeting /workshop	Location	No. of attendees
1	8 Apr 05	Working Group "Scientific Council"	Garching	20
2	4-8 Jul 05	Technology Roadmap for Future Interferometric Facilities	Liège	50
3	09 Sep 05	Working Group "Scientific Council"	Prague	16
4	30Nov – 02 Dec 05	Working Group "Interferometry and Asteroseismology	Porto	40

Table N5.6: overview of meetings.

1.3.5 NA6: OPTICON Telescope Network

Participant number	7	
Participant short name	IAC	**Total**
Person-months	27 (24)	27 (24)

WP1 : Telescope Directors Forum

Although this group has been very active, no staff effort has been charged to the project. The group is chaired by the Project Scientist whose time is accounted to management effort. The telescope directors' time, mostly preparation for, travel to and participation in the director's forum, is not charged to OPTICON but to their national programmes.

The second year's programme has been dominated by managing the success of the access programme (which was very over-subscribed), carrying out a review of the operation of the Trans-National Access office (WP2) and preparing the peer review process for the accession of two new telescopes. The Access Office review was carried out by a 'splinter group' nominated at the last full meeting of the telescope directors. This group solicited input electronically via a questionnaire and visited the IAC, host of WP 6.2, for a face to face meeting. The review concluded that the team had set up an excellent system, that standards of work was very high but that, as the project entered it routine phase, some economies were possible. The conclusions of the review were transmitted to the full meeting of the telescope directors at its Paris meeting, and then to the OPTICON executive and board who welcomed them. In addition a panel was been set up to oversee the accession of the Liverpool Telescope and the Aristarcos Telescope into the Access programme. A conformance matrix for this process has been prepared and circulated.

This group's major meeting was in Paris in September. As well as the above mentioned Access office review other topics discussed were the per review process for two telescopes hoping to joint the access programme, and the possibility of developing common applications forms and procedures. (Meeting Minutes).

In May Chairperson John Davies visited Bulgaria to meet the teams responsible for the operation of the National Rhozen observatory and to promote the Access programme. A visit summary is linked from the OPTICON web page (Meeting Summary). In July Jesus Burgos summarised the Trans-national Access programme at the JENAM meeting and November the Access programme was presented to the Polish National Astronomy Meeting in Wroclaw by John Davies.

WP2: Operation of the Trans-National Access Office

The purpose of the Access Office is to promote the execution of the OPTICON Trans-national Access Programme, guaranteeing a dynamic communication among the bodies and communities involved. To do that, the Access Office has devoted a human effort of 27 person-months in 2005. During this year the Access Office has become a key node between telescope operators, the OPTICON Project Office, the Telescope Directors' Forum, and users.

During 2005 an 18-months Review of the Access Office was carried out by a Panel of Experts appointed by the Telescope Directors' Forum. The overall conclusion of the Panel was that the

"Access Programme is highly appreciated by the astronomers who make use of it. The general management of the Access Office certainly contributes to this satisfaction. The directors of the telescopes involved in the programme are pleased with the level of support delivered, the database and web are well thought of, the user feedback is positive, and reports to EU and TDF are of good quality. The quality of the effort provided by the IAC up to mid 2005 is appreciated".

The Panel considers also that the underlying system is now in place, new staff are now introduced and trained, so the operation could be streamlined in the light of experience. Their conclusions and recommendations have been considered by the implementation plan for the future activity of this Office.

Apart from the assistance provided to the Telescope Operators in the fulfilment of their obligations, the following achievements and their impact resulting from this activity during 2005 can be outlined here:

1. Operation and management procedures
The Access Office has designed two detailed procedures to guarantee the highest quality in providing its services to the astronomical community:

The Telescope Operators' procedure is intended to provide a coherent way of communication with each Telescope Operator to achieve the common Access Programme's goals.

By means of the Users' procedure, the Access Office interacts with those astronomers supported under the Programme, to provide information, to check eligibility, management of travel and subsistence grants, feedback, questionnaires, etc.

2. Database powered website of the Access Programme

One of the key elements for the management of the Access Programme has been the common web platform (http://www.otri.iac.es/opticon/) developed in 2004 and improved in 2005 for sharing relevant information, application forms, reports, documents, statistics, etc.

3. Publicity for the Trans-national Access Programme
As a complement of the publicity made through the website of the Access Programme (and through the OPTICON site), a set of publicity actions has been planned and carried out during 2005:

General publicity: participation in conferences, info days, meetings, etc

Specific Publicity: announcements of opportunity

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

Beyond the daily operation and promotion of the Access Programme, the Access Office is carrying out an important effort to accomplish EC 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 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 awarded time under the OPTICON Telescopes during 2004 and 2005.

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

4.5 Analysis of procedures for awarding time.
Current situation and possible scenarios for a better coordination and optimisation of telescope time.

The Access Office carried out a specific study about the procedure for awarding time at telescopes under the OPTICON Access Programme.

Gathering all this information is contributing to analyse those synergies between the different selection procedures, setting up the bottom line to discuss the approach that could be achieved in benefit of the astronomical community.

Milestone for this WP, as defined by the contract, has been successfully achieved. Likewise,

several deliverables to be provided to the Telescope Directors' Forum was issued in April 2004, and updated in September and November, to include details on those observing runs carried out late 2005:

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

WP3: Enhancement

A first meeting of the enhancement working group was held in Padua. Topics discussed included:

Raising awareness of science career opportunities amongst young people

Keeping the new generation of post-doctoral astronomers abreast of issues concerning the development of new instrumentation in the era where most new instruments are built by large teams to 'facility' requirements with few opportunities for giving practical experience to visiting or service mode users.

Various OPTICON sponsored experts attended the (separately funded) NEON observing school in Calar Alto Observatory (Spain)

The leader of the WP3 activity organised, with the support of the International Astronomical Union, a symposium devoted to the confrontation of the scientific requirements for Extremely Large Telescopes (ELTs) with the technical possibilities. Over 20 OPTICON scientists attended this world-wide event (see Section NA3-WP1), where all major ELT projects were presented.

Milestones and Deliverables

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Task No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
M2	2nd Directors Forum	WP1	PPARC	22	21
M3A/B	Peer review of Aristachos and Liverpool telescope	WP1	PPARC	21	Postponed to 2006
M4	Review of Access Office	WP1	PPARC	21	21
M5	Plan Mid term review of Access programme	WP1	PPARC	22	22
D1	Produce audio-visual material on access programme	WP2	IAC	21	Rescheduled to 2006
D2	Document on Time allocation procedures	WP2	IAC	21	23
D3	Additions to web pages with information about publications and conferences	WP2	IAC	18	Underway at background priority
M2	2nd Report to Directors forum	WP2	IAC	24	15 (preliminary report) 18 (1st update) 24 (2nd update)
Deliverable complementary to M2	Analysis of procedures for awarding time	WP2	IAC	12	23
M1	Working group kick-off Meeting	WP3	CNRS,IAP	6	17

Meetings and workshops

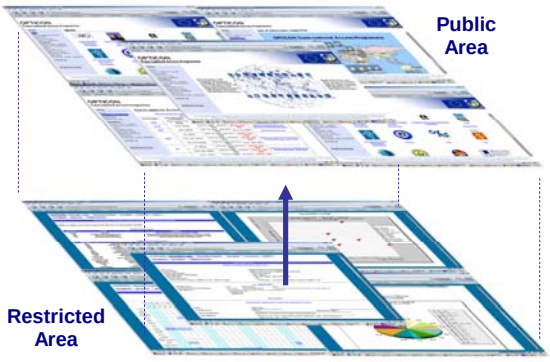
Date	Title/subject of meeting /workshop	Location	No of attendees	Website address
23 May 2005	Kick off Meeting of Enhancement WG	Padua, Italy	8	Agenda and details
30/31 August 2005	Access Office review meeting	La Laguna, Tenerife, Spain	7	See Report to executive and board meetings
14-15 September 2005	Telescope Directors Forum meeting	Observatoire de Paris France	24	Minutes

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

During 2005, a set of promotional measures have been taken to ensure appropriate dissemination of this opportunity for Access under the auspices of this EC contract. In this way, the Trans-national Access Programme has been widely publicised among the international scientific community, specially for new users and European young researchers.



The Trans-national Access Programme homepage (http://www.otri.iac.es/opticon/), developed as a common platform (for users, telescope managers and Access Office) has consolidated as the main reference for relevant information, application forms, reports, sharing of information, documents, statistics, etc.

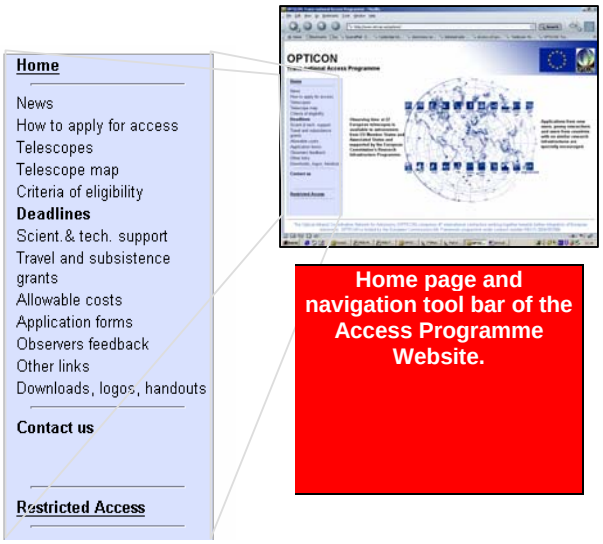
As noted elsewhere in the report on network NA6, various visits and presentations have been made across Europe.

Public Area

The Public area of the website was set up in order to provide detailed advise and assistance concerning the OPTICON Access Programme to those users interested in this joint infrastructure initiative.

This website has been set up using PHP language and MySQL management database. Specifics libraries to generate PDF files as well as graphics (JPGraph) are used as a complement of this.

The main homepage presents the 22 telescopes involved in the Access Programme, encouraging specially new users, young researchers and users from countries with no similar research infrastructures to apply for observing time.



By means of a detailed menu, the user has access to a brief description of each telescope (Location, instruments, full address, funding sources, etc.), a guideline on how to apply for access, which criteria of eligibility apply, how to get a travel and subsistence grant and what are the allowable costs.

This information can be printed on standard templates for all the telescopes and, mainly, for all the information can be obtained through this site (standard headers, OPTICON logo, etc.)

Another important element of the public website is the section where the updated deadline of each telescope is available as well as a direct link to the corresponding announcement of opportunity and application form. In addition, a complete contact list of scientific and technical support is at their disposal, guaranteeing the most suitable level of advice for users.


TRANS-NATIONAL ACCESS PROGRAMME
OPTICAL INFRARED CO-ORDINATION NETWORK FOR ASTRONOMY
www.astro-opticon.org

CANADA-FRANCE-HAWAII TELESCOPE

Location: Mauna Kea, Hawaii, USA

Property: National Research Council Canada, Centre National de la Recherche Scientifique (CNRS), University o

Operated by: CFHT Corporation

Operation since: 1979

Phone: 1 (808) 885-7944 Fax: 1 (808) 885-7288

Email: director@cfht.hawaii.edu Web Page: http://www.cfht.hawaii.edu

Full address: Canada-France-Hawaii Telescope Corporation 65-1238 Mamalahoa Hwy Kamuela, Hawaii HI 96743 USA

Description: It is a 3.6-meter optical Ritchey-Chretien telescope with an equatorial mount and prime and Cassegrain focus instruments.

Its main instrumentation is made of MegaPrime, a prime focus equipped with a CCD mosaic (MegaCam), a set of Gregorian filters, tip/tilt guiding and correctors, offering a 1deg(deg field with a 0.15" pixel resolution, and of a suite of Cassegrain instruments: an Imch IR imager, CFHCIR, a fiber-fed high resolution spectrograph, Gecko, a multi-object spectrograph, MOS, and an adaptive optics bimorph. Plans, installed at the Cassegrain focus, equipped with an infrared 2inch camera (IR) or receiving visible instruments.

In 2005, WIRCam, a wide IR camera with four 2inch Hawaii-2RG detectors, will offer a 20'x20' field of view with a 0.3" pixel resolution and allow to complement in the IR some of the MegaCam observations. A new Echelle spectrograph and polarimeter, ESPaDOnS, should be available by the end of 2004.

All wide-field observations are made in Queued Service Observing and are processed by the CFHT staff. Therefore, programs on MegaCam (and later WIRCam) do not require any travel to the observatory.

Further Details: http://www.cfht.hawaii.edu

How to apply for access: Application forms and further information can be found at the internet link provided.

--A

RELEV" http://cadcwww.hia.nrc.ca/proposal/deadlines.html" http://cadcwww.hia.nrc.ca/proposal/deadlines.html>>

More information: http://www.cfht.hawaii.edu/OnLine/ObservingProposals/

Funding sources: Centre National de la Recherche Scientifique, France, National research Council, Canada, Institute for Astronomy, Hawaii

PDF file generated for each telescope

As a complement of 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 of the Access Programme.

Those users awarded time under the OPTICON Access Programme are provided with a login and password, and they can access to many parts of the restricted-access area. They are allowed to download all the forms related to their observing run, or to complete them on-line:

- Information on the user group (members, PI, etc)
- Application form for travel and subsistence support
- Project Summary Report
- User Questionnaire
- Observers feedback
- Acknowledgement text

Restricted-access Area

The information accessible through the public area is automatically powered and updated by the restricted area. This area allows also the management of the programme and observing runs awarded under OPTICON, providing appropriate tools for the cross-correlation of information like composition of user groups, telescopes, grants, payments, statistics, etc.

Three different levels of access are established to entry into this area:

Level 1: OPTICON Users

Level 2: Telescope Operators

Level 3: Access Office and administrator of the system.

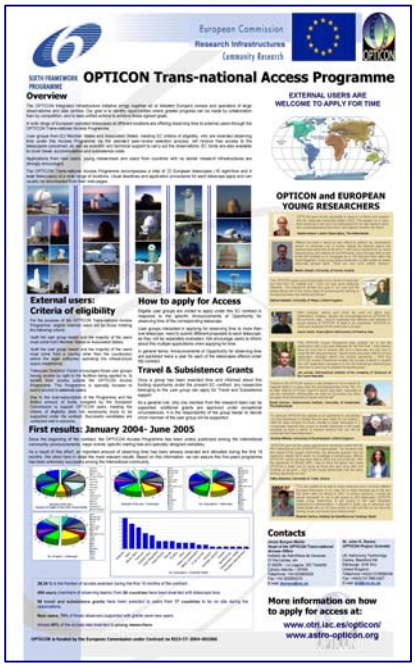
Promotion of the Trans-national Access Programme at other Websites:

Likewise, information about the Access Programme can be found on the corresponding web sites of each of the 22 participant telescopes. Each observing campaign is there widely advertised. 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 of the publicity made through the website of the Access Programme (and through the OPTICON site), a set of publicity actions has been planned and carried out during 2005:

General publicity: participation in conferences, info days, meetings, etc

Further efforts in advertising this Programme were made at the Joint European and National Astronomical Meeting –JENAM 2005 (Belgium, July 04-07). Oral presentations about the Access Programme and about how to apply for time were offered. Preliminary results from the first 18 months of this contract were also shown. Handouts were made available during the conferences and posters summarising the Programme were exhibited.



Poster presented at JENAM 2005

Specific Publicity: announcements of opportunity

Announcements of Opportunity are normally published twice a year in each Telescope Operator website as well as via extensive distribution to the international astronomical community. In addition, the Trans-national Access Office has sent by post (April 2005, October 2005) a general advertisement of the Programme to more than 550 entities (universities, research institutions, observatories and other RTD organisations from EU Member States and Associated States). This announcement included a summary of the scope of the Programme and information on how to participate. A special effort was made to inform researchers from Central and Eastern Europe.

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), 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 scored 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 mainly 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[13] must satisfy the following conditions:

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

The first years of the programme were very oversubscribed so in order to prioritize applications from actual external users (especially 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.

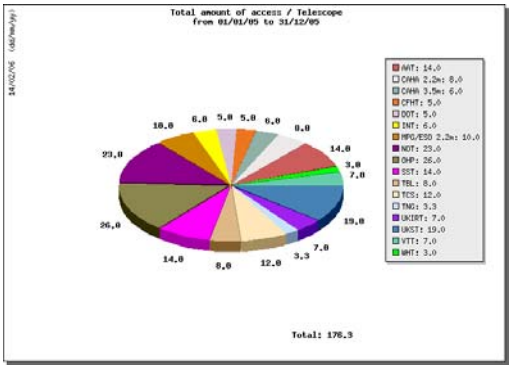
User groups meeting EC criteria of eligibility, and awarded telescope time by these TACs, are informed by the Trans-national Access Office (located at Instituto de Astrofísica de Canarias, Spain) about this funding opportunity. They receive full information about how to apply for travel and subsistence 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.

[13] **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.

1.4.1.3 Trans-national Access activity

Amount of Access delivered:

12,22 % of the total amount of access to be provided under this five-year contract has been delivered in 2005. This amount was actually well below the number of qualifying proposals but support was rationed to avoid massively overspending the available budget. This means 176,3 days/nights/hours and a total of 486,8 days/nights/hours in the first two years of the contract (33,74 %).



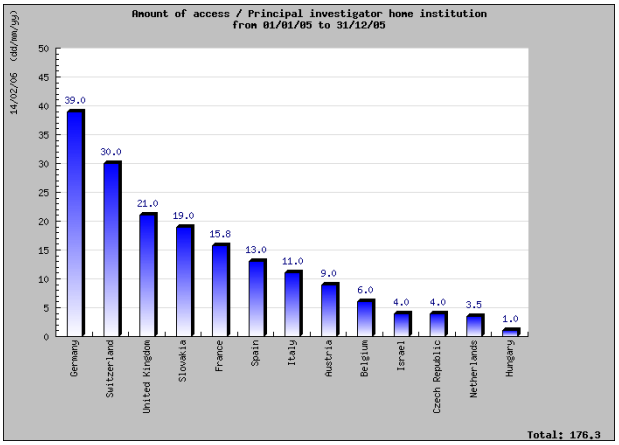
The OHP 1.93m Telescope (Observatoire de Haute Provence) and the Nordic Optical Telescope (NOT), are those telescopes which have delivered the most observing time during 2005 (26 and 23 nights respectively).

All telescopes offering time under the contract in 2005 have received a significant number of applications and all of them have contributed to reach this total amount of 170 days/nights awarded.

User groups and projects awarded with time:

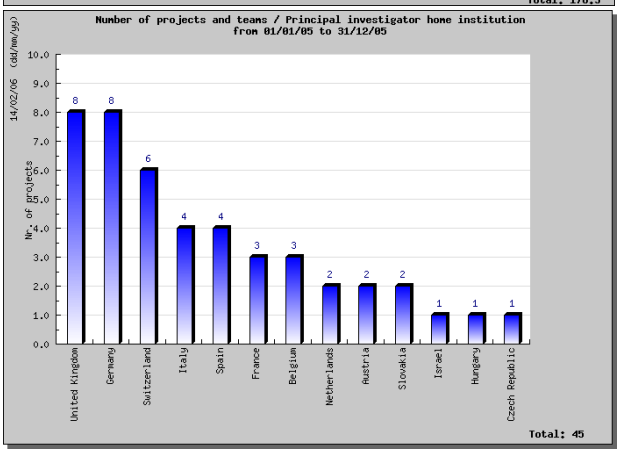
We provide here detailed information about the number of days/nights offered under the contract per country of origin of the group leader.

It should be noted that the amount of observing nights awarded to users groups led by an astronomer working in Slovakia has increased more than 100% (*from 8nights in 2004 to 19nights in 2005*) while in most of the countries the values are lower than in 2004 due to the limited number of nights affordable within the allocated budget.

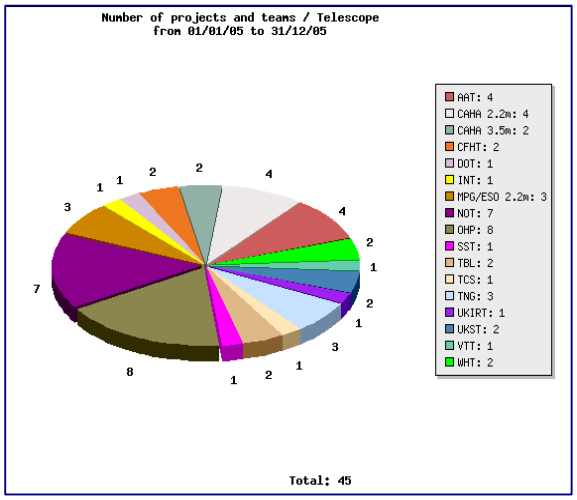


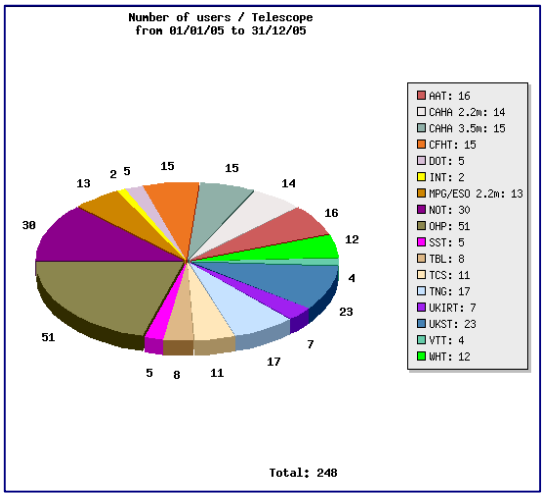
45 user-projects have been awarded time in 2005. 8 of these user-projects have been carried out at the OHP and 7 at NOT.

More detailed information about these user-projects can be found in Annex 3 of this report.

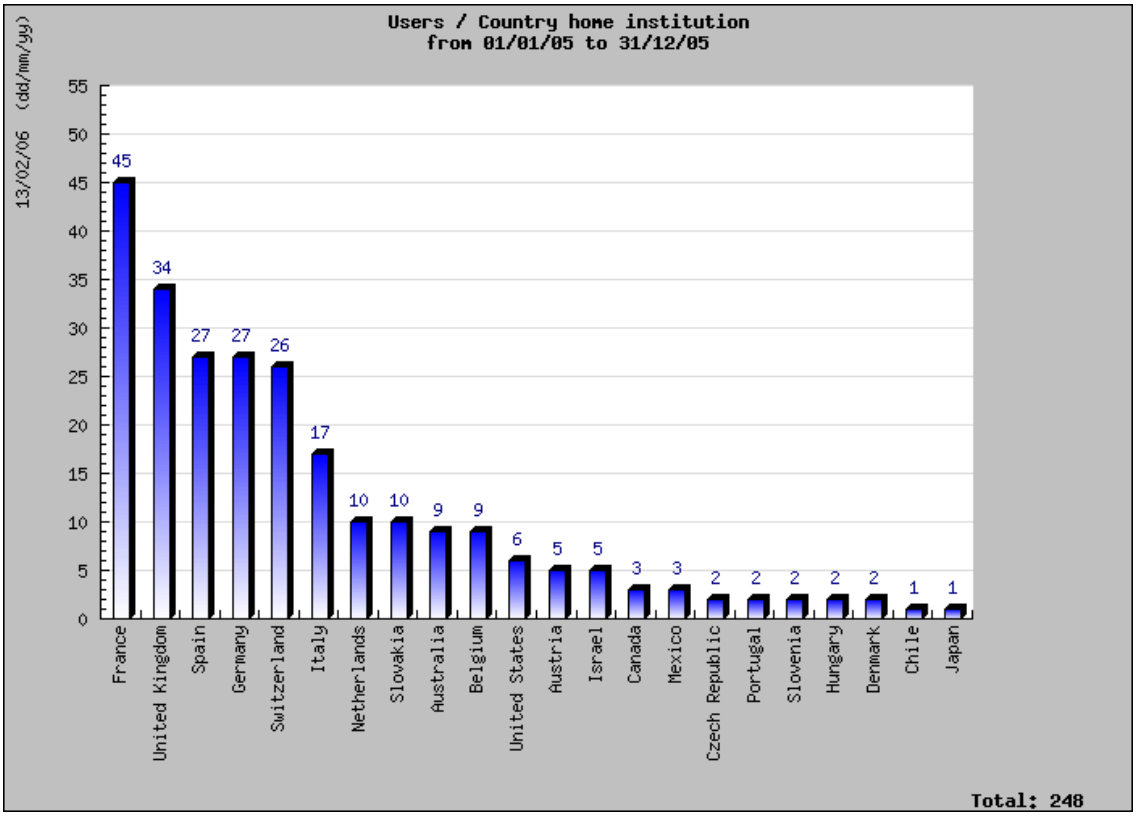


Statistics on users awarded with telescope time:
248 users from 22 different countries have benefited from this Access Programme during this period (members of the user groups). 42 % of these users were awarded observing time at three telescopes: NOT, OHP and UKST.





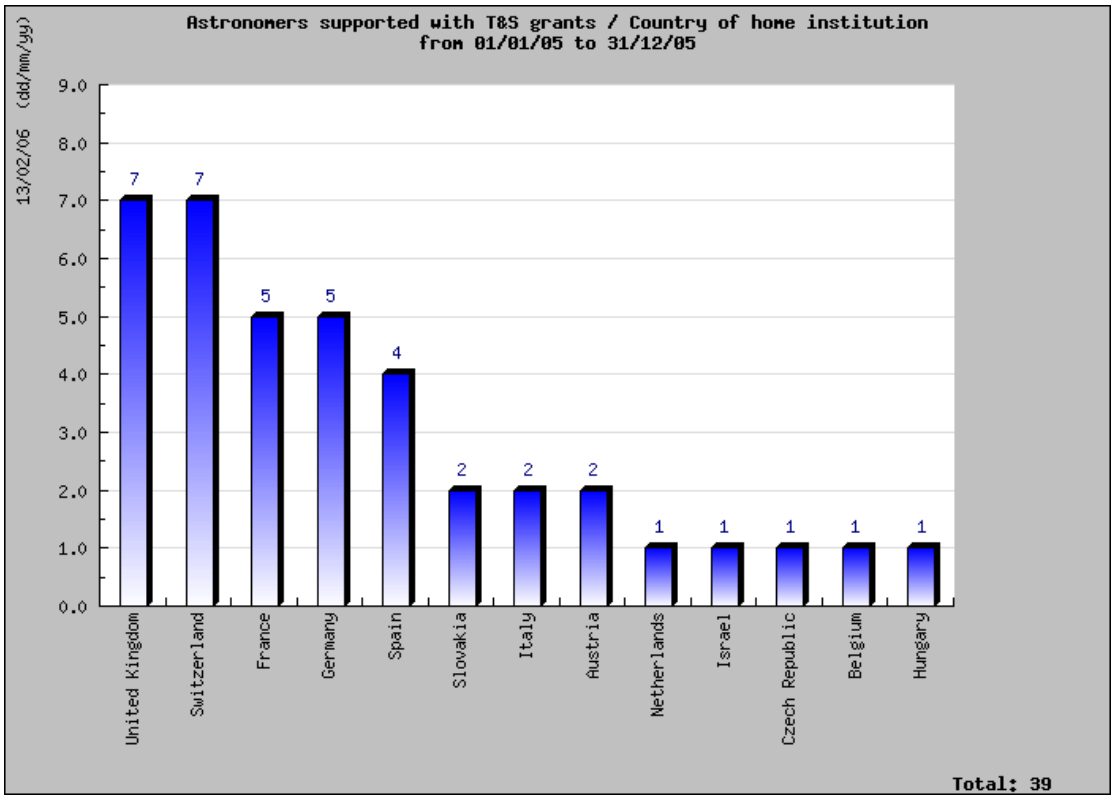
France, UK, Spain, Germany and Switzerland were those EU countries involving most users. (*see next figure*)



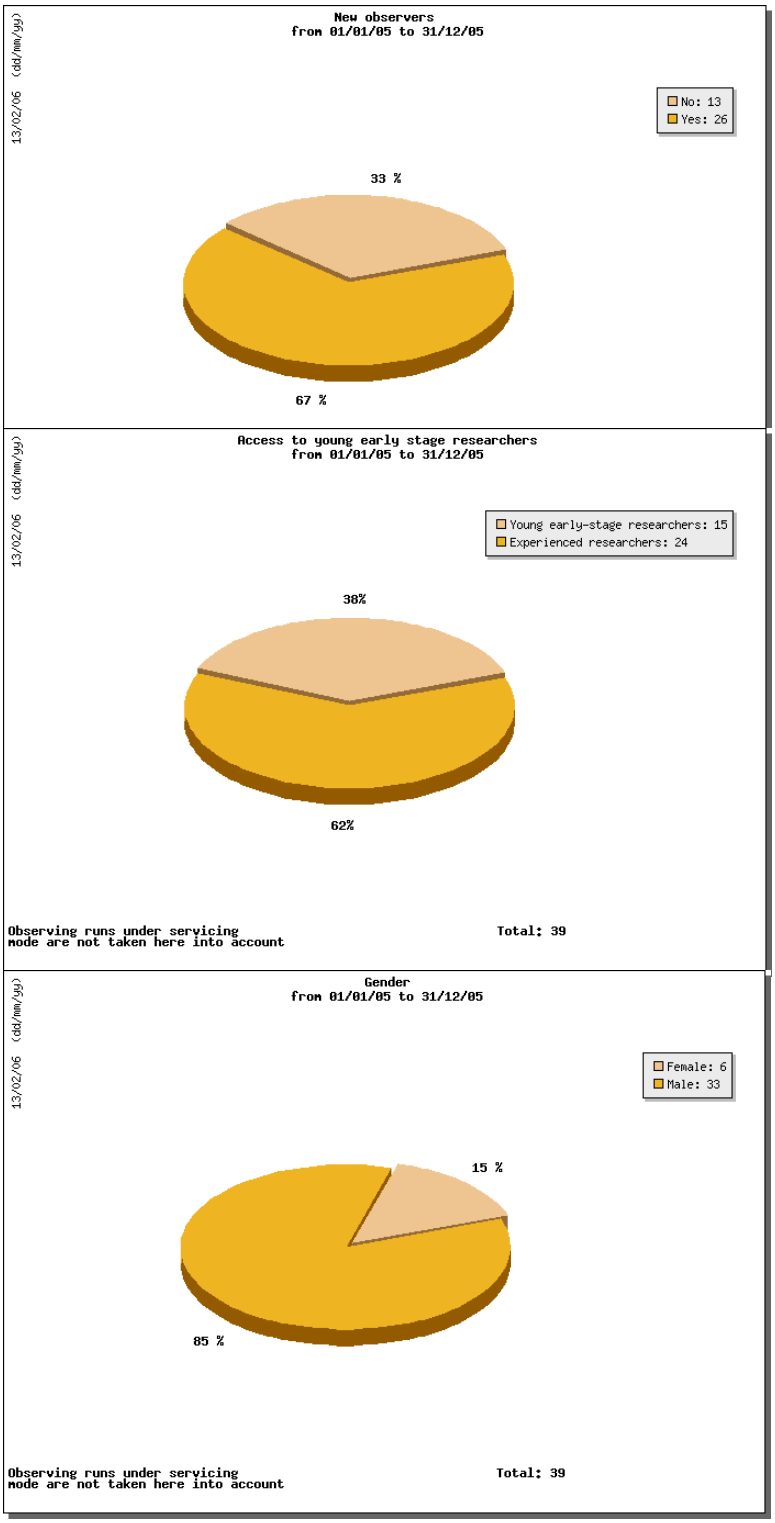
Travel and subsistence grants:

39 of these 248 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:



More than 66% of these visiting astronomers were new observers, and 38 % were young-early stage researchers[14]. The gender ratio among users with T&S grants is 15% female and 85% male



14 **Young-early stage researchers** are those users supported with T&S grants that have less than four years of research experience.

1.4.1.4 Scientific output of the users at the facilities.

During 2005 users have been periodically contacted to collect relevant publication/presentation arising from their observations. In addition, the Access Office is monitoring those relevant newsletters and astronomy bulletins that could include articles arisen from OPTICON supported observing runs.

