

Proposal full title: Optical Infrared Co-ordination Network for Astronomy

Proposal acronym: Opticon

Type of funding scheme:

Combination of Collaborative Project and Co-ordination and Support Action for Integrating Activities

Work programme topics addressed:

FP7-INFRASTRUCTURES-2012-1 Research Infrastructures for Optical/IR astronomy

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1. Scientific and technical quality, relevant to the topics addressed by the call

1.1 Concept and objectives

It is a truism that optical-infrared astronomy is in a “golden age”. Public interest, manifested through such criteria as downloads of HST images and media interest, is higher than for almost any other subject. This follows naturally from scientific progress – there are new stories, new results, new Prizes to celebrate – and the intrinsic interest of the questions addressed by astronomy, which range from the origin of the Universe, through the nature of matter and existence, to exo-planets and life elsewhere. This story of scientific success has however not happened by chance – considerable planning and organisation, and continuing technical research and development, is required to develop the highly-skilled scientists and engineers trained to operate and exploit the state of the art facilities which deliver the scientific advances.

A decade ago planning assumptions for next-generation astronomical infrastructures took for granted that older facilities would become obsolete, would be closed, and their operational budgets would contribute to newer facilities. However, the number of new large expensive facilities is small – the number of extant facilities is large. This course would turn astronomy into a system which delivered research capabilities only to a small elite – inevitably the wealthier elite. In fact, this is the way astronomy was implemented earlier in the 20th century, when global domination was in the hands of a very few wealthy private institutions, all in the US. We do not wish to go down this road again.

The obsolescence paradigm was based on two fundamental errors: first, that older facilities could not be upgraded affordably to retain cutting-edge competitiveness, and second, that all progress came from the new, large facilities. Optical-infrared telescopes are limited by their instruments and their users, not by themselves. The performance of astronomical detectors has been improved by orders of magnitude over the last two decades and can be further much improved, thus maintaining “small” facilities as cutting-edge capabilities. Spectrographs now perform very much better than they ever did, but are still orders of magnitude away from working at fundamental performance limits. We can, and are, continuing to improve.

Furthermore, astronomy, unlike most physical sciences, is still in discovery mode. Most of the topical exciting subjects which dominate public interest – dark energy, dark matter, exoplanets, super-massive black holes and so on – have been discovered in the last two decades and were unpredicted. Astronomy progresses by having very many inquisitive people exploring parameter space on many facilities, not by focussing on a single experiment.

The change from an assumption of obsolescence to an assumption of future opportunity came to be made by the development of a European-scale astronomical community. This community was able to make the case that facilities should be enhanced and shared, not closed, that technology developments were both achievable and affordable, that astronomers could deliver cutting edge science with those enhanced facilities and crucially that the talent, expertise and financial resources to deliver all this would be available if efforts were coordinated on trans-national scales. European astronomy, largely through the excellence of the European Southern Observatory, but also through the coordination, planning, development and technical R&D work supported by the EC via ASTRONET (Strategy) and Opticon (implementation) has made that case. In consequence, Europe has become the international leader in optical-infrared astronomy.

European optical-infrared astronomy is undergoing a dramatic transformation on two fronts, as foreseen in the ASTRONET *Infrastructure Roadmap*. First, the decision has been taken to turn the heterogeneous collection of national 2-4m telescopes into a rational, coherent European facility, with a stable long-term future delivering scientific excellence. Technical and organisational preparations for reaching this goal are underway. Second, the impending decision to construct the European Extremely

Large Telescope (E-ELT) will consolidate European global leadership in optical-infrared astronomy. Opticon has been a driving force in this development by:

- (i) maturing the astronomical community to large-scale European cooperation;
- (ii) preparing the factual and organisational basis for these breakthroughs;
- (iii) coordinating the development of the enabling technologies that will underpin this transformation.