Although it is considered too early to deliver a first report on ''Scientific Output'', taking into account the average amount of time needed to process astronomical data, during 2005 the Access Office started working in the establishment of an adequate procedure to gather this information from users.

See Annex 5

1.4.1.5 User meetings

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

1.5 JOINT RESEARCH ACTIVITIES

1.5.1 JRA1: Adaptive Optics

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

Participant number[15]	4	6	8b	11a	12	19	31	35	
Participant short name[16]	ESO	INSU/CNRS	INAF-Arcetri	MPIA	NOVA	GRANT ECAN	ONERA	Univ Durham	**Total**
Person-months[17]	111,18	55,42	30,4	23,28 (14,16)	24 (12)	4,58	19,96	20,73 (…)	**289,55**

WP 1: Coordination of JRA1

The management (**ESO**) of the JRA1 has been actively solicited in 2005 for the contract negotiations and preparation of Technical Specifications/Statement of Work of Adaptive Optics key components (Piezo deformable mirror, Thin Zerodur shell, Drive electronics for deformable mirrors, MOEMS, wavefront sensor CCD, Deformable Secondary Mirror).

The JRA1 web page has been maintained by ESO to disseminate the information and reports produced in the frame of this JRA (http://www.eso.org/projects/aot/jra1/). Some documents are password protected. Monitoring of the FTE and HW expenditure is now in place and effective.

A General meeting 2 was organised by ESO in July 2005 at INAF in Firenze. Regular teleconferences between the principal work package managers have been organised. Strong interaction between JRA1 and JRA2 has been maintained by **ESO** for the design review of the Adaptive Optics CCD detector, specified in the frame of JRA1 and developed in the frame of JRA2.

WP 2: System design

WP2.1: XAO system Study

Following the 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, **ESO** has 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 has submitted a consolidated instrument concept (see figures) and a strong coherent system and project management to **ESO STC** in October 2005. Documentation presenting efforts of the two former Consortia towards these goals including an executive summary (attached) has been produced. STC recommended to the ESO Council

[15] Lead participant first

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

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

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 now-called VLT SPHERE project (standing for Spectro-Polarimetric High-Contrast Exoplanet Research) has successfully been able to accrete 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. Furthermore the SPHERE is now considered as an important cornerstone for the High contrast imaging of the next generation of European Extremely Large Telescope.

Apart from the Phase A studies the OPTICON funded activities directly related to SPHERE have been pursued in particular:

- Selection by **ESO** of **CILAS** (France) for the development of the 1370 actuator deformable mirror **WP 3.3**. Contract has been signed and design review was passed in October 2005

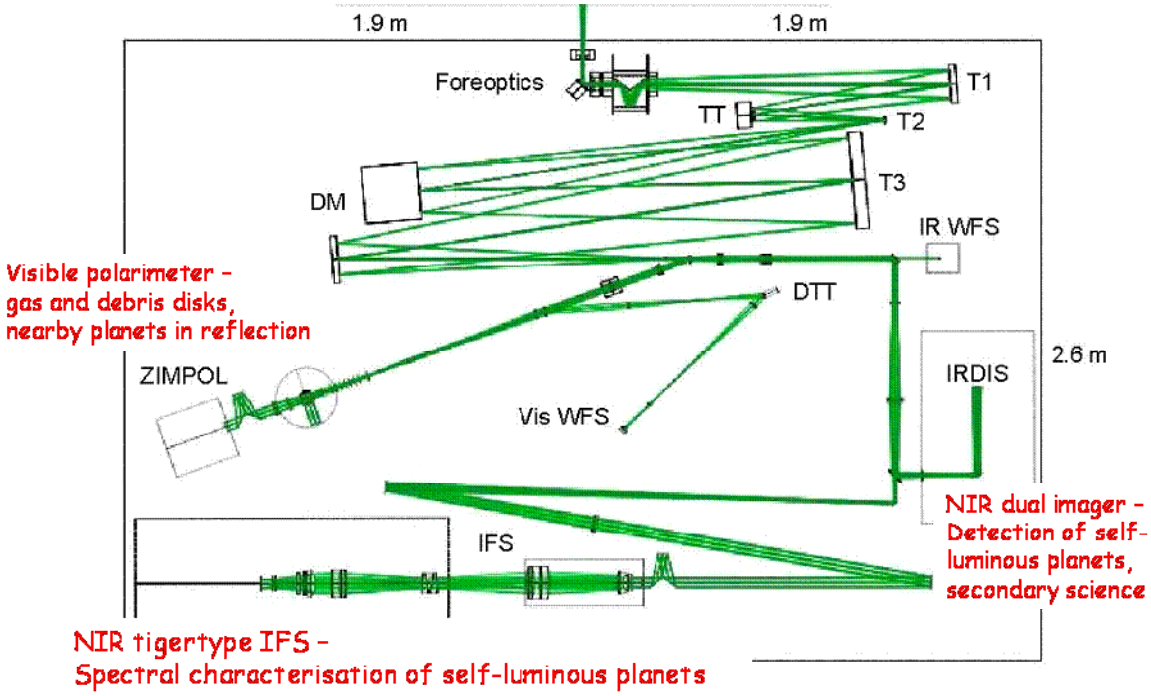
- Selection by **ESO** of **E2V** (UK) for the development of the 240x240 pixels CCD detector for wavefront sensing equipped with 8 outputs and based on L3CCD technology with 0.2 e RON **(JRA2**). Contract signed. Development of a prototype controller has been launched with Observatoire de Marseille for the testing of the chip. The chip CDR has taken place at E2V mid of September 05.

- Real Time Computer Platform (SPARTA) design has been pursued by **ESO** and **Durham WP 3.1**. Procurement of HW has been performed and part of the HW has been tested in the laboratory.

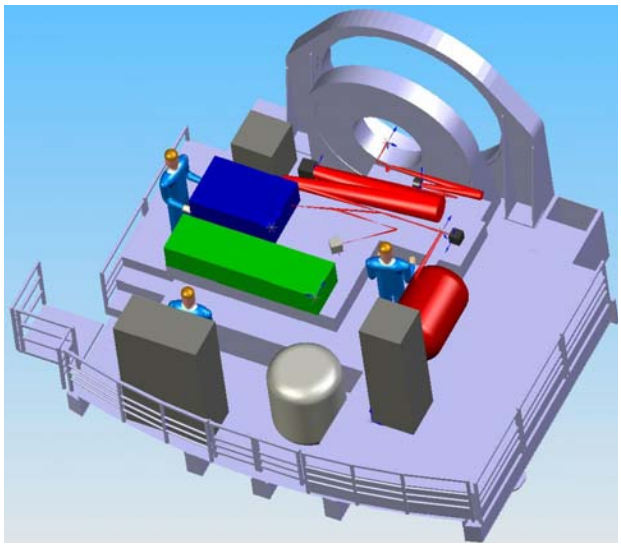
All the documents produced in the frame of this WP are included in the **CD-ROM JRA1/WP2.1**:

- Post phase A statement of work
- Technical report on Coronagraphic concept
- Technical report on integral field spectrograph
- VLT Planet Finder draft management plan
- VLT Planet Finder Optimized optical design
- VLT Planet Finder Status report
- VLT Planet Finder Survey proposal
- VLT Planet Finder draft Technical specifications
- VLT Planet Finder Top level requirements

Logo of the SPHERE project for the VLT



Baseline optical design of the VLT-PF instrument, showing the 3 focal instruments

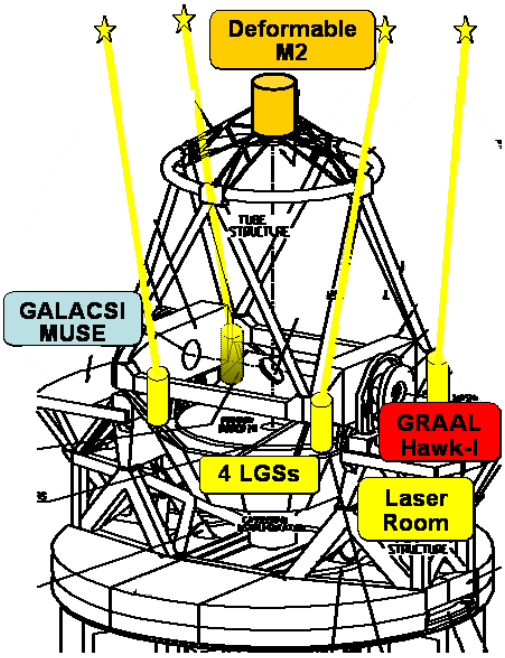


Preliminary implementation of the VLT-PF on the Nasmyth platform (IRDIS is shown in red, IFS in green, ZIMPOL in blue and the associated electronics in grey; instrument cover is not shown).

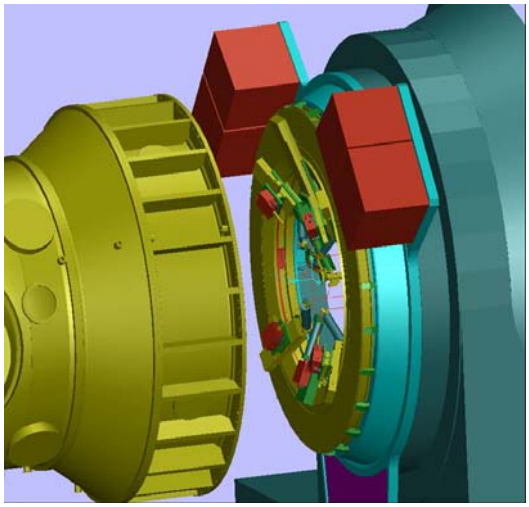
WP2.2: GLAO System Study

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 has been 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.

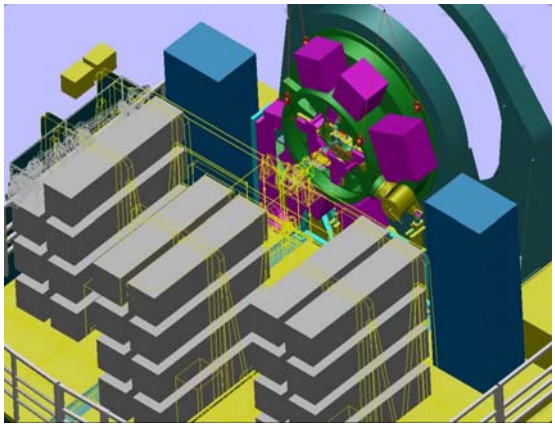
The new Adaptive Optics Facility design has been performed and the design documentation package has been produced by **ESO-INAF-NOVA/Leiden**. A design review involving ESO and international reviewers was conducted on September 29th-30th. The outcome of this design review was that AOF was technically feasible and scientifically worthwhile while risks were considered acceptable and controlled. Following this recommendation from the review board, ESO management (Oct. 10th), ESO Scientific and Technical Committee (Oct. 17th-18th) and ESO Council (Dec. 7th-8th) have given the "green light" for the development of the whole Facility.



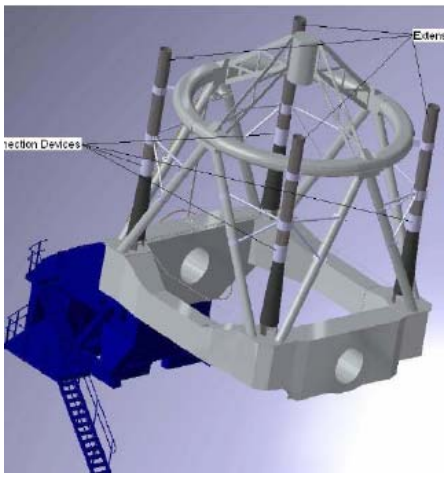
Overview of the VLT Adaptive Optics Facility included the two Ground Layer Adaptive Optics systems: GRAAL, and GALACSI (WP2.2), the Deformable Secondary Mirror (WP3.5) and the 4Laser Guide Stars.



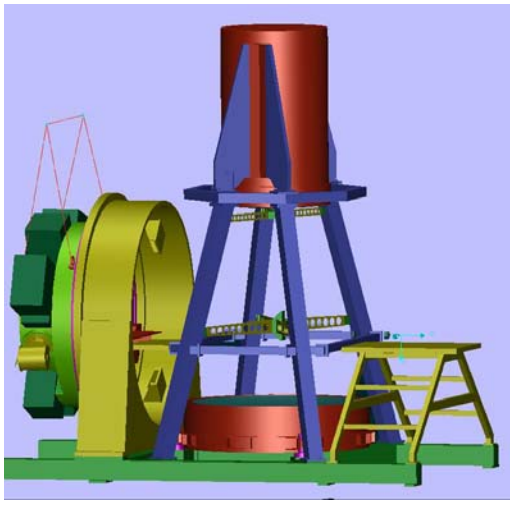
Overview of the GRAAL, Ground Layer Adaptive Optics for the VLT. On the left: HAWK-I NIR imager; on the right: GRAAL attached to the VLT Adapter-Rotator.



Overview of the GALACSI, Ground Layer Adaptive Optics for the VLT. On the left: MUSE visible 3D spectrograph, in green & pink GALACSI attached to the Adapter-Rotator.



Overview of the Laser Guide Star Facility at the VLT: The four tubes are the launcher telescopes for the laser beams.



Overview of the Adaptive Optics test facility (ASSIST): on top in red the Deformable Secondary mirror, on the left in Green the GALACSI or GRAAL during testing, on the right in green the turbulence generator, in the center in blue and red the telescope simulator.

The documents produced in the frame of this WP are provided in **CD-ROM JRA1/WP2.2.**

The feasibility study of the NGS multi-object system based on the FALCON concept (Multi-Object Adaptive Optics) has been completed by INSU-CNRS in Paris. **This corresponds to deliverable M2 of WP2.2: see CD-ROM JRA1/WP2.2/FALCON.**

WP2.3: Multi-Object WFS for GTC

The original work proposal of the GTC Project Office (GTC PO) consisted on 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 a least squares 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. Therefore, we intend to refine the numerical simulations, to proceed with the development of the necessary turbulence generator, to design and produce the telescope simulator.

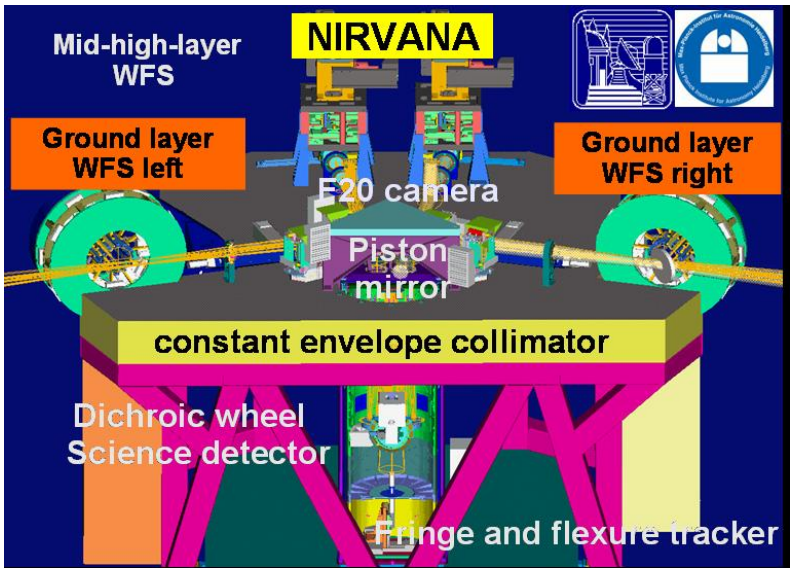
WP2.4: Multiple FOV System with NGS

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).

During 2005, MPIA and INAF-Arcetri conducted a review of the full LINC-NIRVANA Adaptive Optics Facility including the MFoV Sensor in July '05. This represents a major milestone for the whole project. The design documentation of the MFoV-WFS was delivered last year as part of the year 1 annual report.

The procurements of the corresponding opto-mechanical components have been launched in 2006. Some components have been received, e.g. the translation stages and have been tested. Test results were not satisfactory and the company has been asked for corrective actions. This has delayed the progress of the overall mechanical structure of the Mid-High Layer Sensor and the Ground Layer wavefront sensor by about 3 months but is still within the schedule margin planned for the manufacturing of the prototype.

The late delivery of the LBT Adaptive Secondary at project level due to difficulties to manufacture the thin shell might shift the on-sky test out of the current timeline of the JRA1. A laboratory testing of the prototype with a deformable mirror available at MPIA is being investigated to meet the committed final delivery of this WP.



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

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

WP3.1: 2nd Generation RTC Platform

The Top Level requirements of the Real Time Computer (RTC) for XAO and GLAO have been progressively refined, thanks to the progress made with the VLT-PF (Planet Finder, WP 2.1) and the ESO-AOF (Adaptive Optics Facility WP 2.2).

A complete concept based primarily on a CPU-based system with the addition of FPGAs with the role of the acquisition processor has been made and an internal review (**ESO+Durham**) has been made to cross-check the documentation produced (April 2005).

A full set of tests have been designed and executed (report attached) and the results were disappointing. We found problems both on the expected raw computational power and in the computational latency. The analysis of those results concluded that both are architectural: the first is due to the small cache in the CPU, the second to the serialized nature of the CPU which is not optimized for low-latency data transfers. This led to an important change in the concept and the increase use of FPGAs, already used as front-end acquisition processors.

In this second version of the concept FPGAs are in charge of the complete real-time processing pipeline, including all communication layers, acquisition, reconstruction and control. A COTS product has been identified that is able to deliver the required components, a board with 2 CPUs and 2 FPGAs tightly connected. This approach, however, suffers from other problems: FPGAs are very difficult to programme and the SW Development Cycle is very long; moreover the computational density is not very high and the cost of each board is significant. To improve furthermore this concept, a third (current) release of the SPARTA Concept has been put together: FPGAs manage the communication layer, ensuring very low latency in the data transfer. FPGAs are used for processing where appropriate, like the acquisition module where the data processing algorithm is quite well known and data are

mostly integers, a data type that is well managed by FPGAs. Where some more flexibility is required, an array of DSPs is used. A COTS product has been identified that fits nicely in the architecture since it provides 2 FPGAs that manage the communications interfacing with the other FPGAs, sending the data to an array of 8 DSPs, achieving a quite high computational density.

This concept developed by **ESO and Durham** has been submitted to two reviews, one from application point of view, to verify the top level requirements, and another to check the technological and strategic decisions. The former had been concluded successfully, while the second is still running, with positive intermediate results.

After the initial delays mentioned last year for the late recruitment of a SW engineer, SPARTA will have further delays due to the change of direction of the concept. The HW procurement is restarting and one board of the new type has been ordered and it will be tested in co-operation with Durham in Q1/2006. The original milestone for a complete Test Report in August 2006 will then be shifted at the end of 2006 and the Final Design Report at the end of 2007 or beginning of 2008, depending also on the availability of the second of the new boards, still not available.

Documentation of the conceptual design of the Real Time Computer Platform for the 2nd generation AO system is provided in **CD-ROM JRA1/WP3.1 and represents deliverable M1 of WP 3.1.**

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

In this period **ONERA** has completed the theoretical study, the end-to-end simulation tool and the simulation results of Optimal Control Methods for MCAO (OCM) Two papers ([1] and [2]) have been published and a report has been delivered (deliverable **M2 of the WP 3.2** included in the **CD-ROM/WP3.2**).

The end-to-end simulation tool estimates the MCAO performance in star oriented mode depending on the turbulence conditions, the guide-star geometry, the wavefront sensor and deformable mirror characteristics. Several control laws are available: integrator, optimized modal gain integrator, and Kalman control. The Kalman based control looks very promising in the case of Off-Axis-AO and will be proposed for MAD.

The AO bench, BOA, available at **ONERA** was upgraded and experimental validation of the optimal control approach developed above was performed. These experimental results are consistent with the numerical simulations. This pioneering experimental work will drive the specifications and implementation of the future MAD optimal control.

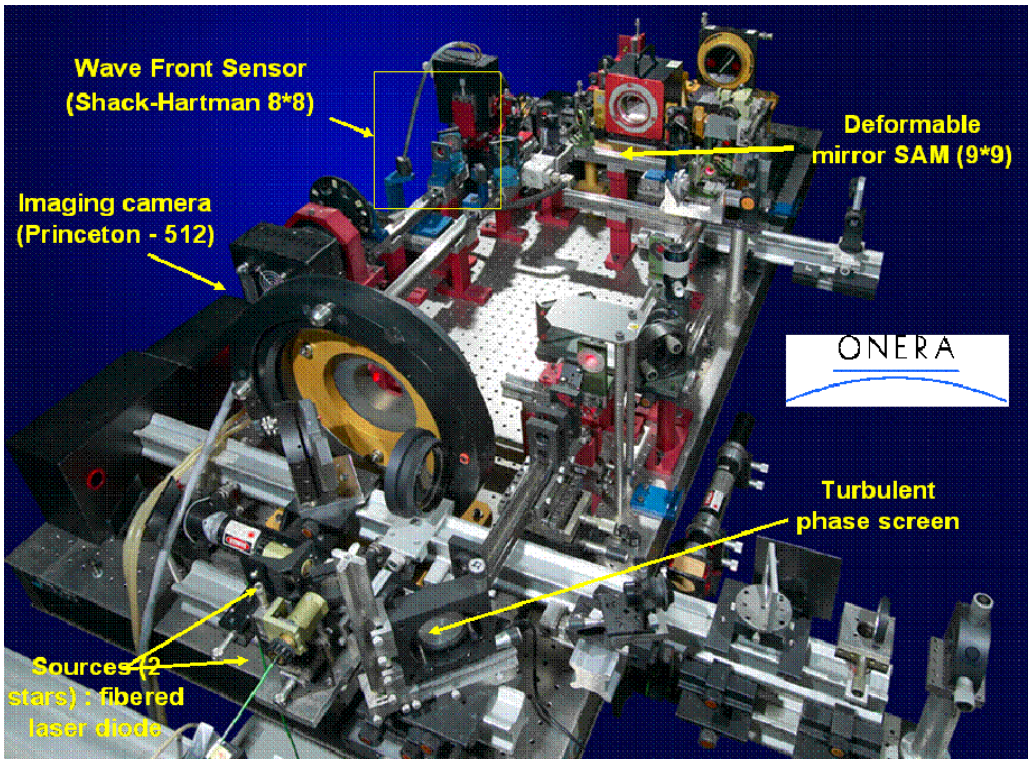
In the area of high performance WFS in MCAO, **ONERA** has conducted the theoretical studies and end-to-end simulation tools. In that frame, three topics are addressed:

- Sky coverage: The concept of Surface Sky Coverage has been developed and applied to both FALCON and MAD.

- Comparison and optimisation of WFS methods: Analytical comparison of the Star Oriented and Layer Oriented wavefront sensing methods was conducted by **ONERA** and optimisation was proposed leading to a significant gain in performance (WFS

noise propagation). An end-to-end model was developed to confirm the analytical results. These results have been presented at several international workshops.

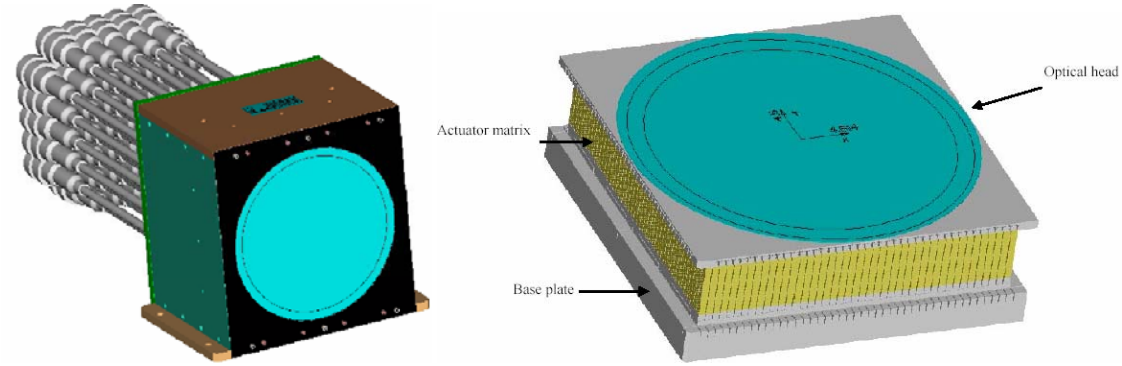
- Studies and optimisation of WFS devices: after the comparison of the WFS devices (Shack-Hartmann and Pyramid) performed last year, the optimization of the slopes measurement in the case of Shack-Hartmann-WFS has been investigated: Center of Gravity, Weighted Center of Gravity, Quad Cell and Correlation. Based on a global merit function, **ONERA** has studied the behavior of each estimator and analytical expressions were established (Collaboration with CTIO in US).



ONERA BOA bench used for the testing of the Optimal Control Method in MCAO

WP3.3: 2nd Generation Piezo DM

Following the Call for Tender issued by **ESO** last year, 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 1370 actuator piezo-deformable mirror and a design review was organised by ESO in November 2005 (**deliverable D1 of WP 3.3**). The design review documentation is provided in **CD-ROM/WP3.3**.

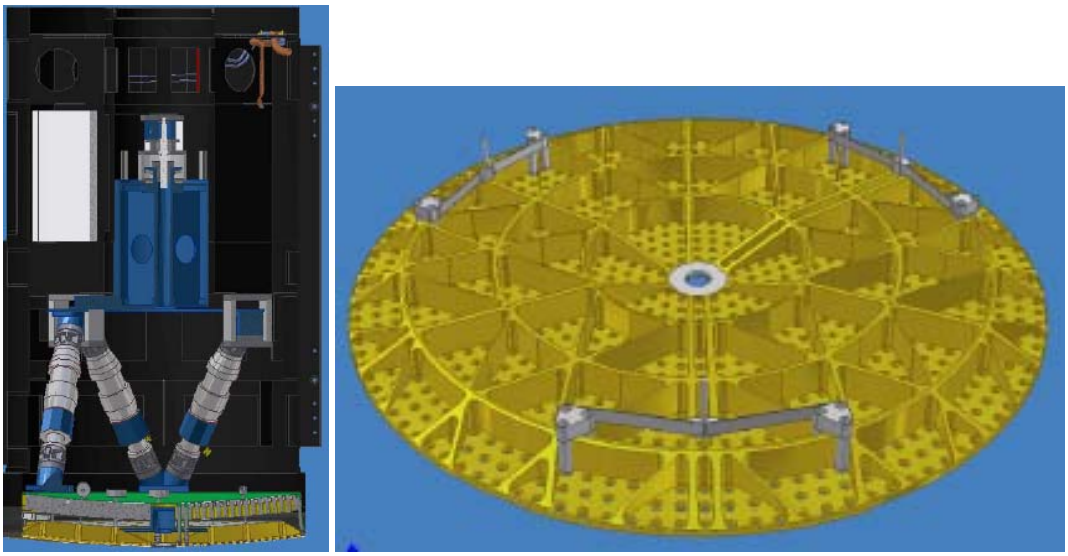


Overview of the 1370 actuators piezo deformable mirror design from CILAS

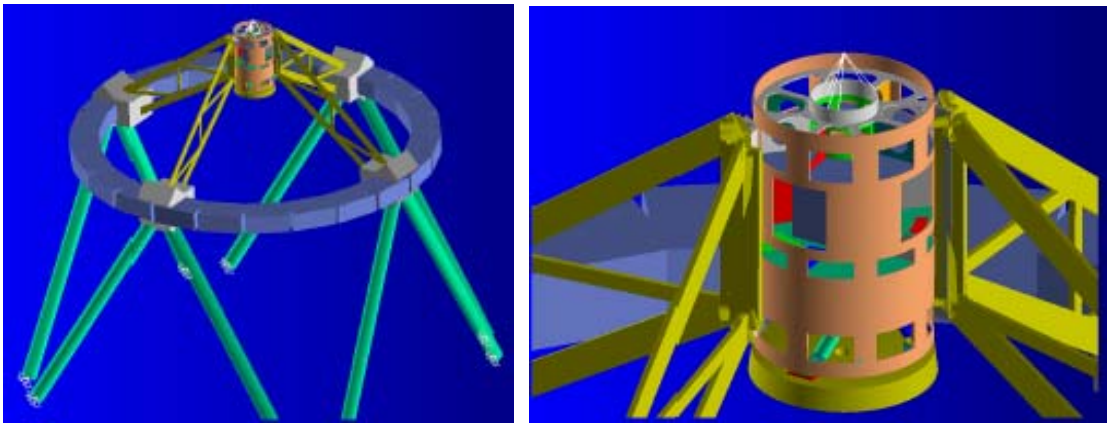
WP3.4: 2nd Generation Piezo DM drive Electronic

The delay which occurred in the selection process of the piezo Deformable Mirror (WP3.3) Contractor and the resulting late design review have not permitted us to finalise the specifications of the corresponding drive electronics –which should include the piezo DM electronic interfaces- as originally planned. Following the design review of the piezo DM, we have finalised these specifications and Statement of Work (provided in the CD-ROM **JRA1/WP3.4** and a Call for Tender for the design and manufacturing of the drive electronics will be issued 1st quarter of 2006.

WP3.5: VLT Adaptive Secondary: In March 2005 the consortium **MicroGate**, **ADS** and **INAF Arcetri** presented a straw-man design for a complete VLT Deformable Secondary Mirror (DSM). In June 2005 the Milestone 2 meeting took place presenting the AO performance of the VLT DSM. On August 22nd the Milestone 3 meeting took place presenting the conceptual design of this system. For all meetings minutes were held and a thorough question and answer process, involving several reviewers at **ESO**, took place and are archived. The feasibility study was concluded as having demonstrated the feasibility of the VLT DSM (**deliverable M1 of WP 3.5**). The documentation is provided in CD-ROM **JRA1/WP3.5.**



Left: Overview of the VLT Deformable Secondary Mirror. Right: Design of the optical reference plate



Deformable secondary Mirror mounted on the VLT

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

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" in the summer 2005. Two (2) answers were received during the first days of August. After the review process both offers were considered non-compliant. It was closed and negotiations were conducted with both potential suppliers to identify areas of compromise. **ESO** issued an updated CfT on December 9th with 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 have been relaxed (however, the initial surface error specification has been maintained as a "goal specification"). Answers from this new CfT have been received on January 13th 2006 and one supplier has been identified. Approval by the ESO Finance Committee is planned to be given beginning of March 2006.

In parallel, **INSU- LAM** has pursued a new manufacturing process based an innovative 'Active Optic' manufacturing technique that will reduce the cost and complexity of the thin shell realization. The complete feasibility study of a 1m glass shell report has been delivered by **INSU** (Deliverable **M1 of WP 3.6**) and is included in CD-ROM **JRA1/WP3.6.**

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

The first activity of work-package 3.7 under the responsibility of **INSU-LAOG** is the development of a MEMS-based 2k actuators deformable mirror. Considering the number of companies and research centers involved in MEMS technologies (113 in Europe), a private consulting company specialized in MEMS market has been hired (*Yole Development*). This company provided support for the writing of the preliminary Request for Information (doc. JRA1-SPE-LAO-0002), and for the pre-selection of the 13 private companies and 10 research centres from (doc. JRA1-SPE-LAO-0004) to be consulted.

The technical specifications and statement of works have been updated for the Call for Tender (doc. JRA1-SPE-LAO-0003). But unfortunately, very few answers to the preliminary Request for Information have been received, and no supplier was willing to sign a contract based on our first technical specifications.

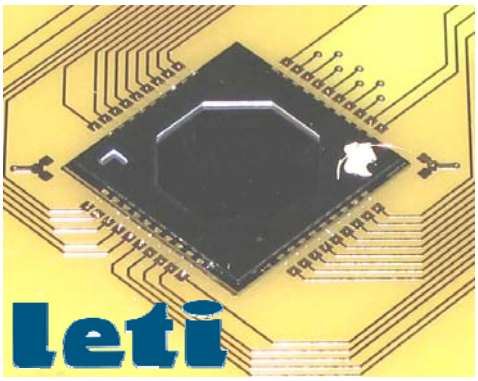
In addition, **INSU** could not identify sufficient additional internal funds to compensate fully for the difference between proposed and actual EC funding. These changed (internal INSU) funds increased the level of financial risk perceived by **CNRS-INSU's** financial head who was concerned about placing a contract without more guarantees.

The JRA1 management together with **INSU** and **ESO** is currently investigating alternative

solutions to overcome the above difficulties. Possible options are to merge development effort with US partners and/or pursue smaller scale prototypes with more intermediate steps.

Note however that important technological steps have been obtained in the framework of a collaborative effort between **INSU** and **CEA/LETI** in term of optical quality of the membrane and actuator stroke with a 19 actuators MOEMS. It is believed that the key technological bricks are in-hand but the 2k actuators Micro Deformable Mirror (MDM) prototype seems to be out of range with the level of available funding at least in Europe. One open point to be addressed in the coming months is the dynamical performance of the MDM prototype.

Test facility at INSU-LAOG: test bench including vacuum test chamber, 19 actuator MDM, 64 channels drive electronics and control software



19 actuators MDM developed by CEA-LETI. 1mm pitch, 4.5 µm stroke with 60V. Wavefront error 1.5nm rms

In addition, INSU-LAOG has issued a Call for Tender for the design and manufacturing of a 1024 channels MOEMS drive electronics and a contract has been signed with ShaktiWare (France) for the realization of the prototype. A design has been produced and the preliminary acceptance is expected in February 2006.

Two prototypes of ~60 actuator magnetic deformable mirror have been produced and delivered to our partners for testing. The patent FR045234 protecting this technology is currently being extended to other countries. Two contracts have been signed by CNRS with private companies for commercialization. This mirror has already been used to improve the performances of a new ophthalmologic instrument partly funded by EC (*SHARP-EYE* project). Seven units have been sold during the second half of 2005, for a total sales turnover of 98k€. (See also www.alpao.fr and www.imagine-eyes.com/ies_products_oem_mirao.htm)

Note that one magnetic deformable mirror has been procured by ESO for future use on the

High Order Test Bench (HOT) –WP 3.8-.

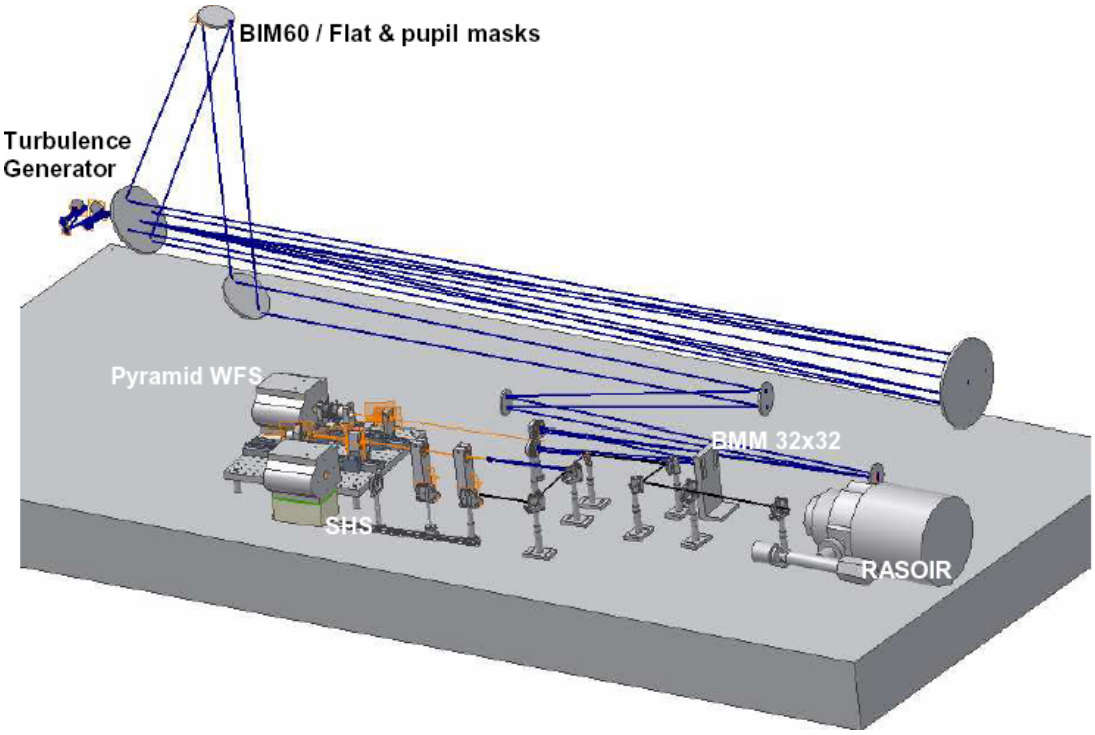
WP3.8 High Order wavefront sensor experimental study

The design of the complete High Order Test (HOT) test bench has been optimized and finalized: Optical common path by **ESO**, pyramid wavefront sensor by **INAF-Arcetri** and Shack-Hartmann wavefront sensor by **University of Durham**. This design report is the deliverable **M2 of WP 3.8** and is included in the **CD-ROM JRA1/WP 3.8**. Most of the opto-mechanical components for the test bench have been procured by the different institutes. The 1k actuators Micro Deformable mirror manufactured by **Boston Micromachine** has been delivered to **ESO**. The fast readout CCD camera for the Pyramid wavefront sensor has been delivered by **ANDOR** to **INAF-Arcetri**. A second camera of the same type should be delivered to **ESO** any time soon. Technical specifications for the turbulence generator have been prepared and **SILIOS** has been selected (after a price inquiry) for the manufacturing of the phase screens. A simulation report and the technical specifications are included in the **CD-ROM JRA1/WP 3.8/**.

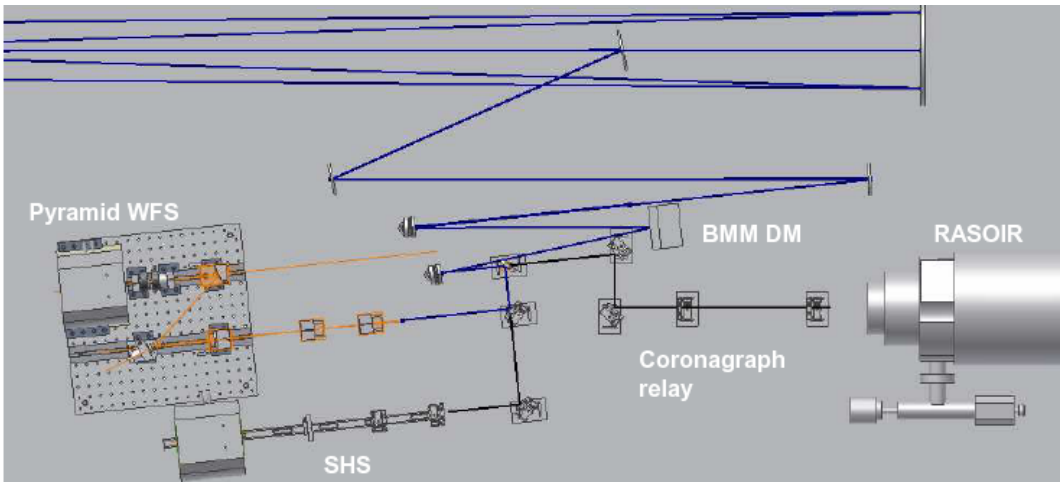
The micro-deformable mirror drive electronics is being procured by **ESO** and **INSU** to **Shaktiware**. The design review has taken place in Marseille.

The development of the RTC platform for the Shack-Hartmann wavefront sensor has been pursued in the framework of WP3.1 by **ESO**. **INAF-Arcetri** has issued a subcontract for the development of the RTC platform for the pyramid wavefront sensor with **Microgate**. As a result of the 2004 technology survey, the first coronagraph for the high order test bench has been designed and all the components have been ordered. The coronagraph design report is included in the **CD-ROM JRA1/WP 3.8/)**

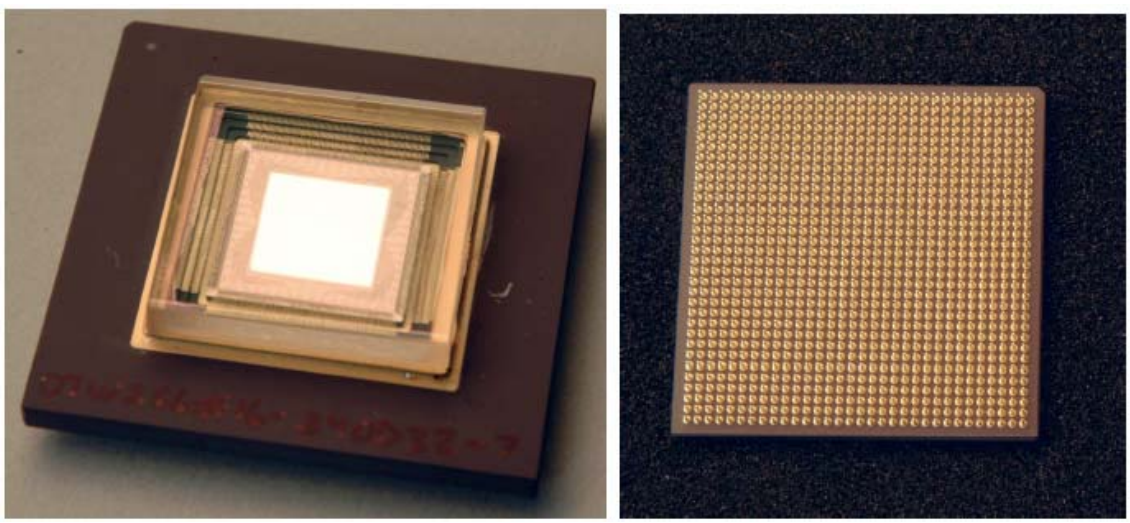
A first draft of the Assembly, integration and test plan has been issued. This document containing contributions from **ESO**, **INAF-Arcetri** and **Durham** is included in the CD-ROM.



Overview of the High Order Test bench (HOT) design. On the left, the turbulence generator, on top, the first stage deformable mirror, on the right, the 1000 actuators Boston Micromachine DM and the IR imager RASOIR, in the central area the two wavefront sensors (Pyramid and Shack Hartmann)



Top view of the HOT Wavefront sensor and imaging area with the coronagraph relay



32x32 actuator Boston Micro-machine micro-DM. Left: frontside with the glass window protecting the DM from humidity. Right: backside with the connectors for the 32x32 actuators

Milestones and Deliverables

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Task No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
M1	JRA1 General Meeting 2	1	ESO	21	20
M2	Complete NGS MCAO feasibility study based on FALCON concept	2.2	INSU	24	24
M1	Complete conceptual design of the Real Time Computer platform for the 2nd generation of AO	3.1	ESO	18	21

	systems				
M1	Complete theoretical study of the optimal control for MCAO system	3.2	ONERA	23	23
D1	Design report of a 1200 actuator piezo stack deformable mirror	3.3	ESO	21	23
M1	VLT Adaptive secondary conceptual design report	3.5	ESO	20	20
M1	Complete feasibility study of a 1.1 m Zerodur shell for an Deformable Secondary Mirror	3.6	INSU	23	24
M2	Complete design of the high order test bench	3.8	ESO	24	24

List of JRA1 Meetings:

Date (2005)	Title/subject of meeting /workshop	Location	Number of attendees	Website address
March 2nd	Straw man design of the VLT Deformable Secondary Mirror (WP3.5)	ESO Garching	10	CD-ROM
May 9th	VLT Planet Finder Management meeting (WP2.1)	LAOG Grenoble	4	CD-ROM
March 18th	HOT status –wavefront sensors designs (WP3.8)	Telecon	8	
April 19th	Piezo Deformable Mirror Kick-off meeting, (WP 3.3)	Videocon	7	CD-ROM
June 24th	VLT Deformable Secondary Mirror Progress meeting (WP3.5)	ESO	15	CR-ROM
July 7th 8th	JRA1 general meeting 2 (WP1)	Arcetri	30	http://www.eso.org/ projects/aot/jra1/
July 21st - 22nd	Final Design Review of LINC-NIRVANA (WP 2.4)	MPIA	20	
July 20th	Piezo Deformable Mirror Progress Meeting (WP3.3)	Videcon		CD-ROM
August 22nd	VLT Deformable secondary Mirror (WP3.5)	ESO	12	CD-ROM
September 12th	VLT Planet Finder Optical design (WP2.1)	ESO	7	
Nov. 7th	Piezo Deformable Mirror design review (WP3.3)	Videocon	7	CD-ROM
Nov 8th	VLT Planet Finder Management meeting (WP2.1)	INSU	5	CD-ROM
Dec 1st	VLT-Planet Finder detector meeting (WP2.1)	ESO	10	CD-ROM
Dec 5th	HOT status and Assembly Integration and Testing Planning (WP3.8)	Telecon	11	CD-ROM
Dec 9th	VLT-Planet Finder differential polarimeter meeting (WP2.1)	ESO	6	CD-ROM
Dec 13th	VLT Planet Finder Real Time Computer meeting (WP2.1)	INSU	10	CD-ROM

1.5.2 JRA2: Fast detectors for AO

Human effort

Participant number[18]	6	4	7	31	
Participant short name[19]	INSU/CNRS	ESO-INS	IAC	ONERA	**Total**
Person-months[20]	44.22	4.87	0.9 (0)	0	**49.69**

Progress report

WP1: Management

Several meetings were organised, see list at the end of this section.

WP2: Detector specification and fabrication work package.

The following table highlights the major milestones and deliverables achieved in 2005 for WP2 plus future ones until work package completion.

In 2004, the top level detector requirements (AD1) were established, a Call for Tender (CfT) was issued to known detector manufacturers, replies received and E2V Technologies were selected as the winning bidder for the development and supply of a 240x240 pixel, very low noise (1e- or less), fast readout (1.2kframes/s) AO WFS detector.

During 2005, a contract was signed with E2V and development begun. The following major milestones have been achieved:

- On the 3rd March 2006, the kick-off meeting was held at E2V. The CCD design definition document (AD4) that detailed E2V's design approach was reviewed and accepted. In addition, a preliminary draft of the test equipment requirements document was discussed.
- On the 22nd April 2005, the contract was signed between ESO on behalf of JRA2 and E2V for the supply of 4 science grade detectors (delivery within 24 months) that meet guaranteed minimum specifications at a cost of €1,385,000. The option of saving €270,000 by OPTICON providing test equipment was taken up. This reduced the costs to €1,115,000. This equipment is being developed and built by work packages WP3 and WP4.
- On 21st September, a package discussion meeting was held at E2V where the preliminary design of the E2V package was discussed. Feedback from thermal, electrical and mechanical simulations and analysis performed by WP3 and WP4 led to the following improvements being adopted. A custom Peltier at an addition cost of €15,000 to get the detector colder to improve the tradeoffs between PSF and dark current. This was deemed necessary to improve the chance of success of the deep depletion variant which is being fabricated on a best effort basis. More package pins

[18] Lead participant first

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

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

to improve the substrate connection and electrical performance at a cost of €6,000. Additional substrate ground planes to the Aluminium Nitride chip carrier to reduce clock track inductances and improve high frequency performance at no additional cost,

- On 22-23rd September 2005, the CDR of the detector was held at E2V (review report AD10). The design presented by E2V was conservative using many of their well proven CCD design techniques and processes. It was therefore considered to have a high probability of success. This is in line with the nature of the contract with E2V of a device with guaranteed performance. The review board agreed that the design of the baseline standard silicon device will meet the minimum requirements as stated in AD 1. In addition, except for the quantum efficiency, QE, in the red and the point spread function, PSF, the design should go close to meeting the goal requirements. The QE in the red can only be improved by thicker silicon, i.e. by the success of the deep depletion variant. The PSF is dependent on the thickness of the undepleted region at the backside of the device and can only be improved by thinning the device (not considered as a real option as this will decreases the red QE) or running the image area clocks out of inversion during the exposure. This may result in 100x higher dark current, but may be an acceptable compromise if the low goal dark current is achieved and the proposed technique of "intrinsic dithering" provides a pseudo-inversion effect that reduces the 100x increase of dark current to a much lower level when the device is run non-inverted. The design was accepted and approval given to begin.
- Fabrication of the CCD die has begun with a completion date of April 2006.

On 13th January 2006, the package review meeting was held at E2V. The majority of the design was accepted and approval given to begin ordering parts. It was agreed that the CCD carrier will be redesigned to provide more substrate ground planes. This may cause a 2-3 week delay in fabrication. Fabrication, assembly and test will continue throughout most of 2006 with delivery of the mechanical samples (M5) mid year. E2V are on schedule for delivery of the science devices in the first half of 2007.

Detector Requirements

The top level requirements were set by OPTICON JRA2 science working group after carefully considering the needs of AO systems for future instruments and their science programmes. From these top level requirements, detailed requirements were established (see AD1). The following provides a brief summary and rationale behind the requirements:

1. big pixels, square 24µm (goal), to ease the optical design, but not too large to produce excessive dark current (DC) or CTE problems.
2. versatility of a 100% fill factor and 240x240 square grid array of pixels that can be used by any WFS systems: SH, curvature, or pyramid, with or without gaps (guard bands) between subapertures.
3. format size of 240 pixels being a number that is divisible by the number of output nodes, 8, and binning factors and aperture sizes of 1, 2, 3, 4, 5, 6 and meets the minimum pixel requirement of 40 subapertures x 6 pixels/subapertures.
4. low read noise of < 1 e-/pixel and goal of 0.1 e-/pixel.
5. range of operating frame rates from 25frames/s for use when photon starved with faint-NGS (Natural Guide Star) to highest sampling rate of 1.2 kframes/s for use with bright-NGS and LGS (Laser Guide Star).
6. easy to use; eight output nodes each operating at maximum pixel rate of 15 Mpixel/s, that provide a good compromise between the number of connections between the detector and the outside world and operational practicalities such as power dissipation, pixel rates and clocking rates.

7. low image smearing (<5%) when transferring image to store area; an undesirable affect that can be corrected.
8. cosmetically defects free as every defect will either complicate the centroiding or make it impossible to centroid a sub-aperture.
9. good spatial characteristics, PSF < 0.9 pixel FWHM over 460 to 950 nm, to accurately determine where the photons interact.
10. very low Dark current, DC, of < 0.01 e-/pixel/frame at 1200 frames/s and < 0.04 e-/pixel/frame at 25 frames/s to minimize the large errors introduced by the quantum nature of DC; electron is the smallest unit. A single electron of DC creates a large error when centroiding on a small number or single photon. DC includes contributions from clock induced charge (fixed amount per frame readout), image area during exposure (α exposure time), frame store and serial register during readout (α frame read out time).
11. Peltier cooled package for small compact size, maintenance free, and minimal support equipment so that final assembled camera system can fit in the small space volumes usually reserved for AO systems.
12. detection signal limit of 5 ke-. In normal operation, the system will be photon starved as there are not too many bright NGS and the power of laser of LGS will be reduced to a minimum. Well depth and output amplifier dynamic range can be traded to improve other parameters such as higher gain of output amplifier and lower clock amplitudes to transfer charge.
13. linearity of < 2%. Analysis shows that this level of linearity introduces insignificant errors. Linearity can be corrected by a look-up table.

Detector Design

The detector design (Figure 1) is a 24 µm square 240x240 pixels split frame transfer 8-output back illuminated L3CCD, designated as CCD220 (reference AD7). The image and store area are built with metal-buttressed parallel clock structures to enable line shifts of 10 Mlines/s for total transfer time from image to store of 12 µs and low smearing of under 1.5% at 1,200 fps. Two phase clocking was chosen for simplicity, lower power dissipation, and symmetry of drive.

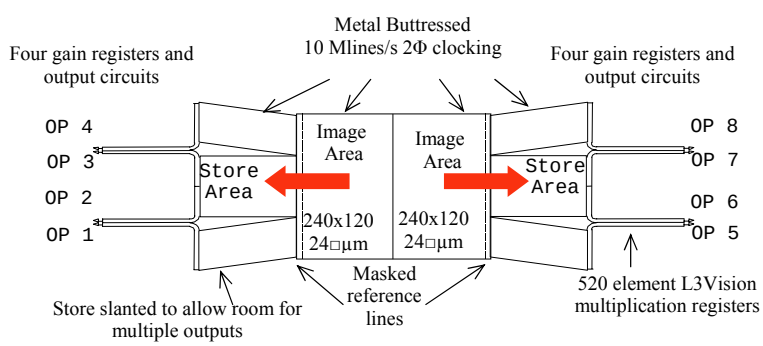


Figure 1: Schematic of CCD220.

The store area is slanted out to make room for the standard serial registers (three phase clocking) to curve around and provide space for the output circuitry. Each output will have a 520 element 16 µm standard L3Vision gain register whose gain is controlled by the voltage of the multiplication phase. The output amplifier will be a single stage and of similar design to that employed on recent L3V CCD97. The gain register and output amplifier will be optimized for a gain of 1000, a value typically expected for AO applications, to provide an overall effective read noise of under 0.1 e-. The serial registers, gain registers, and output

amplifiers are designed to operate up to 15 Mpixel/s to achieve a full goal frame rate of over 1,500 fps.

The baseline device will be built in standard silicon and is low risk with guaranteed delivery of devices that meet minimum requirements. A split wafer run will enable a speculative variant in deep depletion silicon to be built. Deep depletion improves the "red" response and is important for applications that rely on natural GS such as VLT Planet Finder.

The device will be mounted in a custom compact Peltier cooled package that will cool down the CCD sufficiently (-45°C) to meet the DC requirements over the full operating frame rates. The package will be sealed and filled with 0.9 bar of Krypton gas to minimize heat transfer to the outside. An AD590 temperature sensor will be glued to the ceramic chip carrier to provide a sensor for temperature regulation. The sapphire entrance window will be of a high optical quality (double path wavefront error of < 50 nm rms), good surface quality (defects meet 5/2x0,05 DIN3140), and AR coated with transmission > 98% over wavelength range of 400-950nm.

WP3: Controller workpackage

Research & development activities

The current period is fully dedicated to the development and fabrication of the final CCD controller. As the WP2 has finished the chip (CCD220) definition, the controller design can be done, especially on the front end electronics parts. The final controller review is to be held at ESO headquarters 8-9 March 2006. The CCD chip being developed within the OPTICON JRA2 consortium has several uncommon characteristics. The final design of the chip (named CCD220) has been provided to the consortium at the detector design review held at E2V's premises in Chelmsford on 21-23 September 2005. The first is the number of L3vision amplifiers, 8 in this case. This will be the first time that a multiple output L3vision chip is produced. The second is the readout speed that implies high frequency drives and high frequency design.

phases drivers:

CCD 220 needs 13.6 MHz serial and parallel phases to be operated at the frame rate foreseen. All phases drivers have been simulated and prototyped. During the test sessions, all these designs were validated and are ready to be integrated in the final design.

A/D conversion:

There is a hard constraint on the performance of the analog to digital conversion of the 8 outputs of the CCD220. The final conversion method uses an integrated 14 bit Analog Front End. In parallel, data dispatching has been solved and is done by ultra high speed serial links.

Sequencer:

The sequencer study has started and is in the simulation phase. The sequencer uses a high performance FPGA circuit to generate all the phases needed. The main issue with this development is the required timing accuracy of about 1ns which means an equivalent working frequency of approx 1GHz. A technical solution has been found to this problem and has been validated by simulation.

Classical developments

Microcontroller:

The microcontroller and microcode has been fully developed. The first version is fully operational and does not need any further modifications. The microcontroller board is the first part of the controller to be realized. It has been released in April 2005, in advance of the schedule. It has been fully tested and characterized for normal operation and meets all the constraints of the programme.

Interface:

The interface has been developed and tested. It has been fully validated and since it is capable of simulating the output of a CCD, it is used to test the link with the acquisition and serves as a virtual camera for all the software developments and other tests related to acquisition software and hardware. The interface module has been released in june 2005 in advance on the schedule. It has been fully characterized and validated.

Acquisition system & software development:

The acquisition system demonstrated it's ability to cope with the extreme bandwidth needed with this development (220 Mbytes/s). 1600 + FPS acquisition has been tested, more than needed by the project. Software development has also started using the interface board as a camera simulator. The software is also capable of handling the necessary data rate. All features asked for by E2V and WP5 will be implemented in the next phase.The acquisition system has been released in June 2005 in advance on the schedule. It is now fully operational and acquisition software is under development

Activity for the next year

Current research & developments around drivers and the analog front end are now complete. The analog front end study is at an advanced stage and will continue for the next months. The sequencer development and final global design will be held during the first half of 2006.

The end of 2006 will be a realization phase. We expect to deliver the final controller to E2V by the end of october 2006. The very end of 2006 and 2007 will be used to duplicate the controller and install it at IAC for the consortium test of CCD220.

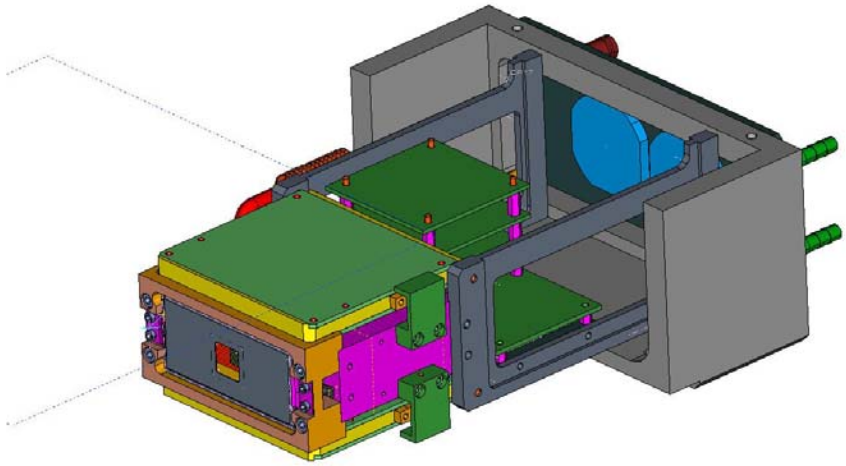
Conclusion

For the moment, no big technical issues were encountered. The work package 3 is on time for the delivery of the controller to the E2V manufacturer and to the JRA2 consortium.

WP4: Cryogenic system

The mechanical design of the camera will be complete at the Test Camera Design Review to be held at ESO in March 9th 2006.

The following figure shows the mechanical and thermal design of the camera:

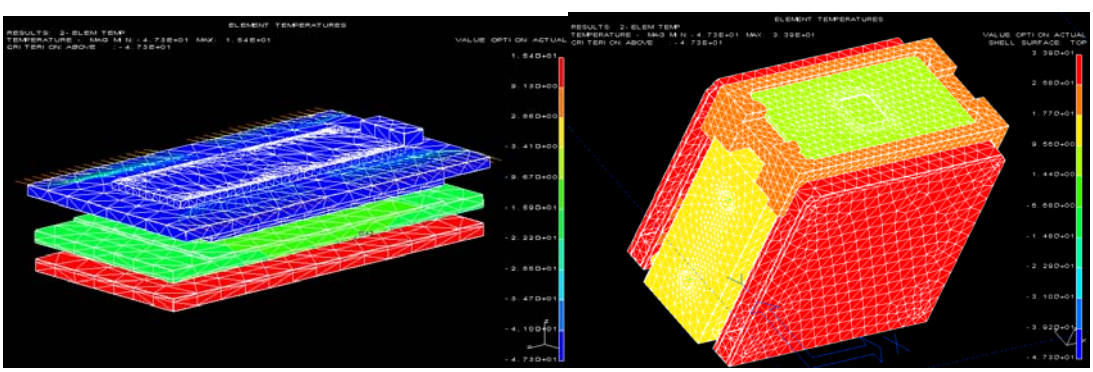


This design includes:

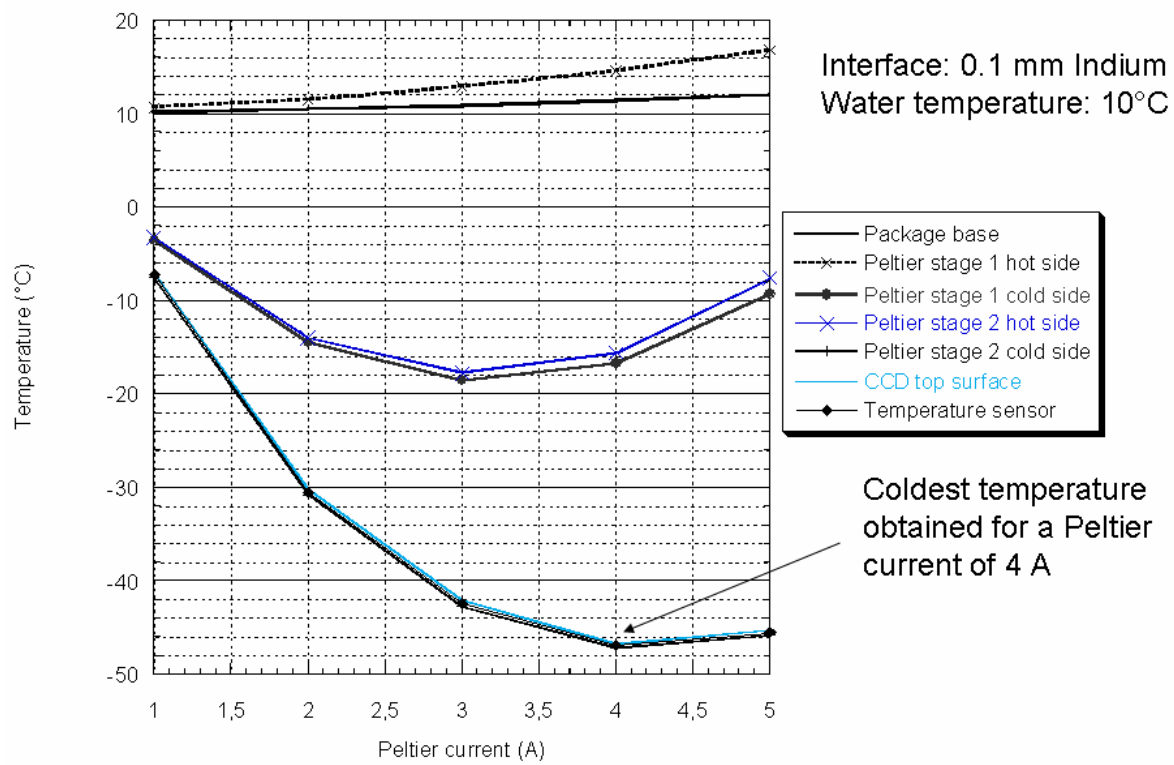
- the CCD integrated in its Peltier Package
- the electronics boards of the camera
- the heat sink of the Peltier back side and the cooling circuit

The camera is designed to allow an easy access to the detector: this one can be dismounted quickly, easily and safely.

A full FEA thermal analysis was done to verify that the current design of the camera achieves the thermal performances that are required for the CCD. The following figure shows some example of FEA thermal analysis. On the left hand side is showed the double stage Peltier cooler with the CCD on top, current in the Peltier stages is 4 A. The picture of the right hand side shows the cooling of the electronic boards and of the package.



The following figure shows the temperature of different parts of the package, including the Peltier stages, the CCD and the temperature sensor glued on the CCD:



Thermal modelling results show that we should obtain a CCD temperature of -45 °C with a Peltier current of 4A. This is the nominal temperature that is necessary to meet the dark current specifications for the CCD.

WP5: detector testing

The contribution of the IAC to the JRA2/WP5 has been mostly devoted to:

- To review the documentation related to the Detector Design Review, with special focus on the definition of the acceptance tests at the factory.
- Attend the CCD design review meeting held at the factory.
- Documentation revision and beginning of the testing plan definition with the generation of a first draft to determine the KeyWords to be used in the data files obtained during the detector tests.
- Preliminary definition of the detector tests to be performed to validate the JRA2 detector as a responsibility of the WP5 assigned to the IAC.