These strategic breakthroughs will fundamentally change the role and environment for Opticon in 2013-2016. Specialising the 2-4m telescopes and their instrumentation will optimise the role of each of them in reaching their assigned goals in the *ASTRONET Science Vision*. Chief among these goals is the realisation of wide-field spectroscopic surveys to complement existing and impending imaging surveys from the ground and in space, as developed and formulated by the joint *ASTRONET-Opticon Working Group* working under the current FP7 contract. Large European consortia are being assembled to construct the necessary advanced instruments for 4m-class telescopes in both hemispheres, with smaller-scale projects to equip other telescopes to fill their new roles within the overall system on a time scale of 4-5 years. In parallel, other consortia will embark on the construction of the first generation of the even larger instruments needed for the E-ELT - the decade-long, top-priority project in the *ASTRONET Roadmap*. The E-ELT is undertaken, funded and managed by ESO but the instruments, which will deliver the science, are the responsibility of the community. Cutting-edge technology must continue to be developed over the next decade to ensure the next generation instruments are as good as they can be. Maintaining the crucial role of Opticon as a driver of this process of change and essential provider of intellectual and financial seed capital will be crucial at this critical juncture.

Each of the above instrumentation projects is comparable to or larger than the budget of an entire I3 grant and they will be funded by consortia of national funding agencies. In addition, conducting the planned surveys implies the commitment to operational costs for many hundreds of nights on dedicated telescopes, displacing the other types of science currently conducted there. The logical solution, spelled out in 2010 by the *European Telescope Strategy Review Committee*, managed by Opticon on behalf of *ASTRONET*, is to provide access for the whole European astronomical community to the common telescope system through a single time allocation process. This cannot happen overnight, given the time scales needed to build new instrumentation and overcome the considerable organisational, financial and cultural barriers separating the new system from the existing one; good will and hard work are required.

This leads to a new strategy for Opticon in the period 2013-2016, focused on the following three main challenging but viable top-level objectives:

- Provide continued Trans-National Access to the existing 2-4m telescopes during the transition to their new scientific responsibilities and corresponding new complement of instruments. Notably, the prototype common observing proposal and time allocation procedure system must be developed and field tested to handle 100% of the time on all the telescopes. This involves management of User Fees, operating an International Time Allocation Committee, maintaining a Telescope Director's Forum and further developing and maintaining the NorthStar web-based application system prototyped by Opticon during the current contract.
- Coordinate the common development of essential enabling technologies for the next generation of instruments on the existing system of European 2-4m and 8-10m telescopes and for the even more advanced second generation instruments that will populate the E-ELT later in the next decade. This involves the JRAs which develop detectors, which are basic to everything; adaptive optics, which is on the critical path for almost every instrument on large telescopes and for every application from cosmology to exoplanets; new potentially paradigm-changing applications of photonic systems and "smart optics" and innovative dispersive systems, applying capabilities developed in industry to astronomy and in turn delivering industrial spin-offs back to industry and society. Our six Work Packages will deliver this effort.
- Nurture and optimise a set of networks to promote European synergy in astronomy education; coordinate a distributed telescope network to respond to transient-source event alerts, notably from the

ESA mission Gaia, and facilitate other forms of time-domain astronomy, including asteroseismology; provide long-term foresight and prototyping on emerging technologies; and facilitate the integration of optical interferometry and the data expected from the E-ELT in the fabric of mainstream European astronomy in 2015-2020.

1.2 Progress beyond the state-of-the-art

The state of the art in the fields in which Opticon is investing has been, to a real extent, defined by previous work by the partners involved in Opticon. These partners are the European leaders in their respective fields and define the state-of-the-art. Thus although the workpackage structure looks similar to that of previous contracts, the *content* of those workpackages has been radically redesigned. Each detailed WP description introduces its relevant background, which we do not duplicate. We provide a brief overview here, for context.