The list of tests will be proposed and discussed in the next 18 months. Also the instrumentation, facilities, planning and personnel required for the execution of such tests will be determined.

Milestones and Deliverables

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Task No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
M1	Date of Constitution of Contract	WP2	INSU/CNRS	16	16

M2	Kick-Off Meeting	WP2	INSU/CNRS	15	15
M3	Detailed design review of the detector	WP2	ESO	18	21
M4	Package Design Review	WP2	ESO	18	24
M1	Complete cryogenic system design	WP4	INSU/CNRS	6	24

Major meetings and workshops

Date	Title/subject of meeting /workshop	Location	No. of attendees	Website address
March 3rd and 4th, 2004	CCD Kick-off meeting	Chelmsford E2V	15	http://www-laog.obs.ujf-grenoble.fr/JRA2 link "Detector kick-off "
Sept 21st to 23rd, 2005	CCD Design Review	Chelmsford E2V	16	http://www-laog.obs.ujf-grenoble.fr/JRA2 link "CCD Design Review"

1.5.3 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	PPARC ESO	MPG MPA	MPG MPE	NOTSA	NUIG	LSW	USFD	Warwick	**Total**
Person-months	18 (12)	2 0 (0)	18.5 (12)	18.5 (12)	0.5 (0)	10 (10)	1 (0)	3 (0)	3 (0)	

After a slow start of some workpackages (especially WP3 and WP4), JRA3 as a whole is now operating at full speed. By the end of the current 18 month planning period, i.e. at contract month 30, total spending is expected to have reached 700 kEuro (including actual spending in year 1 and the current proposed 18month budget). By this time, we expect all workpackages to be on target with respect to milestones and deliverables.

Splendid progress can be reported from essentially all the workpackages. To be highlighted in particular is the progress with the EM-CCD controllers (WP5), which in the reporting period have demonstrated performance unmatched by any existing design. The second highlight is the progress with development of avalanche-amplified PN-sensors (AA-PN). The production of the first version of the critical silicon elements for this device will be completed in early 2006. JRA3 will issue a subcontract early 2006 for the first fabrication steps of a practical device based on AA-PN.

WP1: Management

Difficulties caused by the forced incorporation of the Landessternwarte Heidelberg (JRA3 contractor LSW) into the University of Heidelberg created insurmountable problems with management of JRA3. As a consequence it was decided to transfer management from LSW to MPA Garching, with H. Spruit taking over as manager, effective 1 July 2005. As a consequence of this change, some funds sent already to LSW will be transferred back to the co-ordinator for redistribution to other JRA3 partners

A major meeting was held 19-20 October 2005 in Galway, Ireland, with its focus on evaluation and comparison of the 7 workpackages. Adjustments in the relative contributions of the partners to the workpackages were made, and the initial indicative distribution of OPTICON resources between the partners modified accordingly. A financial plan based on this agreement was submitted to, and accepted by, OPTICON management.

The main changes agreed on were:

1. Transfer of the tasks of partner NOTSA to partner IoA.
2. Additional funding for partner IoA, partly in connection with (1).
3. Increased spending at partner NUIG, needed to complete the tasks of WP4 on time.
4. Reduced spending at LSW due to redesign of WP8 (see below), and reduced spending at MPA.

Adjustments in schedules of the workpackages.

The technology reviews in February and October 2005 have led to adjustments in the workpackages.
These are detailed further in the individual workpackage reports below.
The main changes are:
1. As announced in the previous annual report, the scope of WP3 (Development of PN-sensor for HTRA) has been expanded to include development of an additional on-chip avalanche amplification stage.
The milestones and deliverables have been adjusted accordingly. Additional funding (from outside the OPTICON budget) has been secured to make this expansion possible.
2. A critical analysis of the common testbed concept has revealed that part of its required functionality can be obtained more economically with individual testbeds for the 3 technologies. The key goal of the common testbed, the evaluation of relative strengths of the 3 technologies pursued in JRA3, can be realized by development of a virtual testbed in software. The milestones and deliverables of WP8 have been redefined in this sense.

Milestones and deliverables for management:

M1 (preliminary design review) has been achieved per Feb 2005. In addition, the viability of technologies for all workpackages has been confirmed at that time, with the exception of that for the PN sensor (WP3). The new JRA3 manager has convinced himself that appropriate planning for implementation of the technologies in the workpackages was in place as of 1 July 2005. An external review of the avalanche-amplified PN-sensor design was made in August (see WP3 below), and accepted by OPTICON management as basis for a subcontract by JRA3 to the MPE semiconductor laboratory. These steps complete M2 (Critical design review).

WP2: EMCCD developments
Following a detailed procurement exercise, where we looked at the EMCCD's available from 3 different companies, we selected the CCD201-20 from E2V as the chip which most closely matched our functional/performance requirements and budget. An engineering grade and science grade device was ordered from E2V, but they did not arrive until the end of Q3/2005. While awaiting the new devices, a detailed theoretical model of the output of EMCCD devices was completed, which will be an essential diagnostic/optimisation tool during the final laboratory characterisation phase of the project.

WP3: PN-sensor development
Several critical developments took place in 2005.
1. A Critical Design Review was performed in August 2005. An external team, with experts in CCD design (Mark Downing, ESO Optical Detector Team), readout and electronics (Javier Reyes, ESO ODT), and avalanche amplification (Dr. Carl Jackson, Chief Technology Officer, SensL Technologies Ltd., Cork), reviewed the concept, development plan, and schedule of the AApnCCD project. The report of the external review is available at the JRA3 TWiki pages https://ssl.roe.ac.uk/twiki/bin/view/HTRA/JRA3 (Passwords can be provided to EU reviewers on request to the JRA3 PI).

2. Agreement was reached in negotiations with ESO (G. Monnet and his group) that a financial engagement of ESO in the Avalanche-Amplified pnCCD detectors (AApnCCD) development is of interest for ESO's plans in adaptive optics (AO). The further commitment by the MPE director G. Hasinger, to make in-house funds available for the programme, now confirms a solid financial budget for the activity.

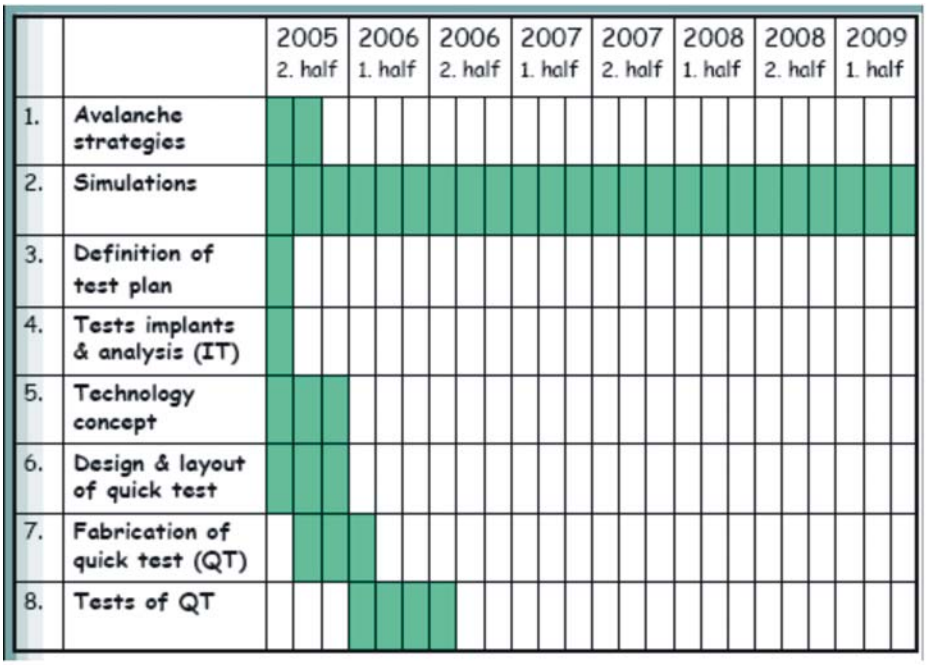
The internal plan for development of the AApnCCD detectors has been updated and revised

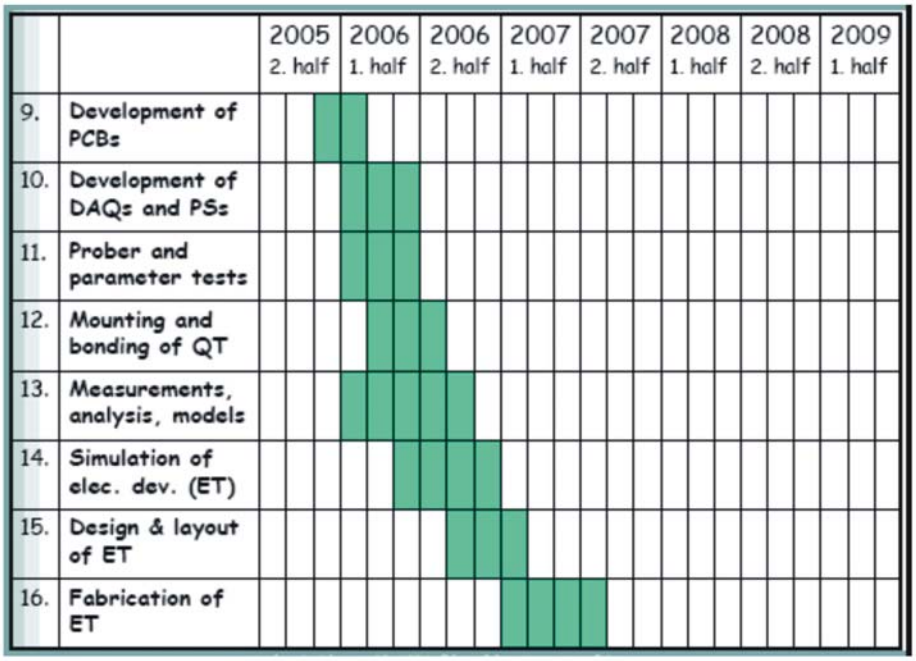
from the previous version reported in the previous Annual report. The main changes concern the designation of the programmatic phases of the project:

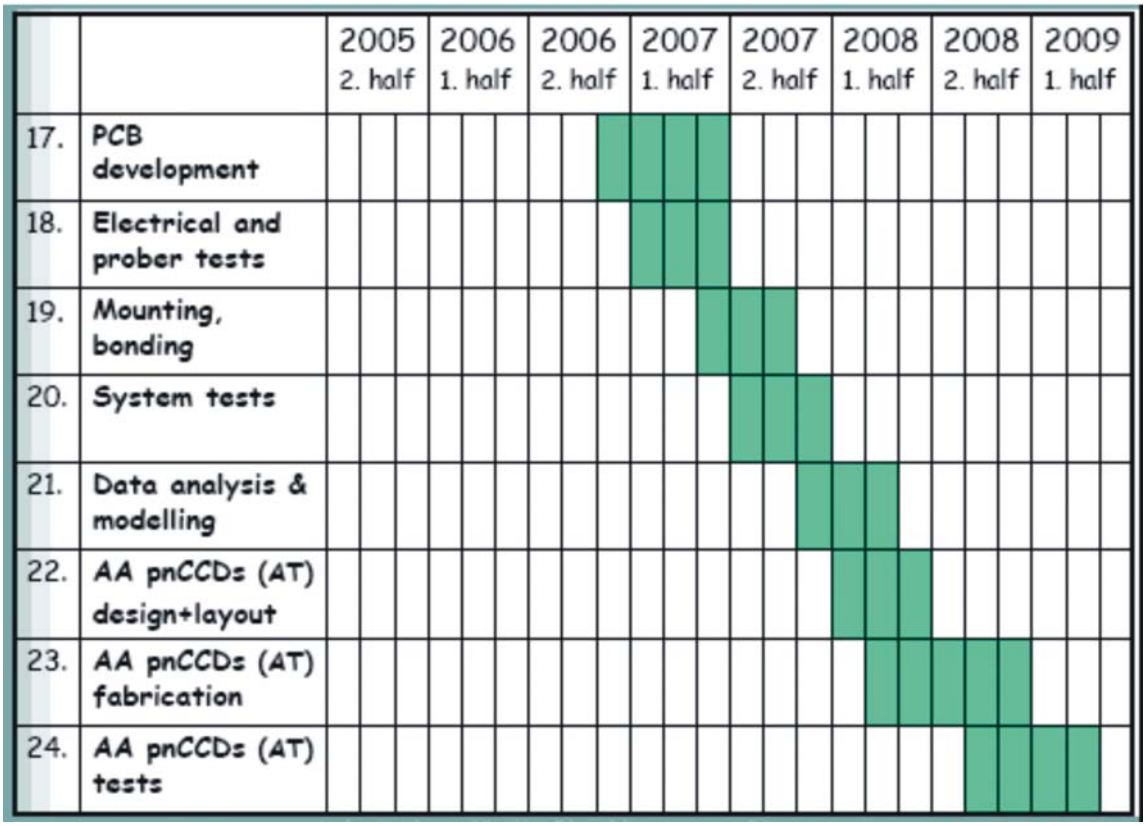
Old	New
V-0 IT: Implantation Tests (2005): completed	QT: Quick Tests (2005-06): design, fabricate and test AR coatings fabrication of individual avalanche cells with various geometries (Oct 05-Mar 06))
	Test MOSFET/JFET on-chip preamplifiers
V-1 ET: Electrical Test (2007-08):integrate CCD and Avalanche Amplifier	
Fabricate test arrays (64x64; 128x128). Test with electron feed structures	
V-2 AT: Array Test (2008-09): AApnCCDs design and layout,	
256x256 array fabrication & test. Final Report early 2009	

More details on the available results of the QT phase have been described in the mid-2005 report to OPTICON management and in response to the CDR comments (see report of the external review cited above in paragraph 1)

Schedule: The figures below show a schedule to be used internally in WP3 for the AA-PN development; the subcontract to be issued will be based on this schedule. The main steps in this schedule are part of the milestones and deliverables of WP3 listed above.


2005 2. half
2006 1. half
2006 2. half
2007 1. half
2007 2. half
2008 1. half
2008 2. half
2009 1. half
1. Avalanche strategies
2. Simulations
3. Definition of test plan
4. Tests implants & analysis (IT)
5. Technology concept
6. Design & layout of quick test
7. Fabrication of quick test (QT)
8. Tests of QT


2005 2. half
2006 1. half
2006 2. half
2007 1. half
2007 2. half
2008 1. half
2008 2. half
2009 1. half
9. Development of PCBs
10. Development of DAQs and PSs
11. Prober and parameter tests
12. Mounting and bonding of QT
13. Measurements, analysis, models
14. Simulation of elec. dev. (ET)
15. Design & layout of ET
16. Fabrication of ET



Hardware Development: Progress has been made on critical hardware components:

- production and control of deep ion implantation techniques was verified on test samples using new masking layers and new dopants (e.g. Arsenic which was used for the first time). The implant structures were verified with SIMS (=secondary ion mass spectroscopy) and spreading resistance measurements.

Avalanche test structures have been manufactured and are currently in testing.

Readout electronics and controller: an improved new CAMEX readout chip was tested. Attached to (conventional) pnCCDs, framerates of up to 1100 Hz were achieved.

Antireflective coatings: the design tools to customize ARCs for high efficiency in wide wavelength ranges were verified. Different types of ARCs were deposited on sample diodes and on CCDs. In the first case, a quantum efficiency above 90% was confirmed by measurements for the range 430nm to above 700nm. Recently two new wide band ARCs, reaching well into the near IR, were designed and experimentally verified:
* QE > 80% for wavelengths 450-1020 nm, peaking at 98% at 590nm,
* QE > 80% for wavelengths 550-1020 nm, peaking at 98% at 740nm.
These optical windows are already very close to the design goal.

Milestones and deliverables

Completion of the critical design review in September 2005 opened the path to negotiate for supporting funds from ESO and MPE. The milestones have been changed slightly in content to reflect the technology change (Avalanche Amplifier stage). Adjustments in the schedule were caused by the delay due to a more extensive design stage than anticipated.

WP4: APD array development
Following extended collaboration with University College Cork, the preliminary design stage for different size APD arrays has been undertaken. The largest planned device is a 10x10 APD array of 25micron elements with a pitch of 100micron. Smaller devices have also been designed, with different layout configurations. Due to the distance between the APD elements, a lenslet array is to be employed to increase the fill factor of the device. Mounting considerations, alignment techniques and packaging have been studied, including mounting the APD die directly on a hybrid package rather than wire bonding in a dual-in-line package well.

While our collaborators are currently fabricating and process tuning the development of the 2-d APD arrays, experimental work is continuing in NUI, Galway on linear arrays, which is providing important experimental data in relation to cross-talk between pixel elements. This data is enabling further important work in developing different quenching strategies that can be implemented for the optimum operation of the array devices.

New research carried out under this project has provided the possibility of using the APD devices at lower temperatures, down to 77K, rather than limiting the device operation to Peltier cooled temperatures. This would have significant advances in enabling the development of larger element devices, without the problem of increasing the dark count of the APD. These lower operating temperatures have proved problematic in the past, with an increase in afterpulsing. A new cryostat system, housing the APD has been constructed, with the AQC and associated novel circuitry outside the cryogenic system. This work has enabled further development of the APD array system, with operation now possible at lower temperatures, while allowing fine tuning of the AQC parameters to be adjusted during operation of the device.

With the evolving APD arrays, it has become necessary to further integrate the AQC design. As one AQC is required per pixel, the larger APD devices will require over 100 circuits, with the necessity of keeping track distances between pixel and circuit as small as possible. Hybrid AQC designs are currently in fabrication, based on surface mount technology, which will significantly reduce the size of the AQC boards.

The experimental characterisation of the devices is successfully continuing throughout the project. New experiments have been designed to allow more accurate temperature and quantum efficiency measurements. The development of a system for characterising the timing
of the APD has also been achieved with a high speed laser and acquisition board, similar to time correlated single photon counting. An afterpulsing experiment has also been implemented based on a high speed digital I/O card and associated electronics and software, to measure the autocorrelation of the APD with a resolution down to 25ns. This work has allowed further research into implementing a novel strategy for reducing after pulsing.

New PID electronics and controllers have been designed for operating the APD devices. These have been adapted to operate in either a Peltier or cryogenic system, enabling further flexibility for both packaging and operation of the APD array system. The interface definition between the hardware of the APD module and the software has been investigated, with possible strategies and solutions being discussed to cater for the large data rates.

WP5: Controller Development
Work done at USFD and Warwick

Lab-based testing of a small-format engineering grade EMCCD with the first generation

UKATC high-voltage clock driver board and SDSU-III controller was performed. This new clock-driver board can be used in any SDSU-III controller without modification, and has gain-levels which are controllable through software in 20 milliVolt steps. The new driver board
provided good stability for testing EMCCD's, but suffered from feed-through of noise onto a critical voltage supply to the CCD, meaning that we were experiencing high-frequency noise in image data. An updated clock-driver board that uses different power sources to remove this effect has now been designed. The new clock-driver board (Version 2) also allows for faster edges on the clock pulses, which we believe will enable us to minimise the clock-induced-charge effects so prevalent in EMCCD's. This second generation board was ordered at the end of the reporting period and is currently being fabricated.

Alongside the above hardware developments, low-level software (DSP) has been written to extend the functionality of SDSU-III controllers to photon-counting applications. The new DSP code sits in the SDSU-PCI card in the data acquisition PC and uses a simple thresholding
algorithm to record if a photon has been detected. This mode can easily be switched on or off and the thresholding levels can easily be change. The new code has been successfully tested with the engineering grade device.

The next 18 months call for detailed lab-based testing and optimisation of version 2 of the clock-driver board with the science grade chip. Once complete, we will have delivered EMCCD functionality to SDSU-III controllers.

Work done at UCAM

The experience of controller developers whose background is in astronomy very much puts the emphasis onto precision readout at relatively slow pixel rates. At the high pixel rates of EMCCDs, an entirely new technical approach is required in order to clock the charge efficiently and reliably at these high pixel rates without compromising other parameters such as the readout noise, dynamic range and the linearity of the CCDs. The areas that are technically rather difficult include the creation of a controller structure that allows not simply high pixel rates but can control the precise timing of the clock edges (and particularly those used by the analog to digital conversion circuitry) to a very small fraction of the pixel period. The clock drivers themselves need to be able to produce very fast clean waveforms and the signal processing system must allow the full dynamic range of the CCD even at the highest pixel rates.

The development of a controller dedicated to L3CCDs and to EMCCDs has been under development in the Institute of astronomy, University of Cambridge for some while. This work has been funded largely outside the OPTICON consortium and this source of funding came to an end in early 2005.

Because of the delay in approving funding for a technician in Cambridge relatively little progress was made on the controller during 2005. We expect the speed of progress to increase now that this technician appointment has been agreed. There was some progress, however, in the following areas:

The decision was made to move to using the Kodak KSC-1000 sequencer integrated circuit which is extremely powerful. This device is programmed serially in the same way that several other components on the controller board are programmed. In order to make this as easy to use and change as quickly as possible, we decided to use a Philips LPC2148 ARM7 based microprocessor on the camera control board. We further decided to make the camera

significantly more compact and it now is completely on a single board the same size as the original which we used in the previous generation of controller.

The basic specification of the controller is unchanged and we are progressively improving its performance and getting closer and closer to the goal performance. For example we now have the clock waveforms operating happily at 35 MHz pixel rate which is necessary for the Texas Instruments EMCCD. The current specification is:

EMCCD Controller System: minimum performance (desirable goal performance):
Must operate full frame, frame transfer and interline transfer CCDs with a high-voltage multiplication gate, and with up to four phase parallel clocks in both image and store registers.

High-voltage clocks must be able to provide 45 volt swing with 16MHz pixel rate (for E2V L3CCDs) and 25 volt swing for 35MHz pixel rate (Texas Instruments EMCCDs)

To operate at a pixel rate of at least 15MHz (35MHz). To provide clock drivers capable of working with at least 15 centimetres of track length between driver and CCD chip. To provide 14 bit digitisation at the maximum pixel rate with full double correlated sampling signal processing. To have the complete analog signal processing chain self calibrating and balancing to guarantee negligible fixed pattern noise.

The structure of the controller must allow it to be expanded to cope with significant numbers of detectors (of the order of 256) being operated in parallel and simultaneously.

The controller must be able to be operated via an industry standard ethernet/USB connection on both Windows and Linux. The data produced by the camera controller to be transmitted with high-speed LVDS drivers so that it may be attached to any industry standard frame grabber hardware that uses the AIA frame grabber interface standard.

CCD Camera Postprocessing:
Fast readout high-performance optical detectors need software at a number of different levels. At the lowest levels, the software that is required to set up and programme the controller has to be at a machine code level and closely integrated with the controller hardware development effort itself. Software at this level cannot be considered to be common in any useful sense although it is important to establish communication standards between the higher level software that needs to grab the camera resource and control it properly.

The EMCCDs are capable of producing very large amounts of data indeed. The sort of volume of data produced by a single Texas Instruments EMCCD is greater than can be handled by a PCI interface card and very quickly any real computer system will become overwhelmed. The consequence of this is that it is essential to integrate the hardware with some kind of high-speed processing system that can extract the information required from the images in real time and pass the results to the host computer with a greatly reduced data bandwidth requirement. JRA3 provided the funding in principle for two-man years of effort but the delay in the funds actually becoming available and then the delays in actually recruiting someone meant that we were unable to get anyone in post until November, 2004, when Frank Suess joined our group for a 2-year appointment. Frank has considerable experience in writing software for CCD systems used in the physical and life sciences as well as having a lot of experience of dealing with digital signal processor systems such as will be important for some of the work with L3CCDs. Frank Suess has made considerable progress investigating a variety of commercially available DSP hardware solutions which have sophisticated development software packages as well. We had hardware manufactured by

Bittware but on much closer investigation we discovered that although it had remarkable levels of processing power, the data bus on the board ran at rather a low rate and was shared by all the processors on the board. Our calculation suggested it would be a major bottleneck and that the processing power was simply not realisable. As a consequence we looked for other boards and generally found that the choice was extremely small. We are currently using a very promising board manufactured by Matrox called the Odyssey. This uses a custom FPGA on board to provide a good number of DSP elements within the chip. The overall processing power looks very promising and it is well integrated with a frame grabber part of the hardware which is important for these applications. It has a further advantage that the library sold with the board is very well developed and compatible with other frame grabbers. This allows the camera to be used with either a standard frame grabber or with the DSP interchangeably.

We are using a commercially written software package for controlling the camera which runs under Windows quite satisfactorily at present. The overall common software development of a system that can control a wide range detectors is being handled elsewhere but it is important that whatever is done is able to operate both under Linux as well is under Windows since the most advanced technical solutions in DSP hardware and FPGA programming all require their development to be done under Windows, the environment in which all the development software operates.

Overall Hardware Design

The boards are mounted on a second printed circuit board which is extended into the vacuum enclosure of the dewar. It is important when designing high-speed camera electronics to minimise the distance between the clock drivers and the CCD, and also to minimise the distance between the CCD and the signal processing and electronics. This latter problem can be avoided by using a buffer transistor adjacent to the CCD and this is what we have chosen to do.

We can make a high-quality vacuum seal by bringing all the signal tracks through the wall of the dewar on an internal PCB layer and by using a gold plated copper area to provide a reliable vacuum seal. We have used this method successfully and found that it gives a good and reliable platform for driving the CCD as well as providing a structure that is easy to work with both when it is outside the dewar and when it is within it. It also appears to have good vacuum integrity and very low out-gassing rates.

Scientific Results

The camera system we have developed has been used extensively on the Nordic optical telescope (NOT) on La Palma as part of a programme of Lucky Imaging. Several research papers have been published and a number of talks at international conferences and other venues have been given. The system has routinely allowed us to produce images with resolution very similar to that obtained with the Hubble Space Telescope, but from ground-based telescope and had an incredibly small fraction of the total cost of Hubble. An example of one of the images we obtained is shown below.

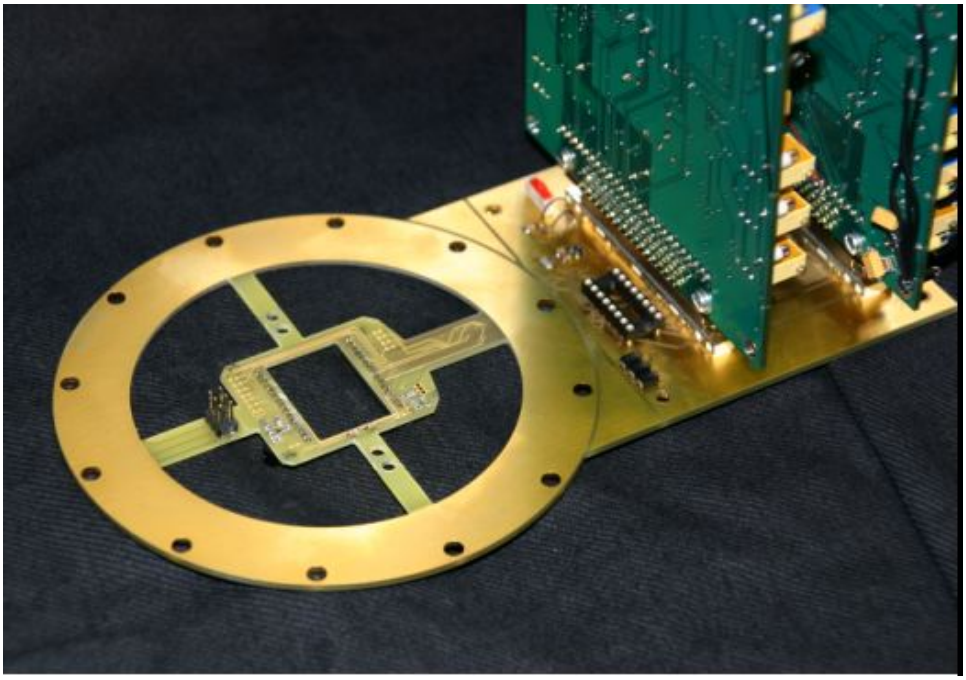


Figure 1: the fibreglass spider that supports the CCD at its centre is shown here with the camera boards attached. The signal tracks enter the vacuum dewar wall indicated by the circle of holes within the fibreglass sandwich and are brought out to contacts once they are within the vacuum enclosure. Connections are also provided for monitoring and controlling the CCD temperature within the dewar. The fibreglass structure provides reliable support for the detector while allowing it to achieve a satisfactorily low temperature.

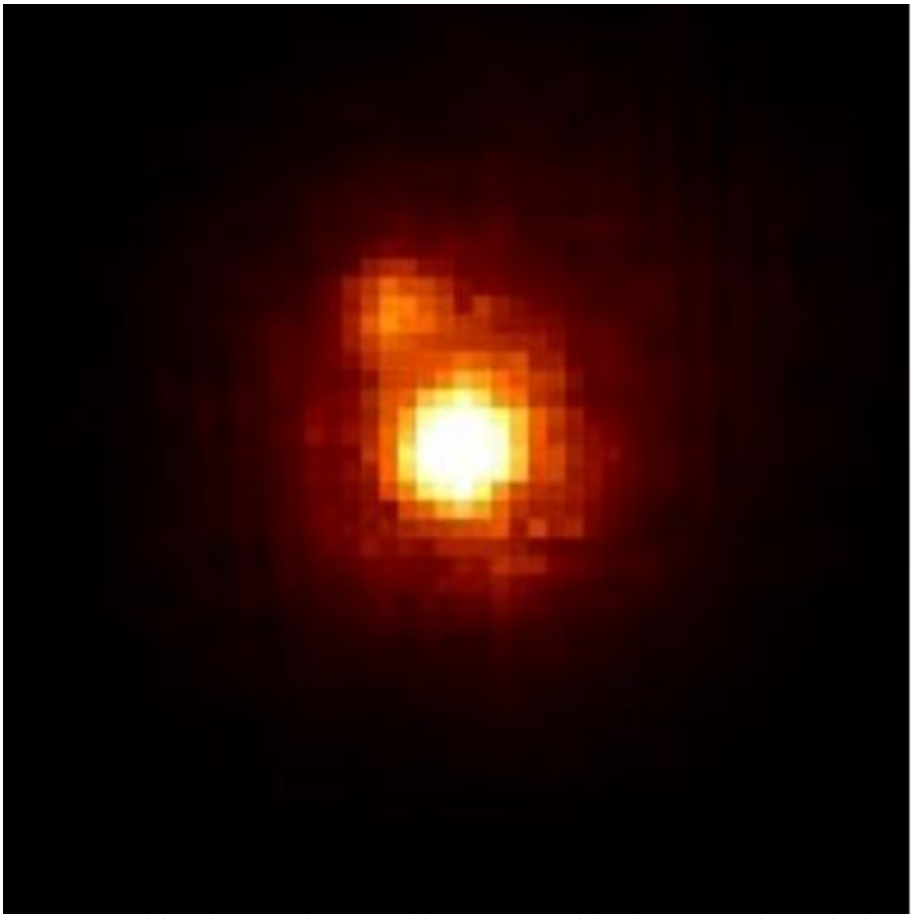


Figure 2: this picture shows a binary star with the separation of about 0.12 arc seconds observed with the EMCCD camera developed here as part of the Lucky Imaging programme we are carrying out on the NOT telescope on la Palma. The brightness difference between the two stars is about 2.5 magnitudes. The image was taken in the I-band (850 nm).

Competitiveness of R&D Programme

Although there is a lot of interest in the application of EMCCDs in astronomy, most of the work being undertaken is targeting relatively low pixel rates. There are now commercially available cameras able to work in a limited range of formats at pixel rates up to 10MHz but, to our knowledge, nobody is even close to contemplating building controllers that are really able to work at the maximum rate that these devices are capable of. In addition, all the commercial designs are only intended to be capable of driving single detector systems and none are, to our knowledge, working on their integration with intelligent image processors. What is also clear is that the commercial offerings are very poor in terms of clock induced charge. Commercial cameras must operate with the internal gain turned off to be able to cope with the large signal levels that the CCD can transfer. This in turn forces the use of relatively high clock levels. When designing a camera for very low level operation the clock levels can be reduced and the waveforms tailored to minimise clock induced charge. In this way we find that we are running at levels that are typically 10-100 times lower than that obtained with commercial cameras. This difference is undoubtedly critical to the ability of these cameras to work effectively at the lowest light levels.

The conclusion is, therefore, that this work is highly competitive and is not being done by any other groups. In addition because of the novel properties of these detectors we are likely to continue to be in a world-leading position in respect of these technologies.

WP6: Common Software Development

The development of software according to the preliminary design has been delayed due to the priorities set by the development of the lower-level software. Software modules suitable for higher level common software have been developed at UCAM and tested under realistic conditions. A significant additional software effort will be needed for the common-level software (image analysis, data compression, archiving). The estimated date for the deliverable is now contract month 48.

WP7: Cooled Camera Head Development

Work done at UKATC

The UKATC dewar reported on last year was used to perform all the lab-based testing of EMCCD's. To perform the forthcoming on-sky tests, however, we will have to mount the EMCCD in a cryostat which can be mounted on an existing optical spectrograph. Following discussions with ESO, we have identified the EFOSC spectrograph on the 3.6-m telescope at La Silla as ideal for our requirements, and we have therefore just taken delivery of an ESO cryostat at Sheffield, where it will be modified to accept our science grade EMCCD. With this, milestone M1 has been achieved.

In view of the change of strategy concerning the common test bed as explained above under WP1 (management) deliverable D1 has been adjusted: delivery will be on a specific testbed, not the common testbed originally envisaged.

Work done at IoA

The work for WP7 that was to be undertaken at UCAM has been described in the report on WP5 under "overall hardware design". If we are to achieve photon counting performance with these detectors then it will be necessary to use liquid nitrogen cooling and the sort of structure that we are developing integrated with the controller looks to be a satisfactory way forward. For some applications it may be preferable to use thermoelectric cooling but we have no resources to allow us to pursue that possibility within JRA3. Another possibility of course would be to operate these detectors using mechanical refrigerators that achieve temperatures close to that of liquid nitrogen for situations where the use of liquid nitrogen would be unacceptable. This is a fairly straightforward and known technology and does not really merit any particular effort at this stage since it is principally a matter of straightforward engineering.

WP8: Common testbed

A first evaluation of the requirements and prospects of a common test bed for the characterization of the three technologies pursued in JRA3 has taken place (M1). It revealed that since the start of the programme, the technologies have developed in such a way that most of the steps necessary for characterization are probably done quicker and more economically on indvidual test beds. For this reason, there is no need for a common testbed in hardware form. To achieve the primary goal of WP8, a comparative characterization on the basis of which the relative merits of the technologies for high time resolution astronomy can be assessed, asoftware based solution will be implemented instead, using as input the characteristics of the devices established on their individual test beds. The development and application of this software will achieve the content of the milesones and deliverables of WP8.

Milestones and Deliverables:

Activity (NAx; JRAy)	Deliverable/ Milestone No	Deliverable/milestone name	Work-package /Task	Lead Contractor(s)	Planned (in months)	Achieved (in months)
JRA3	M2	Critical Design Review	WP1	MPA	18	22
JRA3	M1	Specification of EMCCD to be procured fixed	WP2	USFD	3	15
JRA3	M2	CCD chip procurement	WP2	USFD	6	21
JRA3	M2	Critical design of AA-PNSensor	WP3	MPG-MPE	9	22
JRA3	M2	Critical design fast timing controller L3CCD	WP5	UCAM	12	12
JRA3	M3	Interface with higher level software defined	WP5	UCAM	18	18
JRA3	D1	Fast timing controller L3CCD	WP5	UCAM	12	18
JRA3	M1	Software requirements and implementation plan	WP6	UCAM	12	12

Note Milestone WP8 M1 has been deleted, since a common hard ware test bed has been replaced by software simulation. It's functional equivalent is now part of deliverable D1.

List of Meetings

Name of Meeting 1	Activity	Date and Location	Number of Contractor(s) represented	Any participants present external to network	Total no. of Attendees	Web-link/URL
Main JRA3 Progress meeting	JRA3	14-15 February, 2005, Heidelberg	7	G Gilmore, IoA	7	http://www.astro-opticon.org/agendas_minutes/minutes_jra3_feb05.doc

Description/Purpose:
The main JRA3 meeting was held at the Landessternwarte Heidelberg, 14-15 February 2005, in the presence of OPTICON management (represented by G. Gilmore). Year 1 progress and reports on year 1 were reviewed, discussed and presented to the OPTICON internal reviewer (GG). Detailed plans of the individual workpackages were adjusted according to progress in year 1.

Name of Meeting 2	Activity (NAx; JRAy)	Date and Location (e.g dd/mm/yy, Paris)	Number of Contractor(s) represented	Any participants present external to network	No. of Attendees	Web-link/URL, if any
Evaluation and comparison of Workpackages	JRA3	19-20 October, 2005, Galway	8	0	8	Minutes

Description/Purpose:

A second meeting was held 19-20 October 2005 in Galway, Ireland, with focus on evaluation and comparison of the 7 workpackages.

1.5.4 JRA4: Integrating optical interferometry into mainstream astronomy

The total human effort deployed during this reporting period for JRA4 is summarized in the following table:

Participant number[21]	Participant short name[22]	Person-months[23]
6a	INSU/CNRS	126.4
1b	UCAM/CAV	28 (12)
8e	INAF	21
11a	MPIA	22.8 (13)
11f	MPIfR	12 (12)
12	NOVA	1.25 (1)
21b	Ulg	0
30	Konkoly Observatory	8 (6)
31	ONERA	7
32	CAUP	12.5 (8.3)
33	Technion	9.16 (6.16)
34	NCU/UMK	10 (5)
36	UNIGE	2.4 (2.4)
38	OO	1 (1)
41	UNIVIE	6 (4)
Total		**258.05 (70.86)**

JRA4 is aimed at studying the second generation of VLTI instruments (WP1.1 & WP1.2) and at producing software to interpret interferometric observables in terms of astrophysical observables (WP2).

A web page at the address: http://eii-jra4.ujf-grenoble.fr, was organised for JRA4. It contains the description of the work packages, lists of contributors, working group and all the documents produced within JRA4.

WP1.1: Concept to feasibility studies

The first phase of this work package (Jan04-Jun05) is over. The detailed concept studies of the six second generation instruments for the VLTI (APRES-MIDI, BULK OPTICS, VEGA, VIDA, VITRUV, UVES-I), developed within WP1.1, have been presented at the ESO/EII common workshop of April 2005 in Garching.

At the end of the Garching meeting (April 8th 2005), the Scientific Council of the EII (Euro-Interferometry Initiative) made an evaluation of the concepts. It has classified APRES-MIDI and VITRUV as top priorities and selected these instruments for feasibility studies.

The ESO STC in April did not take any decision concerning the second generation of VLTI instruments (here and after I2) and proposed to first set up a recovery plan for the VLTI. At the next STC meeting in October, the progress of the activities to overcome the VLTI

[21] Lead participant first

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

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

technical internal problems were appreciated and concepts for I2 were proposed and presented by the leading consortia. The STC recommended to ESO to solicit formal proposals for phase A studies of I2, capable of recombining light from up to four telescopes with phase reference, with a deadline of January 30th 2006. The two concepts selected by the Scientific Council of the EII together with the instrument Gravity have been proposed:

- Matisse (formerly Apres-Midi): 4 way beam combiner in the mid IR (PI: OCA, Nice)
- Vitruv-I (formerly Vitruv): 4 to 8 beam combiner in the near IR with integrated optics (PI: LAOG, Grenoble)
- Gravity: Optimized to study gravitational effect in the Galactic Center (PI: MPG)

Milestones and Deliverables

M1: ESO/EII common workshop: "The Power of Optical/IR Interferometry: Recent Scientific Results and Second Generation VLTI Instrumentation", 6-8 April 2005. Done

D2: Instrument concept reports. Done. See the references below.

http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-TRE-1110-0001.pdf (UVES-I)
http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-TRE-1120-0001.pdf (Bulk Optics)
http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-TRE-1130-0001.pdf (APRES-MIDI)
http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-TRE-1140-0001.pdf (VEGA - Concept)
http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-TRE-1140-0002.pdf (VEGA - Science)
http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-TRE-1150-0001.pdf (VIDA)
http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-TRE-1160-0001.pdf (VITRUV - Concept)
http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-TRE-1160-0002.pdf (VITRUV - Science)
http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-TRE-1160-0003.pdf (VITRUV - Manag.)
http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-TRE-1160-0004.pdf (VITRUV - System)

D3: List of contributors to feasibility studies (note that this list may evolve after ESO selection next spring). Done

- Matisse: INSU/OCA (6a), MPIA (11a), MPIfR (11f), Konkoly Observatory (30), MCU/UMK (34), UNIVIE (41)
- Vitruv-I: INSU/LAOG (6a), UCAM/CAV (1b), MPIfR (11f), Ulg (21b), CAUP (32)

Future plans: ESO should select the concepts for phase A studies next spring. After ESO selection, hopefully two or three phase A studies will be started. The next STC in 2007 may decide on the outcome of these studies. With these steps, the next generation of VLTI instruments should have a good chance to get on track. From now on, the milestones and deliverables of WP1.1 will match those defined by ESO.

WP1.2: Cophasing and fringe tracking

The work package 1.2 is focused on analysis and optimisation in three areas:

- Current cophasing instrumentation performances
- Measurement operations
- Cophasing scheme for future instruments

A working group has been settled for WP1.2. Tasks have been identified and distributed among participants. A detailed progress report can be found in the deliverable D2 (see

below), and the most recent results have been published in the proceedings of the ESO/EII common workshop of April 2005, held in Garching.

The work breakdown is as follows:

- VLTI fringe sensor and PRIMA FSU (INAF/OATo)
- Multiple beam combination concepts (Technion)
- Dispersed speckle method (INSU/LISE)
- LINC-NIRVANA Fringe-And-Flexure Tracker for LBT (Koln)
- Group Delay Tracking (INSU/Bordeaux)
- Phase retrieval/diversity (ONERA)

A meeting of the working group was organized in Cambridge on September 29-30th 2005 (see D2 for the minutes), to share experiences and to improve communications within the group. The initial task list has been revised accordingly to match the current understanding of the problems and various topics of collaboration have been identified. The priority in the near future activity shall be focused on the following tasks:

- Analysis of performances of current fringe tracking systems
- Fringe sensors detection schemes
- Multi-beam fringe sensor concepts

Detailed review of the results and planning for subsequent steps is foreseen in the next CFT meeting, tentatively set in Summer 2006.

The main project supported by EU funds within WP1.2 concerns the work in progress at INAF-OATo on the design and analysis activity for the PRIMA FSU and the setup optimisation for FINITO. In 2005, the work on integration of the PRIMA FSU A and B continued, with preliminary acceptance in Europe and delivery to ESO/Garching planned for January 2006. On February 2005, ESO appointed a team with the purpose of assessing the current performance limitations of fringe tracking with FINITO. The main conclusions are that primary limitations to fringe tracking on UT are OPD vibrations in the telescope and beam transport, and that, although it needs improvements, fringe tracking with FINITO has the potential to deliver stable fringes to instruments. The proposed improvements are vibration and tunnel seeing mitigation, variable curvature mirrors commissioning, and improvements to the algorithms of FINITO and delay line control.

Deliverables

The milestone M1 (first phase review) has been replaced by the deliverable D2: 1st Progress Report on CFT. Done.
http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-TRE-1200-0001.pdf

Future plans: Detailed review of the results and planning for subsequent steps is foreseen in the next CFT meeting, tentatively set in Summer 2006.

WP2: Off-line data reduction software

WP2 is aimed at delivering two successive versions of software of general use in a 5 year span, starting from “scratch”. This software aims at facilitating the use of large modern interferometric facilities such as ESO's VLTI to an end-user non-specialist in Optical

interferometry. Due to the complexity of the task the work is split into 5 tasks:

- WP2.1: General Management and User Support
- WP2.2: Common Software
- WP2.3: Model fitting
- WP2.4: Astrometry
- WP2.5: Image Reconstruction

The work packages 2.3, 2.4 and 2.5 evolve quite independently from each other, and provide an aspect of the whole package. Work packages 2.1 and 2.2 coordinate, provide common tools for the three other packages, and are responsible of the software integration and tests. All the Tasks are scheduled to arrive at the same time at each software acceptance release.

See http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-TRE-2000-0004.pdf for the detailed progress report of the year 2005. Because of the late arrival of EU funds, all activities have been shifted by 6 months. For WP2.2, 2.3, 2.4 and 2.5, the milestone M1 (Preliminary Design Review) and the deliverable D1 (Software Functional Specifications) have been replaced by the Software User Requirements. In brief:

WP2.1 General management and user support

No deliverable for the reporting period

WP2.2: Common software Milestones and deliverables: D1 (Software User Requirements). Done. See the link:
http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-SPE-2200-0001.pdf
The Milestone M2 (Final Design Review) and the deliverable D2 (Software Design Description) have been delayed 6 months.

WP2.3 Model Fitting (INSU/CNRS/CRAL): Milestones and deliverables: D1 (Software User Requirements). Done. See the link:
http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-SPE-2300-0001.pdf
The Milestone M2 (Final Design Review) and the deliverable D2 (Software Design Description) have been delayed 6 months.

WP2.4 Astrometry(UL, UNIGE): This WP has been delayed by about 12 months because of the late arrival of EU funds and difficulties in hiring specialists). It has been decided following a kickoff meeting early 2005, that the Geneva University and Leiden University will work separately, and therefore each of them will write their own documents for the software development.

- Geneva University will develop the algorithms and the software prototype allowing the retrieval of stellar relative parallactic motion and orbital parameters of binary stars and stars hosting planets using the narrow angle astrometry mode of PRIMA.
- Leiden University will provide the Interactive Data Analysis Facilities (IDAF) which is part of PRIMA Data Reduction Software, and will make this tool usable by the wider astronomer community.

Milestones and Deliverables: The Milestone M1 (Preliminary Design Review) and the deliverable D1 (Software User Requirements) have been delayed 12 months.

WP2.5 Image Reconstruction (1/ INSU/CNRS/CRAL & ONERA, 2/ UCAM/CAV, 3/ MPIA & MPIfR, 4/ UGR/IAA): Two groups will provide software for image reconstruction. The CRAL/ONERA group will provide a general software dedicated to interferometric data. The MPIfR group will provide a software dedicated to LBT data. The Cambridge group has participated to the elaboration of the User Requirements and will provide at least a robustness report on the algorithm it is developing. All groups have participated to the "Image Beauty Contest" organized by P. Lawson in 2005; see Lawson et al., 2005, *An Interferometry imaging beauty contest,* SPIE 5491, 886.

Milestones and Deliverables: D1 (Software User Requirements). Done. See the links:
http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-SPE-2500-0001.pdf
http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-SPE-2530-0001.pdf

The WP2 project as a whole, and considering the delays that occurred in the first six month, has progressed according to both its internal schedule, with its numerous deliverables, and according to the EU deliverables and Milestones.

Milestones and Deliverables

Activity	**Deliverable/ Milestone No**	**Deliverable/ Milestone Name**	**Work Package/ Task No**	**Planned in (months)**	**Achieved in (months)**
JRA4	M1	ESO/EII common workshop, 6-8 April 2005	1.1	16	16
JRA4	D2	Instrument concept reports	1.1	16	16
JRA4	D3	List of contributors to feasibility studies	1.1	16	24
JRA4	D2[1]	1st Progress Report on CFT	1.2	18	18
JRA4	M1	Preliminary Design Review	2.2	18	18
JRA4	D1[2]	Software User Requirements	2.2	18	18
JRA4	M2	Final Design Review	2.2	24	Delayed 6m
JRA4	D2	Software Design Description	2.2	24	Delayed 6m
JRA4	M1	Preliminary Design Review	2.3	18	18
JRA4	D1[2]	Software User Requirements	2.3	18	18
JRA4	M2	Final Design Review	2.3	24	Delayed 6m
JRA4	D2	Software Design Description	2.3	24	Delayed 6m
JRA4	M1	Preliminary Design Review	2.4	18	Delayed 12m

[1] Deliverable D2 replace the Milestone M1 (First Phase Review)
[2] The Deliverable D1 (Software User Requirements) replace the Software Functional Specifications

JRA4	D1	Software User Requirements	2.4	18	Delayed 12m
JRA4	M1	Preliminary Design Review	2.5	18	24
JRA4	D1[2]	Software User Requirements	2.5	18	24

List of Meetings

Date	**Workshop/Meeting**	**Location**	**Number of attendees**	**Website address**
April 6-8th	ESO/EII common workshop: "The Power of Optical/IR Interferometry: Recent Scientific Results and Second Generation VLTI Instrumentation"	Garching	250	http://www.eso.org
April 8th	EII Scientific Council Meeting	Garching	20	http://www.mpia-hd.mpg.de/euinterf/
September 9th	EII Scientific Council Meeting	Praga	20	http://www.mpia-hd.mpg.de/euinterf/
September 29-30th	Meeting of the CFT working group	Cambridge	8	http://eii-jra4.ujf-grenoble.fr/doc/approved/JRA4-TRE-1200-0001.pdf

1.5.5 JRA5: Smart Focal Planes

Participating Contractors and Effort Deployed

Participant number	**1**	**2b**	**5**	**6c**	**6d**	**7a**	**8d**
Participant short name	UCAM-IOA	PPARC	CSEM SA	CRAL	LAM	IAC	Padua
Person-months	TBD	34.8	9.8	TBD	49	2	12
Participant number	**10**	**26**	**35**	**44**	**45**	**47a**	
Participant short name	ASTRON	UNI BREMEN	UNIV DURHAM	Reflex s r o	TNO/TPD	AAT Board	**Total**
Person-months	14	6(6)	26	4	2	12	**TBD**

Introduction

The momentum built up in the Smart Focal Planes JRA in the second half of 2004 has been maintained throughout 2005, and the high level of effort that the participants have expended on the various parts to the JRA has been rewarded with technical progress across a number of areas. To reiterate, the project goal is the development of technologies to gain maximum scientific benefit from the focal planes of Extremely Large Telescopes by targeting the objects to be observed in the most effective manner. The strategy to achieve this has been to develop a Smart Focal Plane roadmap to identify which technologies to target, and to develop instrument concepts which link scientific goals with specific parameters for these technologies. Further the strategy has involved bringing together partners together that have complimentary expertise to progress these technologies and to focus on increasing the Technology Readiness Level of all the technologies under development.

2005 has been a year of concerted effort with 83% of the planned expenditure for the 18 months Jan 05 to June 06 spent. The consequence of this is that to maintain the project at the same level will involve a contraction of the project from 4 years to 3.5 years.

WP 1.0 Management (PPARC)

The provision of the 2nd 18 month plan was successfully completed at the start of the year. Planning changes arising from CSEM's change to a FC cost model from an AC model were introduced. AAT's desire to change from an AC model to a FC model, which was rejected by the EU, has caused some planning difficulties but these have been resolved. Continued use has been made of the restricted web-page https://ssl.roe.ac.uk/twiki/bin/viewauth/Smartfp/ for JRA5 participants and the use of emails and telecons for managerial purposes. An overall consortium meeting with all participants was held in November to determine the technologies to progress to prototyping in the next 18 month phase.

WP 1.1 System Design and Systems Engineering

The specifications for the technologies being developed within JRA5 have been set by two "Smart " instrument concepts that were developed within this workpackage, principally by the UKATC (PPARC) with additional support from LAM and IAC. The first is an Integral Field Unit (IFU) based Multi-Object Spectrograph (MOS) and the second is a multi-slit based

MOS.

The IFU based MOS is based on the original concept for the Multi-Object Multi-field Spectrometer and Imager (MOMSI). Our SMART-MOMSI concept involves positioning 100-200 pickoff mirrors across a 350-mm diameter, cryogenic focal surface. This surface is spherical and convex, with a nominal radius of curvature of ~2 metres. Each pickoff relays a 100-milliarcsecond subfield to out-of-plane relay optics for spectroscopic analysis. The required pickoff field of view, and modelling of the relay optical path, determines that the pickoffs should have an aperture around 5 mm in diameter. Subfield image stability of near a tenth of a resolution element must be maintained during an exposure, and field configurations must be reproduced to the same few micron accuracy. Such positioning tolerances significantly exceed those of any existing instrument.

The second instrument concept "Smart-MOS" we have developed to derive technology specifications aims to fill the ample scientific niche for a large field of view NIR MOS instrument, employs seeing-limited or ground layer adaptive optics. The science case for a SMART–MOS instrument points to a large FOV of up to 4 arcmin. However, initial optical design studies suggest that it would be very hard to obtain a field of over one arcmin for OWL and so a FOV of 1 arcmin was taken as the baseline. This specification results in the need for an exceedingly fast camera, of the order of f/1 (for a 2k detector array with 18 micron pixels). It is highly desirable that the slit is fully reconfigurable in a short time to allow for efficient operation of the instrument. This suggests that custom manufactured replaceable slit masks will not be practical in a cryogenic instrument. The two options we have considered are mechanically reconfigurable multi-slit masks and programmable micro-shutters or mirrors based on MOEMs devices.

WP 2.1 Image Slicers (CRAL)

CRAL undertook the development of an image slicer which has gone on to be the basis of the image slicers which are to be included within the MUSE instrument for VLT.

In the first year of the programme the CRAL activities covered the preparation of test and plans and the establishment of an optical test bench assembly. The second year has consisted of the build and test of a slicer consisting of 38 curved, tilted mirrors. The prototype consisted of 12 active slices and 26 dummies. The optical test bench comprises three independent modules with an illumination unit, a telescope pupil unit and a detection unit. Measurements in the intermediate pupil plane enables a determination of the location of the pupils and hence errors in alignment of the slicers. The prototype showed 2 pupils out of tolerance, one of which which was attributed to a manufacturing error and the other to an assembly error. The validation of the magnification of the system was made with no alignment and cross-talk.

The CRAL part of WP 2.1 has been successfully completed.

WP 2.1 Image Slicers (Padua)

Challenger mandrels (described in 2004 annual report) were replicated using the Media Lario galvanic technique and tested by the University of Padua. These results showed that there was no significant mandrel wear and that the replicas are only slightly rougher in surface finish. The results showed shape deflection of the mandrels of typically 5 microns – determining means to reduce this deflection to less than 0.25 microns.

Investigations have been undertaken on the use of Nickel Phosphide coatings on aluminium mandrels, but it was found to offer marginal advantage .

WP 2.1 Image Slicers (Uni Bremen)

University of Bremen have participated in the image slicer development through the production of custom challenger mandrels, and image slicer pupil mirrors, to designs produced by the University of Durham. Micro-surface roughnesses were typically 10 microns. These mandrels were subsequently replicated at the Reflex and University of Padua (Media Lario).

This work package has been successfully completed.

WP 2.1 Image Slicers (Univ Durham)

University of Durham have continued to manage the investigation of electrochemical replication of integral field unit image slicers, and to provide technical guidance and to undertake comparative measurements on the mandrels and test pieces.

Goal specifications were formulated at the start of the programme based upon the preliminary considerations of the MOMSI concept which is to be the subject of a FP6 point-design study.

The parameter space of IFU replication include mandrel material, surface topology and replication methods being used. Apart from that there are special requirements of the small surfaces, being very near together to each other. The conditions of the surface border, as used in x-ray mirror replication, seems to clash with the need for a high fill factor of a slicing mirror array in and IFU. Hence it was necessary to challenge these border conditions.

Results are that:

- For an aluminium mandrel there is no minimum chamfer size / step angle so that the fill factor for replicated slicers can be very high.
- Deterioration in surface roughness on replication is tolerable, and that there is on some occasions evidence of improved microroughness
- Replication from Zerodur mandrels did not result in replicated parts as the mandrels broke on separation. The Zerodur would appear to make too good an optical contact with the alloy replica.
- Modelling shows that replication become an attractive means of manufacture when the number of image slicers exceeds approximately 20.
- There is a problem with shape deviation as discussed in section 2.1 Padua, which requires to be addressed.

WP 2.1 Image Slicers (Reflex sro)

Galvanic techniques were used by Reflex to replicate test mandrels, challenger mandrels coated with NiP, the GNIRS slicing mirror array and the MIRI slicer mirror.

Reflex undertook test measurements (discussed elsewhere in this report) using atomic force microscopy, a Taylor Hobson profilometer and a Zygo interferometer.

Results from Reflex were generally similar to those from Media Lario though there is some inconclusive evidence that the releasing agent used by Reflex results in slightly improved surface roughness.

Reflex have plans for changing the bath chemistry in order to reduce the stresses on the replica parts and so reduce the shape deformation exhibited by the replicas.

WP 2.1 Image Slicers (TNO/TPD)

The activities of TNO were in the area of Integral Field Unit Modelling and Technology. This included:

- Modelling of the IFU including the interfacing with preceding and following units in the optical chain. This model enables the coupling of the IFU with the spectrometer chain to be optimised.
- Investigation of the technological issues concerning the production of IFU key components (slicer and mirror array following the slicer). An experimental monolithic image slicer was produced and its optical properties measured. The measurement results so far support the validity of the manufacturing approach adopted.
- Discussion of a practical example (IFU proposed for NIRSPEC) enabling the testing and illustration of the study results.

WP 2.2 Beam Manipulators (AAO)

This work has been directed at the development of "starbugs" which are independently controllable microrobots capable of deploying arbitrary optical payloads across an optical surface. The number of prototypes developed was extended from 6 to 12 during 2005. The Smart MOMSI specific goals were for a starbug with footprint of 10 mm, positional accuracy of ~1 micron, microtracking up to 50 micron, bug rotation, adherence to a focal plane at 90° and operation at 70K.

The starbug which best met the requirements was called Res-J. This demonstrated a footprint of 6 mm, arbitrary x-y and rotation motion with step increment < 2 micron, speed of motion up to 5 mm/s, operation to -100 °C, closed loop operation with feedback under an arbitrary gravity vector.

An alternative concept for pick-off positioning was also developed. Called the "crowdsurfer" this gets rounds the potential difficulty of trailing wires for the starbugs by having the actuators attached to the focal surface. Though at an earlier stage of development this approach has obvious potential.

WP 2.2 Beam Manipulators (LAM)

The beam manipulator work by LAM is being undertaken within the context of the Smart MOMSI instrument concept. The technical goal of this work is to produce a system which is capable of acquiring the astronomical target selected by the ~100 pick-off mirrors, and reimaging it on to a spectrograph. The system consists of two mirrors, a larger beam steering mirror and a smaller active deformable mirror. Importantly this system must operate at cryogenic temperatures. Note that to our knowledge there to date there has been no use made of active optics in on-sky instruments.

To date this work has involved:

- Development of a novel beam manipulator concept including Zemax model
- Analysis of techniques and materials (aluminium and nitonol) for use in the beam steering mirror

- Development of a metrology concept for the beam manipulator subsystem with an IDL model involving pyramid wavefront sensors.

WP 3.1 Fibre Systems (UCAM-IOA)

UCAM-IOA have produced a report on the use of optical fibre technologies in Smart Focal Planes. Central to this is an analysis of the manufacturing issues which covered lens arrays, cryogenic performance, miniaturisation and quality control. In relation to material properties the report covers the status of silica fibres for the visible as well as fluoride and chalcogenide for the near infrared as well as the advantages of new photonic crystal fibres. In addition a new concept was presented for a Near Infrared Multi Fibre IFU Instrument which is both robotic and highly configurable.

WP 3.2 Reconfigurable Slits and Masks and WP 2.2 Beam Manipulators (CSEM-SA)

This work was focused on developing the JWST reconfigurable slit mask subsystem and making technical advances to make it suitable for use in a major terrestrial instrument. In particular the goal was to reduce the cost of the sliding bars which were very expensive, which is an obstacle to the use of this mask concept in large MOS systems.

On the basis of the bar design used in the CSEM prototype for JWST various alternative designs have been explored which are both lighter and promise a reduction of manufacturing cost. As a first improvement step, a sample bar was manufactured by milling only, which reduced the manufacturing cost by about half. The outcome was analysed and found adequate to the requirements. This advance has contributed to CSEM being awarded a commission by Caltech to develop a reconfigurable slit mask system for the Keck telescopes.

WP 3.2 Reconfigurable Slits and Masks (IAC)

This work has been directed at the design, fabrication and test of several high precision mechanisms for use in cryogenic instruments. In particular IAC evaluated the properties of several combinations of materials which might be used in the building of mechanisms functional at cryogenic temperatures. Specifically, the behaviour of the materials under forced dynamical friction was characterised.

Comprehensive testing and analysis showed that nituff-nituff and stainless steel bronze N6 were acceptable materials in terms of friction and breakwear, but that “soft” materials such as Al6061 are not appropriate.

WP 3.2 Reconfigurable Slits and Masks (ASTRON)

This work was directed towards the development of a linear micropositioner with a precision level of 100 nm, a sliding range of between 10 – 100 mm, and a small space envelope. This should be operable at cryogenic temperatures.

In 2005 the following work was undertaken in the area of linear slides and actuators for cryogenic temperatures.

- Test of potential solutions on friction and accuracy:
- Design build and test of a sliding prototype without an actuator.
  Suitable materials were ascertained. Tests on slider bearing materials are currently underway.

- Test of the most promising actuator(s)
  Two solutions were tested, a Squiggle and a piezolegs solution, each of which have different potential astronomical applications.
- Combination of slide bearing prototype and actuator,

WP 3.3 MOEMS

The development of micro-mirror arrays has been carried out within the framework provided by the Smart-MOS instrument concept which has been used to guide the technology goals for this work. This has involved:

- Review European microtechnologies laboratories and industries with the selection of IMT, Neuchatel as the preferred partner.
- Modeling multi-sit device to determine impact on overall MOS instrument performance, with validation using existing MOEMs devices.

WP 4.0 and Management (PPARC)

Continuation of WP 1.0 described above

WP 5.0 Trade off Study (PPARC)

A trade-off study was undertaken to determine which pick-off mirror technology would be taken forward as the preferred option to full prototype level. The autonomy of starbugs as seen as having many attractive features particularly in relation to its ease of reconfiguration. The JRA would have liked to have proceed both with starbugs and the Planetary Positioner system, but given the very limited resource has concluded that the Planetary Positioner System is the preferred option as it offers the most scalable approach to one hundred plus pick-off-mirrors.

WP 6.1 Prototype IFU (PPARC, Durham, Reflex, Padua)

WP 6.1 is an extension of the activities of WP 2.1 Image Slicers, with the addition of the design of an slicer replication challenger which was undertaken by the UKATC (PPARC) which will enable the most exacting replication requirements to be investigated.

WP 6.2 Pick-off prototype (PPARC)

This has involved the creation of a concept and design of a robotic positioner to work at cryogenic temperatures to arrange passive pick-off mirrors (POMs) on the focal plane. While the time taken to position each mirror can be relatively short, it will still be necessary to arrange that one pattern of POMs is set up while another is observing if excessive telescope time is not to be wasted. To allow this to happen, the POMs are placed on both sides of a focal plate which can be turned over so that as one set of POMs is illuminated from the sky while the other set is being re-configured ready for the next observation, in the same way fibre positioning robots such as 2df operate.

The Planetary Positioner System consists of two focal plates and a tumble mechanism (UKATC/ASTRON), a gripper assembly which provides a means of closing two jaws on to the POM with a controlled force and lifting the POM (CSEM), a new patented three axis rotational positioner (UKATC/ASTRON) and a target acquisition and metrology system (UKATC/AAO). Each POM is moved by being gripped, lifted clear of the other POMs,

moved to a new location, given a new orientation, lowered and released. The first machining of the parts for this were undertaken in November/December.

WP 6.2 Pick-off prototype (ASTRON)

ASTRON have participated in the pick-off prototype of the Planetary Positioner Pick-off System through the design and fabrication of the cable wraps for the rotation stages and by design and fabrication of the polished curved focal surface.

WP 6.2 Pick-off prototype (CSEM)

CSEM have participated in the Planetary Positioner Pick-off System by way of the design and build of the integrated gripper/linear translation unit. This is designed to be able to place a pick-off mirror on a curved focal plane, at any gravity vector, and at any temperature down to 77 K, to an accuracy of 1 micron. The first machining of the parts for this were undertaken in November/December.

WP 6.3 Beam manipulator prototype (LAM)

This work has been a continuation of WP 2.2 This work package will result in the development of prototypes of the optical elements, supports and actuator control mechanisms required for the optical chain between field selection and the IFU. The challenge for the field selection optics is to be very small to enable maximum clustering of the selected fields, but the optic must be controllable very precisely to maintain a diffraction limited image at the IFU over a long period.

Based on several years development work at LAM, The idea is to deform a thin optical surface using 4 piezoelectric actuators. This deformation will adapt the curvature radius of the surface in X and Y directions independently. For the SMART-MOMSI design, we need a mirror diameter of 200 mm, with a toroidal surface of nominal curvature radius of 4000 mm, adjustable to plus or minus 400 mm in each axis of the toroid. Finite element analysis linked directly to optical ray-tracing predicts that it is possible to maintain diffraction limited performance by actuating the surface to control the deformation of this mirror as it tracks the POM or Starbug across the field.

WP 6.4 MOS technology prototype (LAM)

This activity has been a continuation of WP 3.3 – MOEMs micro mirrors.
Our simulations and measurements show that it is best to project one astronomical element on each micro-mirror to reduce scattered light. This requires that each micro-element must be at least 100 µm x 200 µm. To reach a contrast value > 3000 the deflection angle is set at 20°. The mirrors surfaces must be flat and the gaps between mirrors minimized with a fill factor > 90%. Driving voltages of less than 100V enable the use of conventional drive electronics. Additional requirements are reliability and cryo actuation capability. The first arrays of MOEMS mirrors have been produced and are currently under test.
This work has resulted in the:

- Design and fabrication of new shutter based MOEMs to a Smart MOS prescription of 200*100 micron with deflection angle 20°.
- Development of a cryo test facility specifically for MOEMs characterization

Milestones And Deliverables Achieved During The Reporting Period

Deliverables / Milestones No	Deliverable/Milestone Name	Work package / Task No.	Lead Contractor(s)	Planned (in months)	Achieved (in months)
D1	Report on new ways to manufacture fibre-based IFUs for the wavelength range 0.35 - 2.5 microns	3.1	UCAM-IOA	14	18
D2	Smart Focal Planes instrument concepts & requirements document	1	UKATC	15	10
M2	Pre-Prototype pick-off mechanism made	2.2	AAO	15	13
D1	Report on concepts, technology and materials for Cryo mechanisms for actuators and linear slides	3.2	UKATC	15	14
D2	Report on slit configuration technologies and manufacturing	3.2	CSEM	15	12
D2	Development plan for Cryogenic MOEMS test facility	3.3	LAM	15	15
D1	Report on image slicer technology and manufacturing	2.1	UNIV DURHAM	17	18
M1	Smooth image slicer optics test pieces made	2.1	UNIV DURHAM	17	17
M2	Transmissive devices test pieces made	2.1	CRAL	17	16
D2	Report on fibre materials and fibre IFUs for multi-object applications	3.1	UCAM-IOA	17	18
D1	six monthly progress reports	1	UKATC	18	18
M3	Prototypes of key beam steering elements made	2.2	LAM	18	24
D3	Phase A report, including Roadmap	1	UKATC	20	18
D1	Report on Trade-offs and recommendations for Phase B	4 (5)	UKATC	20	12, 30
D1	MOEMs prototype development plan	6.4	LAM	20	23
D1	Report on beam manipulator technologies and manufacturing	2.2 (6.3)	LAM	21	30
D1	Design of replicable small IFU	6.1	UNIV DURHAM	22	23
D1	Design of scalable field selection device	6.2	UKATC	22	24
D1	Six monthly progress reports	5	UKATC	24	24
D1	Design of beam manipulator (possibly a path length compensator)	6.3	LAM	24	24

Major Meetings And Workshops Organised During The Reporting Period

Date	Title/subject of meeting /workshop	Location	Number of attendees	Website address
3-4 Feb 05	Concepts for Smart Momsi	Edinburgh	8	EdinburghMeeting
9 Mar 05	Replication of Slicers	Durham	6	DurhamMeetingMarch05
30 Mar 05	Slicer Design Meeting	Delft	6	CfAI presentation
12-13 Apr 05	Reconfigurable Slit / MOEMs	Neuchatel	15	NeuchatelMeetingMOS
13-14 Apr 05	Pick-off and Beam Manipulator	Neuchatel	17	NeuchatelMeetingPickOff
19 May 05	Replication of Slicers	Prague		Minutes of the meeting

31 May 05	Planetary Positioner	Dwingeloo	7	
5 July	Replication of Slicers	Durham	6	Juergens Presentation Minutes of the meeting
12 July 05	Planetary Positioner	Edinburgh	8	Meeting Minutes
12-13 Sept	MOS Instrument Concepts	Laguna	8	TenerifeMeetingMOS
27 Sept 05	Replicable IFU design	Edinburgh	5	Minutes of the meeting
29 Nov 05	Consortium Meeting	Edinburgh	24	EdinburghReview

1.5.6 JRA6: Volume Phase Holographic Gratings (VPHG)

A. Contractors:

Participant number	**4a**	**7a**	**8c**	**21b**	**23**	
Participant short name	ESO - INS	IAC	INAF – Brera	ULg – CSL-AOHL	POLIMI	**Total**
Person-months	2	3 (3.5)	7.8	0(6)	5(3)	**17.8 (12.5)**

B. Summary of Objectives and progress made:

The JRA is currently organized in 5 main work packages (also referred to 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 first 18 months of activity, completed in June 2005, has been dedicated to the production of laboratory prototypes with specific characteristics inherent to the WP objectives. A full description of these prototyping activities is given in the 18 month report available on the JRA web-site.

During the reporting period (12 months) the first part was dedicated to the final phase of laboratory prototype production and the second part to a critical analysis of their characteristics. The above is in agreement with the original schedule.

The following is a brief summary of the activity organised per work package. A more detailed description is given in the Annual Technical report available at the JRA web-site. Information contained in the web-links is not public and the access to the document is password protected. OPTICON Board members have the password, other authorities entitled to access the documents can request the password from the JRA leader.

WP 1 – Management

The activity of this Work Package concerned mainly the interconnection between the Work Package activities. Indeed each of the contractors in JRA-6 contributes to more than one work package, offering their specific expertise in every research line. A coordination activity, e.g. making everyone aware of the expertise, infrastructure and facilities available has been demonstrated to be of paramount importance for the success of the research.

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 at the relevant meetings and by assuring the preparation and delivery of the technical document in a timely manner. As an example of this activity the PPT presentation of the JRA-6 activity given to the executive board meeting in Leiden (September 17, 2005) is available for consultation on the JRA website.

WP-1 also takes care of the JRA web-site which is a source of information for the use of the

participants, the OPTICON members and the general public. The WEB-site has been recently restructured for faster and more rational access.

WP-1 organized the single plenary meeting we had in the reporting period in la Laguna, Tenerife, Spain (July 2005) and took care of the collection and dissemination of the information collected at the meetings. The minutes of this meeting are available for consultation in the JRA 6 website.

WP 2 – IR VPHGs

The objectives of this work package for the 12 months object of the present report were:

- the design and manufacturing of the prototypes, optimizing the fabrication procedures.
- the definition of a standard test plan to evaluate their performances.
- the upgrade, refurbishing and setting of the test laboratories at IAC.

The above tasks were established earlier in the project, i.e. at contract signature, and have been kept as such until completion

The 4 objectives listed have been successfully achieved during the current phase of the project with the exception of the final test-plan on the prototypes delayed because of the delays in the cash flow. The results on each of these goals is extensively described in the Annual Technical report . Below we report a summary of the most outstanding results.

- Three fully functional laboratory prototypes have been produced for the three near infrared atmospheric windows referred to as J, H and K bands.
- Expected Efficiency of each of the prototypes has been computed via RCWA
- Diffraction Efficiency was measured at room temperature
- Diffracted wavefront was measured at room temperature
- Cryogenic measurements of the diffraction efficiency and the transmitted wavefront have been initiated.

WP 3 – Non Traditional VPHG-based configurations

Within the OPTICON JRA-6 activities the WP-2 is dedicated to the study and realisation of non-traditional configuration making use of VPHGs. The reason to have this research line in the JRA comes from the consideration that the use of existing VPHGs has not been pushed to 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.

Following the general guidelines of the JRA-6, the activity in the reporting period has been to demonstrate the feasibility and to test the characteristics of a possibly innovative device at a laboratory level. This phase will be followed by another phase up to project completion aimed to obtain science grade devices.

The goal has been to manufacture a number of innovative VPHGs assemblies in the visible wavelength domain. Out of many possible configurations we singled out in the very first phase of the study the following:

- VPHG based tunable photometric filters

- Use of VPHGs for High Resolution spectroscopy in multi λ-ranges by optimising the Focal Plane Array filling.

Such goals were to be achieved via 3 steps :

- Preliminary design study of a feasible item for each of the three main topics of the line,
- From preliminary to industrial-ready design for each of the above three representative items
- Fabrication and testing of the three classes of prototypes in parallel.

The work plan for the reporting period foresaw some modelling and computational activity followed by a phase of laboratory prototype manufacturing. Budget restrictions and the delays in funds severely affect the prototype manufacturing phase, which depends on the purchase of material. This prototyping phase started as soon as it was possible to start it and is therefore delayed by 12 months corresponding to the 12 month delay in funding. Nevertheless some preliminary laboratory results could be obtained and are presented in the Annual Technical report. Below we report a summary of the most outstanding results:

- The possibility of combining a stack of VPHGs to produce a tunable filter was thoroughly studied producing a construction plan.
- A rough prototype of tunable filter obtained by combining existing broad-band VPHGs was built and tested in the laboratory
- The manufacturing drawing and the procurement of most of the optics and mechanics needed for the laboratory level VPHG-based spectrograph was completed.

WP 4 – Polymer based VPHGs

In the context of OPTICON-JRA6 activity WP4 is meant to investigate possible alternatives to DCG as the photosensitive layer in the fabrication of VPHGs. The limits imposed by the time, the manpower, infrastructures and the budget available, do not allow a 360 degrees investigation on all possible DCG alternatives. The 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 by the general term of Photochromic polymers although many different species can be used for our purposes.

The goal of the reporting 12 months of activity of WP 4 of OPTICON has been to obtain the first laboratory level prototype of a photochromic polymer based infrared VPHGs. In order to achieve this goal the following issues had to be addressed both under the theoretical and practical point of view:

- Study and syntheses a polymer with specific optical and mechanical properties
- Study and perform the optimal coating system to obtain the substrates for grating preparation
- Study the optimal exposure parameters to obtain an efficient grating.

All the above points have been addressed in the activity and the results are reported extensively in the Annual Technical report. Below we report a summary of the most outstanding results:

- A variety of chemical compounds with increased molecular polarizability (enhanced diffraction index contrast) and molecular weight (simple mechanical properties) have been synthesised and tested
- The first ever prototype of re-writeable photochromic based VPHG for NIR wavelength was successfully produced and tested.

WP 5 – UV VPHGs

During the reporting period it was decided to concentrate on VPHG devices that may replace the UV crossdisperser grating in UVES, a cross-dispersed echelle spectrograph on ESO's VLT whose UV performance exceeds that of comparable instruments on 8-10 m class telescopes. Despite several attempts, no more than 55% efficiency has been obtained in the 300 – 400 nm range with current reflective ruled grating technology. The higher efficiency that may be achievable with VPHG would boost overall instrument efficiency in this photon-starved but astrophysically interesting regime.

The definition of the grating characteristics has been made in a collaboration between ESO who defined the grating parameters and the CSL who have performed RCW analyses. After several iterations, two prototypes have been defined:

- UV-1. A VPHG working in transmission but having the same angular dispersion as the current reflection grating. Being a transmission grating, it cannot be used to replace the current reflection grating, except in a thought experiment, or in a newly developed instrument
- UV-3. A transmission VPHG operating in a double-pass optical arrangement so it can physically replace the reflection grating.

The above gratings have been manufactured and tested. The results of the tests are extensively reported in the Annual Technical report . Below we report a summary of the most outstanding results:

- The double pass arrangement to replace reflective cross-dispersers with VPHG-based devices was thoroughly studied and manufactured.
- UV VPHG with acceptable diffraction efficiencies down to 320 nm was obtained.
- A complete characterization of the transmitted wavefront and the diffraction efficiencies of the manufactured prototypes has done.

Milestones and Deliverables achieved

Milestones and deliverable are in agreement with the workplan proposed in annex 1 of the contract. The documents describing the deliverables are available in the JRA6 web-site. The document code is reported in the last column of the following table.

Name of deliverable/milestone	Activity (NAx; JRAy)	Work-package /Task	Delivered by Contractor(s)	Planned (in months)	Achieved (in months)	Doc #
M1 – Material, Fabrication and test plan doc	JRA6	WP2	ALL	6	6	003
M1 – Preliminary design study report	JRA6	WP3	ALL	6	6	003
M1 – Theoretical and Experimental analysis report on the materials to be used	JRA6	WP4	ALL	6	6	003
M1 – Material, Fabrication and test plan	JRA6	WP5	ALL	6	6	003
M2 – Test Plan and test equipment procurement path document	JRA6	WP2	ALL	12	12	006
M2 – Industrial ready design report	JRA6	WP3	ALL	12	12	005
M2 – Production of small quantity of the selected material and analysis	JRA6	WP4	ALL	12	12	005
M2 – Test Plan and test equipment procurement path document	JRA6	WP5	ALL	12	12	006
M3 - Prototype manufacturing dossier and Test report	JRA6	WP2	ALL	18	18	009
M3 - Prototype manufacturing dossier and Test report	JRA6	WP3	ALL	18	18	009
M3 - Prototype manufacturing dossier and Test report	JRA6	WP4	ALL	18	18	009
M3- Prototype manufacturing dossier and Test report	JRA6	WP5	ALL	18	18	009
M4 – Prototype Analysis Report Document	JRA6	WP2	ALL	24	24	009
M4 – Protoype Analysis Report Document	JRA6	WP3	ALL	24	24	009
M4 – Protoype Analysis Report Document	JRA6	WP5	ALL	24	24	009

Meetings and Workshop Table

Date	Title/subject of meeting	Location	# att.	Website address
17/18-03-04	Progress Meeting	IAC-Tenerife	15	Doc-008
21/22-10-05	KTN Workshop	INAF-Rome	40	Workshop website

- Progress Meeting. At the end of the 18 month activity and with the prototypes in house. Purpose of the meeting was to define the tests we want to perform on laboratory prototypes and address the future developments based on the preliminary test already performed on them.
- Workshop on "challenges in Optics for the ELT instrumentation" organized by the JRA-6 team together and under the auspices of the KTN (Network N3.5).

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

1. Fully functional J,H,K NIR Laboratory prototypes
2. Fully functional UV devices and Cross Dispersing Assemblies
3. The first VPHG based Tunable filter
4. The first polymer-based NIR VPHG

2. List of deliverables

Activity	Deliver--able No	Deliverable Name	Workpackage /Task No	Delivered by Contractor(s)	Planned (in months)	Achieved (in months)
NA1	M8	Executive meeting. Zurich	WP1	UCAM, PPARC	14	14
NA1	M9	Complete Annual report to EU	WP1	UCAM, PPARC	14	14
NA1	M10	Executive meeting, Leiden	WP1	UCAM, PPARC	20	20
NA1	M11	Presentations at JENAM meeting	WP1	UCAM, PPARC	19	19
NA1	M12	OPTICON Board meeting. Autumn 05, Rome, Italy	WP1	UCAM, PPARC	21	21
NA1	M13	Executive meeting, Paris	WP1	UCAM, PPARC	26	26
NA2	D1	Updated Progress report and revised roadmap	WP1.1 Dissemination of good practices.	IAC	24	24
NA2	M1	Regular ENO meetings	WP1.1 Dissemination of good practices.	IAC, IOA-KUL, INAF, THEMIS, IFAE, UCAM, Jodrell Bank.	16	17
NA2	M1	Regular ENO meetings	WP1.1 Dissemination of good practices.	IAC, IOA-KUL, INAF, THEMIS, IFAE, UCAM, Jodrell Bank.	22	22
NA2	M2	Meetings among telescope operators	WP1.2: A co-ordinated Laser Traffic Control System (LTCS) for the ORM	PPARC, IAC, IOA-KUL, IFAE, NOTSA, INAF	14	18
NA2	D1	Document on hardware specifications	WP1.2: A co-ordinated Laser Traffic Control System (LTCS) for the ORM	PPARC	14	17
NA2	D2	Documented model for ORM geometry	WP1.2: A co-ordinated Laser Traffic Control System (LTCS) for the ORM	PPARC	14	20
NA2	D3	Document on site software requirements	WP1.2: A co-ordinated Laser Traffic Control System (LTCS) for the ORM	PPARC	20	23
NA2	M1	Automate monitor DA/IAC	WP2.1: Co-ordination of night-time seeing measurements with DIMMs	IAC	12	12
NA2	D1	Report: Systematic measurements of seeing & meteorology	WP2.1: Co-ordination of night-time seeing measurements with DIMMs	IAC, INAF, PPARC, NOTSA	24	25
NA2	M1	Systematic measurements using a DIMM	WP2.2 Co-ordination of day-time seeing measurements at Teide Observatory (OT)	IAC	16	18

NA2	M1	Scintillation measurements	WP2.2 Co-ordination of day-time seeing measurements at Teide Observatory (OT)	IAC	16	18
NA2	D1	Annual report on measurements of extinction and dust	WP2.3 Joint actions for meteorology, dust, extinction and Sky Background	IAC	24	24
NA2	D2	Annual report on stations already existing	WP2.3 Joint actions for meteorology, dust, extinction and Sky Background	IAC	18	20
NA2	D1	Report on techniques to get wind profiles	WP2.4 Joint actions for Measurement of turbulence and wind vertical profiles (SCIDAR, GSM & DIMM)	IAC	24	24
NA2	D1	Annual report on discussion forums for site-selection	WP2.5 Distribution and discussion of results and participation in the scientific forums	IAC	24	24
NA2	D1	Draft proposal for design and contents of Central Site	WP.3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities.	IGAM, IAC,	14	14
NA2	D2	Final prototype/version of the tool	WP.3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities.	IGAM, IAC,	18	19
NA2	D3	Report on new institutions interested in JIS	WP.3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities.	IGAM, IAC,	22	22
NA2	D4	System fully operative	WP.3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities.	IGAM, IAC,	20	22
NA2	D5	FINAL REPORT: JIS	WP.3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities.	IGAM, IAC,	24	24
NA2	M3	Workshop	WP.3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities.	IGAM, IAC,	16	16
NA2	M4	Open Announcement	WP.3.1 Development of a Joint Information System (JIS) on European Solar Physics Facilities.	IGAM, IAC,	20	21
NA2	M1	Co-ordinated actions on transfer of knowledge and public outreach.	WP3.2: Co-ordinated actions on transfer of knowledge and public outreach.	IAC, PPARC, INAF, IOA-KUL, IFAE	20	20

NA2	M2	Distribution of new editions	WP3.2: Co-ordinated actions on transfer of knowledge and public outreach.	IAC, PPARC, INAF, IOA-KUL, IFAE	18	18
NA2	D1	New editions of outreach material	WP3.2: Co-ordinated actions on transfer of knowledge and public outreach.	IAC, PPARC, INAF, IOA-KUL, IFAE	16	17, 20
NA2	D2	ENO website. Final design operative	WP3.2: Co-ordinated actions on transfer of knowledge and public outreach.	IAC, PPARC, INAF, IOA-KUL, IFAE	17	24
NA2	D3	Annual report on ENO website and public outreach	WP3.2: Co-ordinated actions on transfer of knowledge and public outreach.	IAC, PPARC, INAF, IOA-KUL, IFAE	24	24
NA2	D4	Programme of activities for the next event	WP3.2: Co-ordinated actions on transfer of knowledge and public outreach.	IAC, PPARC, INAF, IOA-KUL, IFAE	16	23
NA2	D5	Exhibition elements and educational material	WP3.2: Co-ordinated actions on transfer of knowledge and public outreach.	IAC, PPARC, INAF, IOA-KUL, IFAE	18	23
NA3	M1	ELT Science Meeting (Cape Town)	WP1	PPARC	23	23
NA3	D2	Science Case Document	WP1	PPARC	30	18
NA3	M1	Meeting on Future of UV Astronomy	WP2	PPARC	30	Now month 32
NA3	M4a	Conference Planning Meeting	WP3	NUIG (was MPG)	21	22
NA3	M4b	Hold Conference	WP3	NUIG (was MPG)	18	Now month 30
NA3	M1	Euro-Vo Workshop	WP4	ESO	25	25
NA3	M1	Set up core Working Group	WP5.1	UKATC	18	20
NA3	M2	Draft High level Requirements	WP6	ESO, PPARC, ESA, RDS, NOVA, INSU/CNRS, NOTSA, INAF.	18	18
NA5	M2	Annual call for applications	WP1	NCU	13	15&21
NA5	M3	Collate list of applicants	WP1	NCU	14	16&22
NA5	M4	Selection of exchange visitors	WP1	NCU	16	16&22
NA5	D1	Report from participants	WP1	NCU	24	24
NA6	M2	2nd Directors Forum	WP1	PPARC	22	21
NA6	M3A/B	Per review of Aristachos and Liverpool telescope	WP1	PPARC	21	Postponed to 2006
NA6	M4	Review of Access Office	WP1	PPARC	21	21
NA6	M5	Plan Mid term review of Access programme	WP1	PPARC	22	22

NA6	D1	Produce audio-visual material on access programme	WP2	IAC	21	On hold
NA6	D2	Document on Time allocation procedures	WP2	IAC	21	23
NA6	D3	Additions to web pages with information about publications and conferences	WP2	IAC	18	On hold
NA6	M2	2nd Report to Directors forum	WP2	IAC	24	15 (preliminary report) 18 (1st update) 24 (2nd update)
NA6	Deliverable complementary to M2	Analysis of procedures for awarding time	WP2	IAC	12	23
NA6	M1	Working group kick-off Meeting	WP3	CNRS,IAP	6	17
JRA1	M1	JRA1 General Meeting 2	WP1	ESO	21	20
JRA1	M2	Complete NGS MCAO feasibility study based on FALCON concept	WP2.2	INSU	24	24
JRA1	M1	Complete conceptual design of the Real Time Computer platform for the 2nd generation of AO systems	WP3.2	ESO	18	21
JRA1	M1	Complete theoretical study of the optimal control for MCAO system	WP3.2	ONERA	23	23
JRA1	D1	Design report of a 1200 actuator piezo stack deformable mirror	WP3.3	ESO	21	23
JRA1	M1	VLT Adaptive secondary conceptual design report	WP3.5	ESO	20	20
JRA1	M1	Complete feasibility study of a 1.1 m Zerodur shell for an Deformable Secondary Mirror	WP3.6	INSU	23	24
JRA1	M2	Complete design of the high order test bench	WP3.8	ESO	24	24
JRA2	M1	Date of Constitution of Contract	WP2	ESO	16	16
JRA2	M2	Kick-off meeting	WP2	ESO	15	15

JRA2	M3	CDR	WP2	ESO	21	21
JRA3	M2	Critical Design Review	WP1	MPA	18	22
JRA3	M1	Specification of EMCCD to be procured fixed	WP2	USFD	3	15
JRA3	M2	CCD chip procurement	WP2	USFD	6	21
JRA3	M1	Definitions of PN-sensors for HTRA	WP3	MPG-MPE	3	12
JRA3	M2	Critical design of AA-PNSensor	WP3	MPG-MPE	9	22
JRA3	M2	Critical design fast timing controller L3CCD	WP5	UCAM	12	12
JRA3	M3	Interface with higher level software defined	WP5	UCAM	18	18
JRA3	D1	Fast timing controller L3CCD	WP5	UCAM	12	18
JRA3	M1	Software requirements and implementation plan	WP6	UCAM	12	12
JRA3	M1	Preliminary design camera head	WP7	UKATC	6	12
JRA4	M1	ESO/EII common workshop, 6-8 April 2005	WP 1.1	INSU	16	16
JRA4	D2	Instrument concept reports	WP 1.1	Various	16	16
JRA4	D3	List of contributors to feasibility studies	WP 1.1	INSU/CNRS, MPIA, MPIfR, Konkoly, MCU/UMK, UNIVIE, UCAM/CAV, Ulg, CAUP	16	24
JRA4	D2[1]	1st Progress Report on CFT	WP 1.2	INAF/OATo, Technion, INSU/CNRS, MPIA, ONERA	18	18
JRA4	M1	Preliminary Design Review	WP 2.2	INSU/LAOG	18	18
JRA4	D1[2]	Software User Requirements	WP 2.2	INSU/LAOG	18	18
JRA4	M2	Final Design Review	WP 2.2	INSU/LAOG	24	Delayed 6m
JRA4	D2	Software Design Description	WP 2.2	INSU/LAOG	24	Delayed 6m

[1] Deliverable D2 replace the Milestone M1 (First Phase Review)

[2] The Deliverable D1 (Software User Requirements) replace the Software Functional Specifications

JRA4	M1	Preliminary Design Review	WP 2.3	INSU/CNRS/CRAL	18	18
JRA4	D1[2]	Software User Requirements	WP 2.3	INSU/CNRS/CRAL	18	18
JRA4	M2	Final Design Review	WP 2.3	INSU/CNRS/CRAL	24	Delayed 6m
JRA4	D2	Software Design Description	WP 2.3	INSU/CNRS/CRAL	24	Delayed 6m
JRA4 JRA4	M1 D1	Preliminary Design Review Software User Requirements	WP 2.4 WP 2.4	UL, UNIGE UL, UNIGE	18 18	Delayed 12m Delayed 12m
JRA4	M1	Preliminary Design Review	WP 2.5	INSU/CNRS, ONERA, UCAM/CAV, MPIA, MPIfR, UGR/IAA (non contractor)	18	24
JRA4	D1[2]	Software User Requirements	WP 2.5	INSU/CNRS, ONERA, UCAM/CAV, MPIA, MPIfR, UGR/IAA (non contractor)	18	24
JRA5	D1	Report on new ways to manufacture fibre-based IFUs for the wavelength range 0.35 - 2.5 microns	WP 3.1	UCAM-IOA	14	18
JRA5	D2	Smart Focal Planes instrument concepts & requirements document	WP 1	UKATC	15	10
JRA5	M2	Pre-Prototype pick-off mechanism made	WP 2.2	AAO	15	13
JRA5	D1	Report on concepts, technology and materials for Cryo mechanisms for actuators and linear slides	WP 3.2	UKATC	15	14
JRA5	D2	Report on slit configuration technologies and manufacturing	WP 3.2	CSEM	15	12
JRA5	D2	Development plan for Cryogenic MOEMS test facility	WP 3.3	LAM	15	15

JRA5	D1	Report on image slicer technology and manufacturing	WP 2.1	UNIV DURHAM	17	18
JRA5	M1	Smooth image slicer optics test pieces made	WP 2.1	UNIV DURHAM	17	17
JRA5	M2	Transmissive devices test pieces made	WP 2.1	CRAL	17	16
JRA5	D2	Report on fibre materials and fibre IFUs for multi-object applications	WP 3.1	UCAM-IOA	17	18
JRA5	D1	six monthly progress reports	WP 1	UKATC	18	18
JRA5	M3	Prototypes of key beam steering elements made	WP 2.2	LAM	18	24
JRA5	D3	Phase A report, including Roadmap	WP 1	UKATC	20	18
JRA5	D1	Report on Trade-offs and recommendations for Phase B	WP 4 (5)	UKATC	20	12, 30
JRA5	D1	MOEMs prototype development plan	WP 6.4	LAM	20	23
JRA5	D1	Report on beam manipulator technologies and manufacturing	WP 2.2 (6.3)	LAM	21	30
JRA5	D1	Design of replicable small IFU	WP 6.1	UNIV DURHAM	22	23
JRA5	D1	Design of scalable field selection device	WP 6.2	UKATC	22	24
JRA5	D1	Six monthly progress reports	WP 5	UKATC	24	24
JRA5	D1	Design of beam manipulator (possibly a path length compensator)	WP 6.3	LAM	24	24
JRA6	M1	Material, Fabrication and test plan doc	WP2	ESO, IAC, INAF	6	6
JRA6	M1	Preliminary design study report	WP3	ESO, IAC, INAF	6	6
JRA6	M1	Theoretical and Experimental analysis report on the materials to be used	WP4	ESO, IAC, INAF	6	6
JRA6	M1	Material, Fabrication and test plan	WP5	ESO, IAC, INAF	6	6

JRA6	M2	Test Plan and test equipment procurement path document	WP2	ESO, IAC, INAF	12	12
JRA6	M2	Industrial ready design report	WP3	ESO, IAC, INAF	12	12
JRA6	M2	Production of small quantity of the selected material and analysis	WP4	ESO, IAC, INAF	12	12
JRA6	M2	Test Plan and test equipment procurement path document	WP5	ESO, IAC, INAF	12	12
JRA6	M3	Prototype manufacturing dossier and Test report	WP2	ESO, IAC, INAF	18	18
JRA6	M3	Prototype manufacturing dossier and Test report	WP3	ESO, IAC, INAF	18	18
JRA6	M3	Prototype manufacturing dossier and Test report	WP4	ESO, IAC, INAF	18	18
JRA6	M3	Prototype manufacturing dossier and Test report	WP5	ESO, IAC, INAF	18	18
JRA6	M4	Protoype Analysis Report Document	WP2	ESO, IAC, INAF	24	24
JRA6	M4	Protoype Analysis Report Document	WP3	ESO, IAC, INAF	24	24
JRA6	M4	Protoype Analysis Report Document	WP5	ESO, IAC, INAF	24	24

*[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).]*

3. Use and dissemination of knowledge

NA 1. Management

OPTICON Web site www.astro-opticon.org is regularly updated.

Handouts, printable from A4 up to poster size, on OPTICON activities downloadable from http://www.astro-opticon.org/download/index.html

OPTICON Overview Presentation at the JENAM 2005 conference in Liege 4-8 July 2005.

NA2: Coordination and Integration of ENO facilities

NA2 Web site: **www.otri.iac.es/na2**

NA2 WP2. Site Characterization.

A.M. Varela & A. Ghedina.April 2005 Cross calibration between particle counters operating at the Roque de los Muchachos Observatory. TNG Newsletter, in press..

A. Tokovinin & T. Travouillon, Model of Optical Turbulence profile at Cerro Pachón MNRAS (submitted), 2005

B.Garcia Lorenzo, J.J.Fuensalida, A. Eff-Darwich (2005), The role of the tropopause layer altitude on the infrared image quality of the astronomical sites SPIE, 5572, 384

Fuensalida, J.J., García-Lorenzo, B., Castro, J., Chueca, S., Delgado, J.M., González-Rodríguez, J.M., Hoegemann, C., Reyes, M., Verde, M. & Vernin, J. (2005), Statistics of atmospheric parameters for multiconjugated adaptative opticsor the Observatorio del Roque del los Muchachos SPIE, 5572, 1

B.García-Lorenzo, Fuensalida, J.J., Mendizabal, E.G., Muñoz-Tuñón, C., & Varela, A. (2005), Climate diagnostic archives: an approach to ELT site selection. SPIE, 5572, 68

García-Lorenzo, B. Fuensalida, J.J., Muñoz-Tuñón, C. & Mendizabal, E. (2005) Astronomical site ranking based on tropospheric wind statistics MNRAS, 356, 849

Conferences: 11th National Conference on Remote Sensing
Title: Calima anticiclónica y mar de nubes: implicaciones en los Observatorios de Canarias
Author: A.M Varela (1), C.Muñoz-Tuñón (1), J.J.Fuensalida (1), B. García-Lorenzo (1) & A.Eff-Darwich (1,2)
Date: 2005-09-21
Site: Puerto de la Cruz. Tenerife.
Affiliation: (1) Instituto de Astrofísica de Canarias (2) Facultad de Biología. Universidad de

La Laguna
Calima anticiclónica y mar de nubes: implicaciones en los Observatorios de Canarias
XI Congreso Nacional Teledetección

Conferences: 11th National Conference on Remote Sensing
Title: Estudio de la conexión entre el viento turbulento sobre el Observatorio del Teide y la velocidad del viento a 200milibares.
Author: E.G. Esteban (1), B. García-Lorenzo (1), J.J. Fuensalida (1), C. Muñoz-Tuñón (1) & A.M. Varela (1)
Date: 2005-09-21
Site: Puerto de la Cruz. Tenerife.
Affiliation: (1) Instituto de Astrofísica de Canarias
Estudio de la conexión entre el viento turbulento sobre el Observatorio del Teide y la velocidad del viento a 200milibares.
XI Congreso Nacional de Teledetección

Conferences: 11th National Conference on Remote Sensing
Title: Medida de la turbulencia atmosférica en los Observatorios de Canarias: la técnica SCIDAR
Author: J.J. Fuensalida(1), B. García-Lorenzo(1), J.A. Castro-Almazán(1), S. Chueca(1) , J.M. Delgado(1) , J.M.González-Rodríguez(1) ,E. Hernández(1) , C. Hoegemann(1) , E.G. Mendizabal(1,2) , C. Muñoz-Tuñón(1), M. Reyes(1) , M.A.C. Rodríguez-Hernández(1), A.M. Varela(1), M. Verde(1), J. Vernin(3)
Date: 2005-09-21
Site: Puerto de la Cruz. Tenerife
Affiliation: Affiliation: (1) Instituto de Astrofísica de Canarias
Medida de la turbulencia atmosférica en los Observatorios de Canarias: la técnica SCIDAR

Conferences: 11th National Conference on Remote Sensing
Title: Archivos de diagnóstico del clima: una herramienta para evaluar la calidad de los observatorios astronómicos
Author: B. García-Lorenzo, J.J.Fuensalida, E.G. Mendizabal, C.Muñoz-Tuñón y A.M. Varela
Date: 2005-09-21
Site: Puerto de la Cruz. Tenerife
Archivos de diagnóstico del clima: una herramienta para evaluar la calidad de los observatorios astronómicos

NA2: WP3 Solar JIS and Dissemination of Knowledge.

Title: Solar JIS (Poster)
Authors: I. Kienreich, A. Hanslmeier, P. Palle and A. Sosa.
Event: Solar Physics Section of European Phys. Society, SPM 11
Solar JIS

Title: Public Outreach at the Canary Islands' Astronomical Observatories. (Poster)
Authors: Members of the Public Outreach working group

Event: Communicating Astronomy with the Public (CAP 2005)
Public Outreach at the Canary Islands' Astronomical Observatories

Title: Joint Brochures of the ENO facilities.
Authors: Members of the Public Outreach working group
Download: On-line version available at: http://www.otri.iac.es/na2/brochure.html

Title: Solar JIS brochure.
Authors: I. Kienreich, A. Hanslmeier, P. Palle, J. Burgos and A. Sosa.
Download: On-line version available at: http://www.otri.iac.es/files/na2/na2-46QDiC.pdf

Title: Astronomy touring exhibition at the Canary Islands' airports.
Authors: Members of the Public Outreach working group
Download: Image available at: http://www.otri.iac.es/files/na2/na2-83A77h.jpg

NA3: Structuring European Astronomy

WP1: ELT

ELT Brochure (Also on CD-Rom)

Science Case Document (Also on CD-Rom)

Presentation at Meeting of SPIE, Glasgow June 21-25 and paper in the proceedings by I Hook. Proceedings of the SPIE 5489 pp 35-46

ESO Messenger Article v.121 p2 - 10

WP2: Network for UV Astronomy (NUVA)

Two papers in 39th ESLAB Symposium: "Trends in Space Science and Cosmic Vision 2020" (Proceedings of the Symposium held in Noordwijk 19-21 April 2005) as follows:

1) A large UV-optical telescope for characterization of the atmospheres of extrasolar planets and satellites:
A. Lecavelier des Etangs, D. Ehrenreich

2) Ultraviolet capabilities to study the formation of planetary systems
A.I. Gómez de Castro, E. Verdugo, C. Ferro-Fontán

WP4: Astrophysical Virtual Observatory (AVO)

The AVO to EURO-VO, P. Padovani & P. J. Quinn, European Astronomical Society Newsletter, 2005, 29, 8

Virtual Observatory Standards and Systems for Data Centres and Large Projects, P. Padovani & M. Dolensky, ESO Messenger, 2005, 121, 60

The Virtual Observatory in Europe and at ESO, P. Padovani & P. J. Quinn, ESO Messenger, 2005, 122, 22

WP6: Future Astronomical Software Environments

Grosboel, P., Banse, K., Tody, D. et al. 2005: 'Requirements for a Future Astronomical Data Analysis Environment' in Proc. of ADASS XIV, Eds. Shopbell, Britton, Ebert, ASP Conf. Ser. 347, 124-128

Tody, D., Grosboel, P., Garilli, B. et al. 2006: 'An Open Architecture and Framework for Astronomical Data Processing and Analysis' in Proc. Of ADASS XV, Eds. Gabriel, Arviset, Ponz, Solano, ASP Conf. Ser. 347, (June 2006)

Grosboel, P., Tody, D. 2006: 'Common Astronomical Software Environment for Data Analysis' in Proc. of ADASS XV, Eds. Gabriel, Arviset, Ponz, Solano, ASP Conf. Ser. 351, (June 2006)

NA5: Interferometry forum

Interferometry Web-site - www.strw.leidenuniv.nl/~eurinterf

WP4 European (Fizeau) exchange visitors programme
Fizeau Exchange Visitors Programme -http://www.strw.leidenuniv.nl/~eurinterf

WP3 Developing the vision for a next-generation interferometric facility

Web-site - http://www.strw.leidenuniv.nl/~eurinterf/Activities/OPTICON-NA/

NA6: OPTICON Telescope Network

WP1 : Telescope Directors Forum

Presentation by J Davies at JENAM 2005 (Liege, Belgium): http://www.astro-opticon.org/download/jenam_papers.html and at Polish National Astronomy Meeting (Wroclaw).

WP2: Operation of the Trans-National Access Office

Web-site http://www.otri.iac.es/opticon/

J. Burgos Martín, J.K. Davies, A. Sosa, A. Martín , OPTICON Trans-national Access Programme. Presented Orally and poster displayed at JENAM 2005, Liege Belgium.
OPTICON Trans-national Access Programme

JRA1: Adaptive Optics

WP 1: Coordination of JRA1

Web-site - http://www.eso.org/projects/aot/jra1/

WP2.1: XAO system Study
Nine papers related to the WP 2.1 have been produced in this period.

- [1] *Science case for the next generation VLT AO instrument "Planet Finder"* , Claire Moutou, Mouillet D., Beuzit J.L., Gratton R., Longmore A., Kasper M., Feldt M., Lagrange A.M. et al, IAUC 200, Villefranche (2005)
- [2] *Search and investigation of extra-solar planets with polarimetry*, Hans Martin Schmid, Markus Feldt, Thomas Henning, Daphne Stam, Rens Waters, Raffaele Gratton, IAUC 200, Villefranche (2005)
- [3] *A planet Finder instrument for the VLT*, Jean-Luc Beuzit, D. Mouillet, C. Moutou, K. Dohlen, P. Puget, T. Fusco, A. Boccaletti, S. Udry, M. Feldt, R. Gratton, H.-M. Schmid, R. Waters, P. Rabou, A.-M. Lagrange, F. Ménard, D. Ségransan, M. Langlois, F. Vakili, L. Arnold, M. Kasper et al., IAUC 200, Villefranche (2005)
- [4] *Direct Imaging of Extra-Solar Planets*, J.-L. Beuzit, D. Mouillet, B. Oppenheimer, and J. Monnier, Protostars and Planets V, Hawaii, 2005
- [5] *"The VLT Planet Finder II: adaptive optics system design",* T. Fusco, G. Rousset, D. Mouillet, J. L. Beuzit, SF2A-2005: Semaine de l'Astrophysique Francaise, meeting held in Strasbourg, France, June 27 - July 1, 2005, Edited by F. Casoli, T. Contini, J.M. Hameury and L. Pagani. Published by EdP-Sciences, Conference Series, 2005, p. 219
- [6] "*Conceptual design of an extreme AO dedicated to extra-solar planet detection by the VLT-Planet Finder instrument*", Fusco, T.; Rousset, G.; Beuzit, J.-L.; Mouillet, D.; Dohlen, K.; Conan, R.; Petit, C.; Montagnier, G., SPIE, Volume 5903, pp. 178-189 (2005).
- [7] ``The VLT Planet Finder I: Status of the project'', Beuzit J.-L., Mouillet D., Dohlen K., Puget P., Semaine de l'Astrophysique Francaise, Strasbourg, France, June 27 - July 1, 2005, EdP-Sciences, Conference Series, 2005, pp. 215-218, F. Casoli, T. Contini, J.M. Hameury and L. Pagani Eds.
- [8] ``VLT Planet Finder III.: expected performance'', Boccaletti A., Mouillet D., Semaine de l'Astrophysique Francaise, Strasbourg, France, June 27 - July 1, 2005, EdP-Sciences, Conference Series, 2005, pp. 223-226, F. Casoli, T. Contini, J.M. Hameury and L. Pagani Eds.
- [9] ``Science cases for the OWL Earth-like Planet Imager and Spectrograph (EPICS)'', Beuzit J.-L., Gratton R., Kasper M., Desidera S., Kerber F., Rahoui F., Mouillet D., Rouan D., Turatto M., Feldt M., Schmid H.M., Stam D., Selsis F., Hubin N., Verinaud C., IAU Symposium 232, Cape Town, South Africa, November 14-18, 2005. Proceedings of IAU Symposium 232, in press.

WP2.2: GLAO System Study

Three papers describing the result of this WP have been written [1-2]

[1] *"GALACSI: The ground layer Adaptive Optics system for MUSE"*, R. Stuik, R. Bacon, R. Conzelmann, B. Delabre, E. Fedrigo, N. Hubin, M. Le Louarn, S. Stroebele, New Astronomy Reviews, Volume 49, Issue 10-12, p. 618-624 (2005)

[2] "*Improving the seeing with wide-field adaptive optics in the near-infrared*", M. Le Louarn, N. Hubin, Monthly Notices of the Royal Astronomical Society, Volume 365, Issue 4, pp. 1324-1332. (2006)

[3] "*Deformable mirrors for the FALCON concept*", Puech, M.; Chemla, F.; Laporte, P.;

Jagourel, P.; Gendron, E.; Hammer, F.; Assemat, F.; Conan, J.-M.; Fusco, T.; Liotard, A.; Zamkotsian, F., SPIE, Volume 5903, pp. 272-282 (2005).

WP2.4: Multiple FOV System with NGS

Corresponding results have been published in the following two papers:

[1] "*Arbitrarily Small Pupils in Layer-Oriented Multi-Conjugate Adaptive Optics"* Ragazzoni, Roberto; Diolaiti, Emiliano; Vernet, Elise; Farinato, Jacopo; Marchetti, Enrico; Arcidiacono, Carmelo The Publications of the Astronomical Society of the Pacific, Volume 117, Issue 834, pp. 860-869, 2005. (PASP Homepage)

[2] *"LINC-NIRVANA: MCAO toward ELTs"* Gaessler, W.; et. al. in Press

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

WP3.1: 2nd Generation RTC Platform

One paper has been published based on the results obtained from this WP:

[1] "*FPGA developments for the SPARTA project*", S. Goodsell, E. Fedrigo, D. Geng, proceedings of SPIE, August 2005.

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

The following papers have been produced in the frame of this WP:

[1] "*Kalman Filter based control loop for Adaptive Optics*", C. Petit, F., F. Quiros-Pacheco, J.-M. Conan, C. Kulcsar, H.-F. Raynaud, T. Fusco and G. Rousset, *Advancement in Adaptive Optics*, **5490**, D. Bonaccini, B. Ellerbroek, R. Ragazzoni eds, SPIE conf. 2004

[2] "*Optimal control for Multi-Conjugate Adaptive Optics*", C. Petit, J.-M. Conan, C. Kulcsar, H.-F. Raynaud, T. Fusco, J. Montri and D. Rabaud, C. R. Physique 6 (2005).

[3] "*Wavefront sensing issues in MCAO*", T. Fusco, M. Nicolle, G. rousset, V. Michau, A. Blanc, J.-L. Beuzit, C. R. Physique 6 (2005).

[4] "*Performance analysis of multi-object wave-front sensing concepts for GLAO*", M. Nicolle, T. Fusco, V. Michau, G. Rousset and J.-L. Beuzit, *Astronomical Adaptive Optics Systems and Applications II,* **5903,** SPIE conf. 2005.

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

Two prototypes of ~60 actuator magnetic deformable mirror have been produced and delivered to our partners for testing. The patent FR045234 protecting this technology is currently being extended to other countries.

WP3.8 High Order wavefront sensor experimental study

The following papers related to WP 3.8 have been published:

[1] *"CAOS, a ``problem solving environment'' for adaptive optics and adaptive-optics-aided astronomy"*, Carbillet, M.; Vérinaud, C.; Fini, L.; Riccardi, A.; Le Roux, B.; Puglisi, A.; Femenía, B.; Anconelli, B.; Desiderà, G.; Boccacci, P et al., SF2A-2005: Semaine de l'Astrophysique Francaise, meeting held in Strasbourg, France, June 27 – July 1, 2005, Edited by F. Casoli, T. Contini, J.M. Hameury and L. Pagani. Published by EdP-Sciences, Conference Series, 2005, p. 275.

[2] "*EPICS, a Planetary Camera-Spectrograph for OWL*", C. Vérinaud et al., , to be published in the proceedings of the workshop "Instrumentation for Extremely Large Telescopes" held in Ringberg Castle (Bavaria, Germany) 25-29 July 2005.

[3] "*The EPICS project: Exoplanets detection with OWL*", C. Vérinaud et al., to be published by Cambridge University Press in the Proceedings of the International Astronomical Union Conference 200 held in Ville-France (France) 3-7 october 2005.

[4] "*Extreme Adaptive Optics for exo-planets detection with ELTs*", T. Fusco, C.Vérinaud, G. Rousset, N. Hubin, to be published in the proceeding of the symposium IAUS232 held in Cape Town, South Africa , 14-18 november 2005.

JRA2: Fast detectors for AO

WP2: Detector specification and fabrication work package.

The following table contains the major documents which have been produced as part of this work package.

AD1	Technical specifications for the Adaptive Optics Wavefront Sensor Detector	VLT-SPE-ESO-14690-3320, issue 3, 19 April 2005.
AD2	Statement of work for the Adaptive Optics Wavefront Sensor Detector	VLT-SOW-ESO-14690-3383, issue 4, 15 April 2005.
AD3	E2V technical and management proposal	E2V-PR-679, Issue 4, 10 March 2005.
AD4	CCD Design Definition	VLT-SPE-E2V-14690-0001, Issue 1, 25th February 2005.
AD5	Test Equipment Requirements	VLT-SPE-E2V-14690-0002, Issue 4, 27th October 2005.
AD6	CCD Test Plan	VLT-PLA-E2V-14690-0008, Issue 3, 26th October 2005.
AD7	CCD Design Report	VLT-PLA-E2V-14690-0014, Issue 3, 3rd October 2005.
AD8	Test Equipment ICD	VLT-PLA-E2V-14690-0012, Issue 2, 27th October 2005.
AD9	CCD Compliance Matrix	VLT-SPE-E2V-14690-0016, issue 1, 26th August
AD10	Adaptive Optics Wavefront Sensor Detector, Critical Design Review Report	VLT-TRE-ESO-14690-3814, Issue 1, 14 November 2005.
AD11	CCD220 Camera System Verification Matrix	VLT-SPE-ESO-14690- 3736, Issue 1.0, 5th July 2005.

One paper describing the progress of this WP has been written [1].

[1] M. Downing et al, "A Dedicated L3CCD for Adaptive Optics Applications", proceedings of the Scientific Detector Worshop 2005, Taormina June 2005, Springer editions, editors: P.Amico and J. Beletic.

JRA3 : High Time Resolution Astronomy

Relevant Papers Published or in Press

JRA3 WP5 C. D. Mackay (2005), ~Near Diffraction Limited Visible Imaging on 10m class Telescopes with EMCCDs, Proceedings of Workshop on Scientific detectors, Taormina, June 2005.

JRA3 WP5 N.M. Law, S. T. Hodgkin, C. D. Mackay, J. E. Baldwin, (2005), 10 New Very Low Mass Binaries Resolved in the Visible, Astron. Nachr. vol. 326, No. 10, 1024~V1025.

JRA3 WP5 C. D. Mackay (2005) Near Diffraction-Limited Visible Imaging on 10-30 m Class Telescopes with EMCCDs, Proceedings of Conference on Instrumentation for ELTs, Ringberg.

JRA3 WP5 N.M.Law, S.T. Hodgkin, C.D. Mackay (2006) Discovery of Five Very Low Mass Close Binaries, Resolved in the Visible with Lucky Imaging, Mon. Not. Roastr Soc, (submitted 181205).

JRA4: Interferometry

Publications related to WP1.1 at the ESO/EII meeting of April 2005

Lopez et al.: Apres-Midi

Malbet et al.: Vitruv – imaging the environment of stars and galaxies with the VLTI at milliarcsecond resolutions

Lardiere et al.: VIDA – a direct imaging instrument for the VLTI

Quirrenbach et al.: UVES-I – High Resolution Spectroscopy for the VLTI

Mourard et al.: Spectroscopy and polarimetry with the VLTI at visible wavelengths

Busher et al.: A photon-efficient multi-way combiner for the VLTI

Publications related to WP1.2

Bertram T., Andersen D.R., Arcidiacono C., Straubmeier C., Eckart A., Beckmann U., Herbst. The LINC-NIRVANA Fringe and Flexure Tracking System: differential piston simulation and detection. Proc. SPIE 5491-167, 2004, in press

Bonino D., Gai M., Corcione L., Massone G. Models for VLTI fringe sensor units: FINITO and PRIMA FSUs. Proc. SPIE 5491-168, 2004, in press

Borkowski V., Labeyrie A., Martinache F., Lardière O. The dispersed speckles cophasing system for direct imaging with VIDA. Proc. ESO-EII Workshop on "The Power of Optical/IR Interferometry: Recent Scientific Results and 2nd Generation VLTI Instrumentation", Garching, Germany, 4-8 April 2005, in press

Borkowski V., Labeyrie A., Martinache F., Peterson D. Sensitivity of a "dispersed-speckles" piston sensor for multi-aperture interferometers and hypertelescopes, 2005, A&A vol. 429, pp.747

Borkowski V. et al. 2004, EAS Publications Series, Vol 12, pp.287-291

Buscher D., Baron F., Coyne J., Haniff C., Young J. A photon-efficient multi-way combiner for the VLTI D. Buscher, F. Baron. Proc. ESO-EII Workshop on "The Power of Optical/IR Interferometry: Recent Scientific Results and 2nd Generation VLTI Instrumentation",

Garching, Germany, 4-8 April 2005, in press

Cassaing F. Multiple beam fringe tracking for the VLTI. Proc. ESO-EII Workshop on "The Power of Optical/IR Interferometry: Recent Scientific Results and 2nd Generation VLTI Instrumentation", Garching, Germany, 4-8 April 2005, in press

Gai M., Menardi S., Cesare S., Bauvir B., Bonino D., Corcione L., Dimmler M., Massone G., Reynaud F., Wallander A. The VLTI Fringe Sensors: FINITO and PRIMA FSU. Proc. SPIE 5491-61, 2004, in press

Gai M., Bonino D., Corcione L., Gardiol D., Lattanzi M.G., Loreggia D., Massone G., Menardi S. Multiple beam fringe tracking at VLTI. Proc. ESO-EII Workshop on "The Power of Optical/IR Interferometry: Recent Scientific Results and 2nd Generation VLTI Instrumentation", Garching, Germany, 4-8 April 2005, in press

Gardiol D., Loreggia D., Mannu S., Mottini S., Perachino L., Gai M., Lattanzi M.G. End-to-end opto-mechanical simulation for high precision global astrometry Proc. SPIE 5497-51, 2004, 461.

Loreggia D., Gardiol D., Gai M., Lattanzi M.G., Busonero D. Fizeau Interferometer for Global Astrometry in Space, 2004, Applied Optics, Vol. 43, 4, p. 721

Loreggia D., Gardiol D., Gai M., Lattanzi M.G., Busonero D. Fizeau Interferometry from Space: a challenging frontier in global astrometry. Proc. SPIE 5491-29, 2004, 255.

Martinache F. 2004, J. Opt. A: Pure Appl. Optics 6, pp.216-220

Ribak E.N., Perrin G., Lacour S. Multiple beam combination for faint objects. SPIE 5491 1624-9, Ed. W. A. Traub, Glasgow (2004)

Ribak E.N. Interferometry following adaptive optics. SPIE 5491 1154-9, Ed. W A Traub, Glasgow (2004)

Ribak E.N., Gai M., Gardiol D., Loreggia D. and Lipson S.G. Multiple anamorphic beam combination. Proc. ESO-EII Workshop on "The Power of Optical/IR Interferometry: Recent Scientific Results and 2nd Generation VLTI Instrumentation", Garching, Germany, 4-8 April 2005, Ed A Richichi, in press.

Straubmeier C., Bertram T., Eckart A., Wang Y., Zealouk L., Herbst T., Andersen D., Ragazzoni R., Weigelt G. The Fringe and Flexure Tracking System for LINC-NIRVANA: Basic Design and Principle of Operation. Proc. SPIE 5491-171, 2004, in press

JRA5,6 : internal technical reports as listed under Deliverables.

Annexes

ANNEX 1: General Meetings

Full minutes of all OPTICON Board meetings are available at the www site http://www.astro-opticon.org

OPTICON I3 Board Meeting 3

http://www.astro-opticon.org/agendas_minutes/opticon-i3-Board-Meeting-3-mins.pdf

D. DETAILED IMPLEMENTATION PLAN FOR THE NEXT 18 MONTHS

1.1 NA1: Management Activity

During Month 26 the executive committee will meet to review the progress set out in the annual report, consider and revise where necessary the future plans and budgets of all activities.

During Month 25 and 26 the management team will work with the Network, Access and JRA leaders to complete the 1st annual report to the commission.

During month 30 the executive committee will meet again (if required) to monitor progress and prepare any recommendations to the board on future plans

During month 34 the annual board meeting will take place in Germany.

The project office will distribute funds from the third advance when they become available.

The Project Scientist and other members of the management team will constantly monitor progress of the various activities to ensure the planned programme can be delivered.

The project team will continue to make presentations and write articles where appropriate to publicise the activities of the project. A stand will be presented at the IAU general assembly in Prague, 14 – 25 August, 2006.

Workpackage	**Milestones/ Deliverables**	**Project Month**	**Description**
1	M14	26	Executive meeting. Paris
1	M15	26	Complete Annual report to EU
1	M16	30	Executive meeting.
1	M17	32	Exhibition at IAU
1	M18	34	OPTICON Board meeting. Autumn 06, Germany
1	M19	38	Executive meeting

1.2 NA2. Coordination and Integration of ENO facilities

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

WP1.1.: Dissemination of good practices: The working group will establish and update the roadmap for the future projects; identifying complementarities between ENO telescopes. International funding opportunities will be identified as well as contacts of interest at European level. Three general NA2 meetings will be organized during the next 18 months. Some special working groups could be also set up to analyse and discuss their specific and common issues affecting subsets of astronomical community, as a result of being located at the same site. These working groups will be set up only if well-defined and specific objectives are identified by the participants at the NA2 meetings.

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

After testing in anger between the WHT and the INT and once everything works correctly, the system can start to incorporate other interested telescope facilities at ORM, testing them in an operational environment.

The last stage of the LTCS will be the software implementation at each ORM facility interested in joining the system.

A final report of the LTCS will be delivered by the end of 2006 (Deliverable D5). No more longer term plans are expected under the OPTICON project given that this workpackage will finish by the end of 2006, as initially scheduled in the contract.

WP2.: Site Characterisation of the Canary Islands' Observatories:

A continuous comparison of the simultaneous data provided individually by the different DIMMS are planned. Cross-calibrations and distribution of data and results will be also addressed under this task.

Using the scintillometers it is possible to recover the turbulent profile at lower layers which is of extreme value to the AO design of solar telescopes presently installed at the observatory. We will jointly explore these S-DIMM and Scintillomer arrays' possibilities at OT. Working sessions, distribution of data/results will be carried out

In addition, the followings report/studies will be approached:
Feasibility Study - CONCAM and sky monitor,
Reports on techniques to get wind profiles
Report on discussion forums for site-selection

Likewise, the following specific actions will be addressed during 2006 and 2007:

WP2.1 Co-ordination of night-time seeing measurements with DIMMs:
Analisys of systematic seeing measurements of seeing and meteorology will be carried out by the participants; results will be made available and a progress report on these measurements will be delivered. An Automatic Differential Image Motion (DIMM) will be developed by an specialized company at Roque de los Muchachos Observatory (ORM).

WP2.2 Co-ordination of day-time seeing measurements at Teide Observatory (OT):
After the final check of the S-DIMM and the Scintillometer mounted at OT, and once initial results are obtained, a progress report will be delivered by the participants.

WP2.3 Joint actions for meteorology, dust, extinction and Sky Background:
Once the permissions have been received, an Automatic weather station (AWS) will be implemented in the pre-selected site for an Extremely Large Telescope (ELT) in order to have

on line weather conditions at both sites. The study of dust pollution monitoring and dust particle will continue being undertaken by the participants.

WP2.4 Joint actions for Measurement of turbulence and wind vertical profiles (SCIDAR, GSM & DIMM):
Analysis of statistical turbulence profiles obtained with the SCIDAR.
Development of techniques to provide the wind profile.

Development of a Generalized Scidar, like Cute Scidar, and a Shack-Hartmann sensor running at the same time. The mechanical design will be modified in order to support the weight of both instruments.

WP2.5 Distribution and discussion of results and participation at the scientific forums
The participation in the discussion forums for Site-Selection (50m, ESO ELT, ATST) and site characterization will be attended when scheduled and contributions will be prepared. It is expected to participate in:

- the Site Characterization / ELT scientific forums as well as in the Coordination Site Testing on South Pole (ARENA network)
- Site Characterization meeting / SUCOSIP. Freiburg (spring 2006)
- Site Testing Design for the ESO ELT

Annual reports will be delivered with all the actions carried out.

WP3.: Joint Information System and Transfer of Knowledge:

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

Appropriate maintenance activities will be carried out for the whole system. An updated report on new institutions interested in JIS will be produced. Efforts will be focussed in promotional activities to guarantee a suitable impact among the Solar physics community (meetings, workshops, leaflets, etc).

WP3.2.: Co-ordinated actions on transfer of knowledge and public outreach:

Installation of explanatory units and displays for public events related to exceptional astronomical phenomena. Efforts will be focussed to support only those astronomical events visible from the Canary Islands.

Final design of the joint ENO Website will be fully operative and a report on public outreach activities carried out will be delivered.

The working group will identify other networks to coordinate public outreach activities, as well as other complementary funding sources in order to prepare joint proposals focussed on Science communication.

Some of the activities already carried out, such as the Open Days, edition of promotional material and expositive units will be organized periodically, in order to optimize the real impact among the general public.

Table with breakdown of human effort for next 18 months (person/months)

Laboratory	WP1	WP2	WP3	Total Effort
24. IGAM	0	0	2.5	2.5
7. IAC	4	7	3	14
2. PPARC	12	0	0	12
Total effort	16	7	5.5	28.5

The deliverables and Milestones expected to be achieved during the next 18th months are listed in the following table:

List of Milestones and Deliverables scheduled (1Jan 06 - 30 Jun 07 / Months: 25th to 42th)

Work package	Milestones/ Deliverables	Project Months	Description
WP1.1	D1	36	Updated progress report and revised roadmap
WP1.1	M1	28,34,40	M1: Regular ENO meetings
WP1.1	M2	34	M2: Working Groups meeting
WP1.2	D4	25	D4: Software implementation at each telescope installation
WP1.2	D5	36	D5: Final report
WP2.1	D1	36	D1: Report: Systematic measurements of seeing & meteorology
WP2.1	M1	25>>	M1: Automate monitor DA/IAC
WP2.2	M1	25>>	M1: Systematic measurements using a DIMM
WP2.2	M2	25>>	M2: Scintillation measurements
WP2.2	D1	30	D1: Report on systematic measurements using DIMM
WP2.3	D1	36	D1: Annual report on measurements of extinction and dust
WP2.3	D2	30, 42	D2: Annual report on stations already existing
WP2.3	M1	28	M1: Install and run an Automatic Weather Station (1 month)
WP2.3	D3	26	D3: Feasibility Study - CONCAM and sky monitor
WP2.4	D1	36	D1: Reports on techniques to get wind profiles
WP2.5	D1	36	D1: Annual report on discussion forums for site-selection
WP3.1	D3	30	D3: Report on new institutions interested in JIS
WP3.1	D6 (new)	36	D6: Annual report with the maintenance activities carried out.
WP3.1	D7 (new)	36	D7: Report of the promotional activities related to JIS
WP3.2	M1	30, 31	M1: Open-doors days at OT and ORM
WP3.2	M2	30	M2: Distribution of new editions
WP3.2	D1	27	D1: New editions of outreach material
WP3.2	D2	30	D2: ENO website. Updated version
WP3.2	D3	36	D3: Annual report on ENO website and public outreach
WP3.2	D4	36	D4: Programme of activities for the next event
WP3.2	D5	33	D5: Exhibition elements and educational material
WP3.2	D6	36	D6: Major events.

1.3 NA3: Structuring European Astronomy

WP1: ELT

There will be continued development of the science case. In particular a number of scientific simulations are needed in order to set requirements for adaptive optics on ELTs. These are currently being done on a best effort basis but more, dedicated, manpower will be sought.

There will be a major ELT science meeting in November 2006 in Marseilles corresponding to WP1, M1). Based on previous meetings this is expected to involve around 50 scientists. The meeting will be held in conjunction with an ESO ELT workshop and a workshop on ELT instrumentation. It is planned that OPTICON will provide support (financial and organisational) for the scientific parts of the meeting.

Occasional (about 6 over the next 18 months) small meetings of 5-10 people will be held on specific aspects of the science case as the need arises.

Dr Hook and others will continue the coordination with the European ELT Design Study and ESO ELT activities.

WP2: Network for UV Astronomy

WP 2.2 D2 – Delivery of the final document will be delayed from May 2006 to October 2006, although this is still ahead of the original planned date. The contents of the draft science case elaborated by the NUVA working groups will be discussed during the "Joint Discussion" on "The Ultraviolet Universe: stars from birth to death" to be held at the IAU General Assembly in August 2006. We want to incorporate into the final document the feedback from the Joint Discussion.

NUVA web will be used as the contact point to refine the science case after the Joint Discussion.

The UV science case and the UV Instrumentation article will be presented at the SPIE conference on: "**Astronomical Telescopes and Instrumentation"** to be held in Orlando, Florida in 24-31 May 2006.

Numerical simulations are being used to re-evaluate the high energy radiation field in the young Solar System. This is a crucial issue for the UV science case.

WP 3 M3 – We have applied for IAU support to organize an IAU Symposium during the summer of 2007 on UV Astronomy. The Symposium will be held in El Escorial (Madrid) at the end of May 2007 and will be entitled: "Space Astronomy: the UV window to Astrophysics".

WP3: High Time Resolution Astrophysics (HTRA)

In the next 18 months, NUI, Galway will be taking over responsibility for the High Time Resolution Astrophysics network activities. During the initial months it is planned to develop both internal and external communications within the HTRA network community. This will be achieved through the development of both internal and external websites. The internal HTRA network communication will be advanced through the Wiki portal that is currently hosted through UKATC.

It is planned to host a meeting of 20 invited experts in early June 2006. During this meeting, presentations will be given by the invited experts on the HTRA activities. These will include such topics as Science Objectives, Instrumentation, Software, Telescopes, and Future Developments.

In the next 18 months, NUI Galway will spend significant effort in the organisation aspects, planning and execution of both this meeting and 'white book'. Following this meeting in June 2006, NUI Galway will establish a board of editors to review the submission of material from the invited speakers for the 'white book'. Once the submission of material has been received, edited and reviewed, the board of editors will proceed with the production, publication and distribution of the 'white book'.

WP4: Astrophysical Virtual Observatory

The European Virtual Observatory (**EURO-VO**) project, the successor of the AVO, is an integrated and coordinated programme of work designed to provide the European astronomical community with the data access, research tools and systems, research support, data interoperability standards, data-flow practices and data centre coordination, necessary to enable the exploration of the digital, multi-wavelength universe resident in European and international astronomical and astrophysical data archives. EURO-VO will act as a natural hub for coordination and integration of the new, GRID-enabled, VO research infrastructure that will be essential to the success of future large European community programmes in astronomy (e.g. ALMA, ELT's, SKA and Planck).

The EURO-VO consists of three new organizational structures which will meet the objectives of the total work programme and which will provide a platform for a long term European VO research infrastructure and capability. These are:

- **The EURO-VO Data Centre Alliance (DCA)**: a collaborative and operational network of European data centres who, by the uptake of new VO technologies and standards, will publish data, metadata and services to the EURO-VO and who will provide a research infrastructure through the adoption and application of GRID-enabled processing and storage facilities.
- **The EURO-VO Facility Centre (VOFC):** an organization that provides the EURO-VO with a centralized registry for resources, standards and certification mechanisms as well as community support for VO technology take-up, VO dissemination and scientific programme support using VO technologies and resources.
- **The EURO-VO Technology Centre (VOTC):** a distributed organization that coordinates a set of research and development projects on the advancement of VO technology, systems and tools in response to scientific and community programme needs.

Partial funding has been secured via a successful FP6 proposal to initiate the work of the EURO-VO Technology Centre (VOTECH Project: FP6-2003 Infrastructures-4 011892 http://eurovotech.org/). An FP6 proposal for the EURO-VO Data Centre Alliance (Coordination Action) was also successful in 2005. However, the EURO-VO Facility Centre is still unfunded. Support from OPTICON in 2006/7 will be providing vital funding to initiate VOFC activities. These will include:

1. Selection and convening of the EURO-VO Science Advisory Committee (SAC). The SAC will meet twice a year and will consist of European astronomers, who will provide scientific input to the project, promote VO science in Europe, and be the contact point between European astronomers and EURO-VO;
2. rganization of EURO-VO science workshops, to increase the involvement of

European astronomers with the usage of VO tools;
3. Setting up of the EURO-VO Web pages, which will provide an entry point to the VO in Europe.

WP5: Key Technologies Working Group

The next 18 months is a crucial period in the planning for Framework Programme 7 – and the Key Technologies Network has an important role in bringing together the various individuals and institutions; scientists, instrument builders, technologists from both institutions and companies. The goal is to arrive at topics, goals and deliverables for new Joint Research Activities that address the most critical challenges for astronomy by playing to combined European strengths.

A KTN meeting is to be held on the last week of April on the use of the William Herschel Telescope (WHT) as a technology test-bed. A 4-m class telescope, the WHT has laboratory-type areas on its Naismyth platforms which make it an ideal facility to test on-sky some of the technologies which are currently under development within the Joint Research Activities.

The following topics will also be the subject of workshop / roadmap activities centred on identifying the way ahead for technology development.

- on NIR IR detector arrays
- on deformable mirrors
- on NIR fibre optic technologies
- SPAD arrays

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Task No	Lead Contractor(s)	Planned (in months)	Delivery / Schedule
D2	Technology Report	WP5.2	UK ATC	30	30

WP6: Future Software

After the delivery of the draft high-level requirements (M2), they should be subjected to a wider, more formal review. Detailed explanation will be added to the requirements which will then go through an internal, written review. This final version will be made available to the astronomical community at large for review through the Internet (new Milestone M2a for December 2006).

The architectural concept was discussed extensively in 2005. On this basis, a draft proposal for architecture, structure and major interfaces will be made (Milestone M3a for June 2006). This will be used for prototypes which should explore different technologies and lead to a interface specification draft (new Milestone M3b for June 2007).

We plan to have three face-to-face meeting in the coming 18 months. The first is planned for May-June 2006 and will deal with the formal review of requirements and the last issues concerning the architectural concept. The fall 2006 meeting (possibly in connection to ADASS 2006) will focus on interface specifications and proto-type implementations. In the spring of 2007, a meeting will review a detailed draft of interfaces and subsystem structure leading up to Milestone M3b.

List of Milestones and Deliverables scheduled:

Workpackage	Milestones/ Deliverables	Project Month	Description
1	M1	35	ELT science meeting (Marseiles)
2	M1	32	Meeting on Future of UV Astronomy
3	M4b	30	HTRA conference (was 1st 18mo plan M4)
5.1	D2	30	Technology Report
6	M2a	30	High-level Requirements version 1.0
6	M3a	36	Draft architecture
6	M3b	42	Draft interface specifications

1.4 NA4: Synergy in space-ground coordination

The documents circulated in late 2005 are in the process of being iterated upon and a meeting to finalize these drafts will occur in Paris on March 9 and 10th. This will be followed by further meetings of the network to discuss these and converge on a consensus on the content and finalization of these documents in June 2006.

In spring 07 the network will have informal discussions with EU and other European agencies on the mechanisms proposed. Assuming the present FP7 schedule and positive reactions of these discussions, proposals will be written in late 2006/early 2007.

1.5 NA5: Interferometry

N5.WP 1: Fizeau exchange visitors programme
Two calls per year are planned for the Exchange programme.

In the following 18 months there are three scheduled deadlines for the FEVP: 15 March 2006 (2006A), 15 September 2006 (2006B), and 15 March 2007 (2007A).

N5.WP 2: Working groups
At least two meetings of the Scientific Council are planned to make critical decisions in the programme of the network and the associated joint research activity. The Scientific Council will also discuss options for the future.

The "Radiative Transfer / Atmospheric Modelling" and the "Interferometry and Asteroseismology" working groups will each come together at least once in 2006, and once in 2007 to discuss progress and enhance the networking activities.

N5.WP 3: Next-generation interferometric infrastructure
After the successful meetings on the science case and technology of a next-generation interferometric facility, 2006 this sequence will be continued with a more comprehensive plan for a technology roadmap. Discussions with potential partners outside Europe will take place at the SPIE conference in Orlando in May. The goal of these discussions will be improved coordination and collaboration between the FP6 Network and scientists on other continents.

Workpackage	Milestones/ Deliverables	Project Month	Description
1	M1	27	Deadline FEVP 2006A
1	D1	28	List of accepted candidates 2006A
1	M2	33	Deadline FEVP 2006B
1	D2	34	List of accepted candidates 2006B
1	M3	39	Deadline FEVP 2007A
1	D3	40	List of accepted candidates 2007A

1.6 NA6: OPTICON Telescopes network

WP1: Telescope Director's Forum

The telescope directors will have a further meeting in the autumn of 2006. If possible this will be held to co-incide with the accession of the Greek Aristarchos telescope into the trans-National Access programme

A sub-committee of the director's forum will convene at appropriate times to review the operation of the newly commissioned Aristarchos and Liverpool telescopes with a view to incorporating them into the trans-national access programme. The schedule of these meeting will depend on progress with these telescopes but the first is expected in the late Spring of 2006.

The forum will develop a plan and terms of reference for an independent review of the access programme to consider, inter alia, the balance of the user groups being supported and the status of the individual telescopes in the network. This review will take place during this forward look period.

WP2: Operation of the Trans-national Access Office

Objectives:
Assessment of the qualifying telescope time awarded and the consequent User Fees due to the telescopes, in accordance with the cash flow approved by the Telescope Directors' Forum.
This office will perform the tasks defined by the Telescope Directors' Forum in support of the Access Programme (6N6 Activity NA6: OPTICON Telescope network, defined in the Annex 1 of the contract)

Activity description:
The Trans-national Access Office, in accordance with the information included into Annex I of the EC contract, will perform the tasks defined by the Telescope Directors' Forum in support of the Access Programme.

In addition to the activities related to the daily operation of the Trans-national Access Programme, our Plan for the next 18 months include also the following special activities:

PROMOTION OF THE ACCESS PROGRAMME: Special efforts will be made to enhance the participation of new users, young researchers, users from Central and Eastern Europe, and users from countries with no similar research infrastructures. New promotional material will be produced and widely distributed among the international scientific community, according to the following list:

NEW PROMOTIONAL MATERIAL:
- Poster and oral contributions at the IAU meeting in Prague
- Brochures

MAIN INTERNATIONAL EVENTS:
- IAU 2006
- Central and Eastern Europe.

PROCEDURES TO AWARD TIME:
The Access Office delivered to the Telescope Directors' Forum a document in which the different procedures regarding Time Allocation Committees and systems to allocate

observing time under the OPTICON contract, studying complementarities and duplications is analysed.

Different scenarios for a better coordination and optimisation of telescope time were proposed to the working group set up for this particular issue. The Access office will implement any new actions entrusted by the Telescope Directors' Forum in order to set up a more coordinated procedure to award time.

SCIENTIFIC OUTPUT: Output from the access provided under this contract will be closely compiled and monitored. Special measures will be carried out to achieve this objective, including the maintenance of a thematic section on the Access Office Webpage of the scientific output compiled, as well as the request of publications in refereed journals, press released and participation in conferences: (Poster & oral contributions).

INFORMING USERS: All successful and eligible applicants (no just those finally selected for OPTICON support) receive complete feedback informing about this programme (reasons for rejection, criteria of eligibility, etc.).

IMPROVEMENTS ON MANAGEMENT PROCEDURES: OPTICON users are normally requested to advance their travel and subsistence costs when observing under the auspices of the Access Programme. We have started several contacts to try to minimise this situation, and to pay directly to the supplier. In the case of Haute Provence and ENO, users do not have to pay the accommodation costs; we will try to extend this best practice to other observatories. For the future, we will also investigate the way to pay directly the travel expenses (allowing to the astronomer to pick up the air ticket at the airport without being charged for that). Other actions will be also taken to improve our current procedure for the reimbursement of expenses.

As explained in the Activity Report it was carried out in 2005 a 18-months Review of the Access Office by a Panel of Experts appointed by the Telescope Directors' Forum. The Panel considers that the underlying system is now in place, new staff are now introduced and trained, so the operation could be streamlined in the light of experience. They considered, and it has been accepted by the entity operating the Access Office, that now the effort can be reduced from 24 to 18 person-months / year. Following figures are in accordance with this.

Participants:
The Trans-national Access Office will continue being operated from the Instituto de Astrofísica de Canarias, IAC. The following table shows, in person months, the total effort needed to carry out the running of this Office for the next 18 months.

Laboratory	WP2	Total Effort (person/month)
IAC	27	27

WP3: Enhancement

A further meeting of the Enhancement Working Group will take place in 2006.

In support of already existing enhancement activities (like those taking place at astronomical telescopes), the required expertise will be analysed and experts sent to these events (typically 5 to 6 per year). The activity will be monitored in small, yearly, meetings.

Preparatory work will start for specialised enhancement workshop(s) in 2007-2008, about use of new instrumentation like adaptive optics, multi-objects spectroscopy, etc.

The particular needs of countries in central and eastern Europe will be analysed during specific visits, organised jointly with the local astronomical authorities and the OPTICON Telescope Directors' forum.

Expected outcomes and deliverables **No Project month info for WP2. No WP3**

Work - package	**Milestones/ Deliverables**	**Project Month**	**Description**
1	M2	33	Annual Directors Meeting
1	M3A /B (new)	30/33	Peer review of Aristarchos and Liverpool Telescopes
2	D1	32	Promote Access programme at IAU meting in Prague
2	M2	34	3rd Report to Directors Forum
3	M1	30	Working Group Meeting

1.7 JRA1: Adaptive Optics

WP 1: Coordination of JRA1

The JRA1 General meeting 3 & 4 will be organised March 30th and 31st 2006 and in January 2007. The JRA1 web page will be updated with the documentation produced by the JRA1 partners. Regular teleconferences between the principal work package managers will be held to ensure progress and coordination between the packages. The interim 12 months report will be prepared and will include detailed work plans for the ensuing period.

WP 2: System design

WP2.1: XAO system Study

The next major milestone is the authorization of the ESO Council in May 2006 to proceed with the contract negotiation and signature with the Consortium. Until then, all required documentation applicable to the contract will be produced (Technical specifications, Statement of work, contract, key component Top Level Requirements and Consortium agreement. After the kick-off meeting foreseen in 1Q 2006, the Consortium will perform the design of the Planet Finder which will end with the design review 1st half of 2007 (**Deliverable D1 of WP 2.1**). In parallel, ESO will pursue the development of the AO key components (Piezo deformable mirror, drive electronics, fast CCD, detector controller, Real Time Computer).

WP2.2: GLAO System Study

Following the Adaptive Optics Facility project approval by ESO committees, an official ESO internal Kick-Off will take place in early 2006; the management structure will be put in place and review board recommendations implemented. The individual sub-systems (GALACSI, GRAAL, ASSIST, DSM and 4LGSF) will be further designed by the project team. Design reviews will be organized for these subsystems first half of 2007 (**Deliverable D1 of WP 2.2**). This is late with respect to the original JRA1 project plan but the size of the Adaptive Optics Facility as described in the delivered documentation, is much larger than the design study of one GLAO system as originally planned in the contract.

The two GLAO concepts (GALACSI and HAWK-I-AO), the multi Laser Guide Star system and the results of the VLT Adaptive Secondary conceptual design study (WP 3.5) will be merged to a so-called VLT multi LGS GLAO telescope facility. The design of this facility will be performed and will be reviewed (**Milestone D1**). Following the design review a recommendation for the development of this facility will be provided.

NOVA will pursue the design of the Adaptive secondary simulator for GALACSI (ASSIST) and will manage the interfaces between GALACSI and MUSE. NOVA in collaboration with ESO will also develop original control algorithms for GALACSI.

WP2.3: Multi-Object WFS for GTC

In the next 18 months the activities will be:

- Based on numerical simulations Grantecan will develop the conceptual design of the single object curvature WFS.

- 1st half of 2006 Grantecan will design the turbulence generator and telescope simulator. 2nd half of 2006 Grantecan will identify the test camera, the optics (e.g camera, beamsplitter) and the WFS CCD and will complete the design (Deliverable **M1 of WP 2.3**)

WP2.4: Multiple FOV System with NGS

Within the next 18 month it is planned to integrate the Mid-High Layer wavefront sensor starting in January 2006. To build the Ground Layer Sensor the last orders for components will be placed in early 2006 for several components separately. The AIT of the GWS will start in November 2006 depending on arrival and compliance with specifications of each component. The AIT will continue until end of this 18 month period.

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

WP3.1: 2nd Generation RTC Platform

To compress the delay in the next period we have already acquired evaluation systems that will help us in understanding the potential of the new HW architecture and start testing it earlier. In parallel the HOT experiment will be the test-bed for the high-latency real time pipeline: in fact the SPARTA system that will be provided to HOT will feature 2 multi-CPU boards and, at a second stage, the FPGA-based acquisition processor. It is planned to have a first level of functionalities by mid 2006 and the rest (including the FPGA application) by end of 2006. This, together with benchmarks of the new hardware, will let us present a detailed test report of all the levels of the system and to anticipate the design of the upper layer software. Two CODE test tools have already been acquired and their SW development already allocated to external resources. The remaining HW procurement will be completed during 2006, for the test system, comprising 1 CPU-FPGA board, 1 DSP-FPGA board, auxiliary hardware and related software. In 2007 we plan to double the system buying one more board of each type to bring the total system complexity close to that required for the Planet Finder.

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

In 2006 ONERA will finalize the experimental demonstration of the Optimal Control method for MCAO on the BOA bench and a test report will be produced (deliverable M2 of WP 3.2). The theoretical study, the simulation tool and the results of our experimental validation will allow us to specify the optimal control to be implemented on MAD. ESO will provide the required characteristics of MAD. A test plan will be defined in agreement with ESO. The implementation by ESO and the tests on MAD in collaboration between ESO and ONERA should occur 1st half of 2007.

In the field of optimum wavefront sensing, ONERA will study the "Maximum a Posteriori" approach to increase the performance of the centroid measurement in the Shack-Hartmann WFS and the application to Ground Layer AO and Extreme AO will be proposed.

WP3.3: 2nd Generation Piezo DM

In the next 18-months CILAS will continue the development of two prototypes required to validate the manufacturing process and will manufacture the piezo deformable mirror. After three more progress meetings foreseen for April and September 2006 and March 2007, the DM will be delivered and preliminary accepted in 1st half 2007, 24 months after kick-off.

WP3.4: 2nd Generation Piezo DM drive Electronic

In the next 18 months, ESO will issue a Call for Tender for the design and manufacturing of the piezo DM Drive electronics and contract will be signed with the selected supplier. The

design of the Drive Electronic will be developed 2nd half of 2006 and the manufacturing will proceed following the design review. Provisional acceptance is foreseen 2nd half 2007.

WP3.5: VLT Adaptive Secondary

Following the ESO Council decision of December 7th-8th 2005, confirming the approval of the VLT Adaptive Optics Facility (WP2.2), the DSM design study will be pursued by Microgate, ADS and INAF to the design stage. The design review is planned end 2006 (deliverable M2 of WP 3.5). At that time the contractor progress will be monitored and the design review meeting will be organized with ESO composed experts review panels.

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

In the next 18 months, the two proposals following the Call for Tender will be analysed and a supplier will be identified. After approval of the **ESO** Finance Committee in March 2006, the contract for the manufacturing of the Zerodur thin shell will be signed and two Zerodur blanks will be procured. 2nd half of 2006 the design review will take place (deliverable M1 of WP 3.6) and if the 1st Zerodur blank has been accepted the test results will be reviewed. The delivery time specified for the thin shell is 18 months after Kick-off and during this time progress will be monitored by **ESO** with the selected contractor.

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

A new procurement and development strategy for the 2k micro deformable mirror will be defined in collaboration between ESO and INSU 1st half of 2006 with the aim to demonstrate the feasibility of such key component for astronomical applications. Potential merging of efforts with US partners will be investigated by ESO as well as development of a smaller scale MDM demonstration in Europe.

The MOEMS drive electronics will be delivered and tested 1st half 2006, and a second unit will be ordered depending on the new MEMS prototype schedule.

All activities related to magnetic deformable mirrors are completed and the technology has been successfully transferred to industry. From now on, commercialization is taken over by industry.

WP3.8 High Order wavefront sensor experimental study

1st half of 2006 the main subparts of HOT will be tested and characterized at ESO (phase screens, Boston Micro-machine micro mirror, Infrared camera). The different parts of HOT will be assembled, aligned and tested in the different institutes of the consortium: INAF-Arcetri for the pyramid wavefront sensor, Durham for the Shack-Hartmann wavefront sensor and ESO for the common path of HOT. Once everything ready the complete system will be integrated and tested at ESO (2nd half 2006). The first light of HOT in closed loop is planned for end 06. The following months will be dedicated to the optimization of the system before to study deeply all the issues associated to high order wavefront sensing. These series of tests will be reported in a final report in the last year.

HOT would highly benefit from additional funding (~100k€) to procure coronagraph masks and develop newly proposed and promising focal plane wavefront sensor. ESO has started the procurement of an additional Boston Micro machine micro mirror in prevision of this future upgrade.

Workpackage	Milestones/ Deliverables	Project Month	Description
1	**M1**	27	JRA1 general Meeting 3

1	**M2**	37	JRA1 General Meeting 4
2.1	**D1**	42	Design of SPHERE
2.2	**D1**	42	Design of the VLT multi-LGS GLAO facility
2.3	**M1**	33	Complete design of the single object WFS for GTC
3.1	**M2**	42	Complete development of the Real Time Computer Platform and performance testing
3.2	**M2**	30	Implementation of the optimal control methods developed above on a simplified laboratory system and performance evaluation.
3.4	**M1**	33	Complete design of fast drive control electronics for the piezo stack deformable mirror developed above
3.5	**M2**	36	VLT Adaptive secondary design review
3.7	**M1**	31	Specifications of a micro deformable mirror prototype; contract signature
3.7	**M2**	36	Preliminary design of a micro deformable mirror prototype
3.7	**M3**	27	Delivery of a MDM control electronic prototype
3.8	**M2**	42	High order Test bench test report

1.8 JRA2: Fast Optical Detectors for AO

As already mentioned in the previous annual report, a delay of at least 6 months is expected for the total duration of the JRA2 due to the late signature of the contract.

The following subcontract is necessary for the execution of JRA2. ESO covers the extra-cost of this subcontract in addition to the expected OPTICON contribution.

In the next 18 months period, the following activities are planned:

- WP1: management

Two general meetings are planned during this period, one will be held at ESO by March 8th 2006 an the other one at IAC about 6 months later to prepare the camera delivering and detector test plan. The JRA2 will also expect to be represented at the next OPTICON board meeting.

- WP2: detector procurement

The work plan for the next 18 months will involve monitoring the progress of the design, development and supply of the detector. The detector development schedule is shown in the table below. Two meetings with E2V are proposed for the period: one in January 2006 for the package design review and one in March 2006 for the test camera design review.

Table 1: Detector development milestones

	Milestones	**Date**	**Status**
M5	Delivery of mechanical samples (4 off)	15th June 2006	On-time
M6	ESO supplies test equipment	12th October 2006	On-time
M7	Delivery of Electrical Samples (4 off)	8th February 2007	On-time
M8	Delivery of Engineering Devices (4 off)	8th March 2007	On-time
M9	Delivery of Science Grade Devices (4 off)	8th May 2007	On-time

- WP3: controller

The controller is now finishing the design phase. Simulations of the digital concepts are finished. Analog simulations based on early data of the chips are also complete. The controller will be finished for the summer 2006 and be shipped to E2V in order to be used for the detector tests at the factory. In addition to the fact that this solution will save funding, we will have the huge advantage of using the same controller at the E2V factory and during the detector tests by the OPTICON partners. This will guarantee that the measured performances will be the same in both cases.

- WP4: cryogenic system

The task of this work-package is simplified by the fact that the detector will be cooled by a 2-stage Peltier package provided by the manufacturer E2V. This solution will be more robust for the future. An overall package of the detector and its Peltier cooler will be integrated with the controller. Since the electrical cables between the controller and the detector have to be very short in this application (a few cm), the cryogenic system is designed taking into account all the mechanical interfaces of the controller and the detector, in order to have a very

compact design including all the sub-components. Thermal simulations of this package made by the OPTICON partners allow us to have good confidence in the thermal design. This work-package has strong interactions with the WP2 and WP3. This task has now started since the interfaces with the CCD package and with the electronics boards are known. Delivery of the cryogenic system is also foreseen for summer 2006 at the same time of the controller, because the two items can not be dissociated.

- WP5: detector test

Although this work-package has not formally started, the detector test activity is now being discussed inside the JRA2, and in particular at the JRA2 meeting to be held at IAC in summer 2006.

Milestones and Deliverables:

Work package	**Milestones/ Deliverables**	**Project Month**	**Description**
2	M4	30	Delivery of demonstration device detector.
2	M5	38	Frontside device test.
3	M2	27	Controller design review.
3	M3	33	Delivery of detector controller.
3	M4	34	Complete controller test
3	D1	35	Controller acceptance report.
4	M1	30	Complete cryogenic system design
4	M2	31	Cryogenic system acceptance

1.9 JRA3: Fast detectors for astronomy

WP2 (EMCCD Developments)
The integration of the new EMCCD's and their laboratory characterisation will be completed during the first half of the next reporting period. Once complete, on-sky characterisation will be performed using the EFOSC spectrograph on the ESO 3.6-m telescope on La Silla. To this end, we have entered detailed discussions with the Director and his staff in Chile to agree on the required interfaces and scheduling.

WP3:
The finance plan for OPTICON JRA3 applicable to WP3 was revised on December 12, 2005 (see report of WP1 management). It now contains a direct budget for MPE (80 000) and MPA (10 000) and a subcontract for WP3 in the amount of 350 000. The subcontract will additionally be supported with funds from ESO (150 000) and by MPE (75 000).

WP4:
In the next 18 months, further research will continue into the development of the electronics and experimental characterisation. With the delivery of the newly fabricated APD arrays, the devices will be initially tested, packaged and integrated with the AQCs and associated electronics. The devices will then be characterised and the optimum operating conditions will be established. Further work will continue into the interface definition and time-tagging solutions for the APD arrays.

WP5:
We have recently had our allocation of funds for this work from the OPTICON programme increased to allow us to appoint a technical assistant for two years. This has been approved at the end of 2005 and we hope to be able to appoint a suitable individual to be in post before Easter, 2006. This will allow us to continue our controller development and make it much easier to transfer those technologies to other potential users.

WP7:
Modification of the ESO cryostat to accept the science grade EMCCD. This will complete deliverable D1.

WP8: As noted earlier, this workpackage has been modified.

WP	Milestone/ deliverable	Project Month	Description
1	M3	30	Integration review
1	D1	42	Test and instruments verification plan
1	D2	48	Assessment report on relative merits HTRA technologies
2	D1	30	Integration L3CCD on testbed
2	D2	36	Test report
3	M3	36	Fabrication of Avalanche amplification elements
3	M4	40	Functional test and characterization of AA stage
7	D1	30	Delivery of prototype camera head on testbed
8	M1	36	Design review of common testbed software

1.10 JRA4: Integrating optical interferometry into mainstream astronomy.

WP 1.1
Next spring, ESO should select next spring the concepts for phase A studies. After ESO selection, hopefully two or three phase A studies will be started. The next STC in 2007 may decide on the outcome of these studies. With these steps, the next generation of VLTI instruments should have a good chance to get on track. From now on, the milestones and deliverables of WP1.1 will match those defined by ESO.

WP 1.2
Detailed review of the results and planning for subsequent steps is foreseen in the next CFT meeting, tentatively set in Summer 2006.

WP 2
The next 18 months will be crucial in the deployment of the activity since the project now enters a phase of production of code from all the participants after the software specifications. The user requirements documents produced request a number of functionalities that will not be immediately present in the first version of the software that will be issued in the coming period. The complete set of user requested functionalities may however be available at the end of the project, but, depending on the complexity of the software specifications needed, a supplementary effort may be requested from OPTICON to fully achieve the objectives.

In the Table below, the milestones and deliverables for the rest of the project are re-defined according to the current progress:

Month →	30	36	42	48	54	60
WP1.1	D4		D5			
WP1.2		D3				
WP2.2	M2/D2		M3/D3		M4/D4	
WP2.3	M2/D2		M3/D3		M4/D4	
WP2.4	M1/D1		M2/D2		M3/D3	M4/D4
WP2.5		M2/D2/D2b			M3/D3	M4/D4

The milestones and deliverables associated to each WP are listed in the Table below:

Work Package	Milestones/ Deliverables	Description
1.1	D4	Selection of projects by ESO for phase A studies
1.1	D5	Selection by ESO of second generation of VLTI instruments
1.2	D3	2nd Progress Report on CHT
2.2/2.3/2.4/2.5	M2	Final Design Review
2.2/2.3/2.4/2.5	D2	Software Design Description
2.2/2.3/2.4/2.5	M3	Software Acceptance release 1.0
2.2/2.3/2.4/2.5	D3	User's Manual (Draft)

2.2/2.3/2.4/2.5	M4	Software Acceptance release 2.0
2.2/2.3/2.4/2.5	D4	User's Manual (Final)
2.4	M1	Preliminary Design Review
2.4	D1	Software User Requirements
2.5	D2b	Algorithm Robustness Report (for UCAM/CAV group only)

1.11 JRA5: Smart Focal Planes

WP 5.0 Management and Systems Engineering

Continuation of evaluation of risks and challenges in the provision of enabling technologies, including identifying routes for further development, culminating in a report which details the way forward to multi-object and multiple field spectroscopy with Extremely Large Telescopes and current facilities.

WP 6.1 Prototype IFU

The emphasis on this work package will be on investigating means by which galvanic replication can be undertaken on image slicers such that there is no appreciable deviation in shape between mandrel and replica.

WP 6.2 Pick off Prototype

This work will continue in the first 6 months of 2006 with the assembly and first tests of Planetary Positioner system. Tests will be conducted of the positional repeatability of the individual elements together with an overall measure of the positioning repeatability of an individual pick-off mirror. A full suite of tests will be undertaken in the second half of 2006, with cryogenic tests being undertaken in the first half of 2007. In parallel to these tests there will be activities to improve the performance of the prototype including an investigation into the use of LVDT controllers and piezo-drives for the rotation stages

WP 6.3 Active optics beam manipulator Prototype

This work will focus in the coming 6 months on the build and test of the active mirror described above. In addition a Wavefront Sensor, test tools and software will be established to test its performance during the second half of 2006.

WP 6.4 MOEMS mirror array prototype

A second mirror array prototype array will be fabricated which will be designed to have improved yield. Once this is achieved, designs will be scaled up to larger arrays.

Milestones and Deliverables:

Work package	Deliverables Milestones	Project Month	Description
5	D4	30	Mid Year Report
5	D5	36	Year End Report
6.1	M1	30	Prototype of replicable slicer
6.2	M1	30	Prototype of scalable field selection device
6.2	D1	36	Report on Warm Tests
6.2	D2	42	Report on Cold Tests
6.3	M1	30	Prototype of active mirror
6.3	D1	36	Report on Warm and Cold Tests
6.4	M1	30	Prototype reconfigurable slit
6.4	D1	36	Report on Warm and Cold Tests

1.12 JRA6: Volume Phase Holographic Gratings

During the activity carried out in the last reporting period no need emerged for major changes in the work packages activity nor in the distribution of milestones and deliverables. Due to the delays in the cash flow some of the milestones expected to be completed in the reporting period were not. This was mainly due to delays in acquisition of laboratory equipment needed for the test. The "leftover" activities are marked in italics in the following table.

The plan for the activity in the next 18 months will follow the overall plan presented in annex I of the contract. An extract of the milestones and deliverable list form Contract Annex I and the timeline for their achievement are reported in the following 2 tables:

The most important milestones of the next period consist of a detailed definition of the characteristics of the science grade prototypes, the ultimate deliverable of the whole project. .

Workpackage	Milestones/ Deliverables	Project month	Description
2	M4	27	Prototype analysis report document
3	M4	27	Review of prototype critical points
5	M4	27	Prototype analysis report document
2	M5	30	Science Grade device specification document
3	M5	30	Definition of construction plan and materials trade off analysis
4	M4	30	Review of Prototype Critical Points
4	M5	42	Production and analysis of the material for the science grade device.
5	M5	30	Science Grade device specification document

WP1 will continue the activity of coordination, liaison with OPTICON management and collection and dissemination of the results. At least 2 plenary meetings are foreseen in the next 18 months aimed to compare results and decide future steps into the activity. The link with the KTN (N3 WP5) is also expected to be strengthened in this period in order to better focus the JRA activity with the overall aims of the OPTICON Programme.

Two major milestones are defined in the research activity of WP2 and WP 5. One is a leftover form the previous period and concerns the prototype analysis report (M4) and the other concerns the science grade device preliminary specification document (M5). These milestones and the corresponding deliverables are expected to be achieved in the original timescale.

Also for WP3 we have as a leftover from the reporting period the review of prototype critical points (M4), and the definition and construction plan and materials trade-off analysis (M5). These milestones and the corresponding deliverables are also expected to be achieved in the original timescale.

Due to its nature WP4 is following a different path. It has no leftovers and 2 main milestones to achieve in the next 18 months: the review of prototype critical points (M4) and the production and analysis of the material for the science grade device (M5). These milestones and the corresponding deliverables are also expected to be achieved in the original timescale.