1.2.1 Networking

Networking activities link people and communities and motivate future developments. To appreciate this context, it is perhaps helpful to imagine an (oversimplified!) story of how people are trained and motivated and how this maps onto the Opticon programme. It begins with training and motivation (via schools, exchange visits, outreach), and progresses via experience, often on existing medium sized facilities (TNA activity) whose operations are being rationalised to ensure viability and efficiency (Telescope Directors Forum, ASTRONET implementation activities, common time application system) and whose individual capabilities are being enhanced by new software and hardware (JRAs + exchange visits). These users may require experience of specialist skills (High Time Resolution astronomy, Time Domain astronomy, Interferometry). All this leads toward the E-ELT, for which the science case is being developed, evangelised and co-ordinated with other projects (ELT network and workshops) and for which the community is developing new hardware (JRAs, including photonics, VPH, AO). Some of this is being prototyped (JRAs), while a watching brief is maintained on far future technology (Innovation Network), some of which is already being considered now and for future JRA effort, in the light of science-industry developments in the next decade or more. As a specific example of the success of Opticon networks, we note that the ground-based Solar astrophysics community, currently included inside Opticon, are proposing their own I3, having “matured” into a viable independent community under Opticon support, and having benefited from seeing how a community develops and plans inside an EC-supported context. As a second specific example of success and the current state of the art, we note the Opticon training and exchange Schools. These are so successful they are now a model for others. There are currently requests for help in setting up similar activities from China, Ukraine, the International Astronomical Union in Africa and from South America. Thirdly, we note that Opticon success in developing viable 2-4m telescope networks, assisting in developing state-of-the-art instrumentation for those facilities and in building communities through networking, has led Iran, which is building its first national observatory, to participate in the Canarian observatories, to send students to the UK for PhD training and to apply for observer status in relevant activities in Opticon, to help develop their own national research community. Apparently Opticon networking activities are a model which others consider worth following.

The service enhancement aspect of the networks is related to the efforts to deliver coordination and optimisation of the available telescopes, through the Telescope Directors’ Forum (an Opticon initiative), through the common Call for Proposal system, with standard web interfaces and through the activities of several networks, especially the Key Technology Network and all the JRA activities, which ensure potentially viable new technologies are brought into consideration at the earliest possible opportunity. Indeed, were it not for the Opticon activity, it is far from obvious that many infrastructures would be providing any services at all!

The culture of cooperation is built directly by all networks. Previous networks have learned how to involve wide communities, have developed appropriate contacts in many countries and projects, have

strengthened communications and synergy with technologists, instrument builders and scientists and implemented successful series of workshops connecting the community, e.g. most recently at the time of writing, with a large workshop on the relation between complementary science projects, at other infrastructures and the E-ELT. The current proposal will extend those activities to strengthen links between the E-ELT network and other Opticon activities in the JRAs. For example, one of our planned workshops will explore instrumentation concepts for the long-term future of E-ELT, with emphasis on developments for future instrumentation, which are proposed here, and which will be uniquely investigated inside Opticon (fast detectors, VPH gratings, astrophotonics). A particular strength of this forward-looking approach is the Innovation Network. The current FP7 activity has been very much focussed on bringing new technology into optical and infrared astronomy. The proposed new Innovation Network will build on these activities to generate stronger interaction with industry, to enhance the economic and societal benefits of the Opticon programme and investigate possible future consumer applications.

1.2.2 Trans-National Access

The most fundamental aspect of the “integrated provision of infrastructure related services” is that there was no such provision for European-owned 2-4m telescopes, until it was initiated on a trial basis by the current Opticon. As noted above, plans until recently were to terminate several national infrastructures in favour of a very few, very large infrastructures, all provided through the European Southern Observatory, or various bilateral projects (e.g. the US-German-Italian Large Binocular Telescope). Opticon, working with ASTRONET, and the Opticon partner national funding agencies, sponsored a full detailed review of the capabilities of 2-4 telescopes in the future, including costs and requirements (the ETSRC or ‘Drew-Bergeron’ report). Following acceptance of that report’s recommendations by the national funding agencies, the owners and operators of the infrastructures, Opticon has implemented a “proof of principle” implementation of a common mode of operation. This experiment has started under the present contract and will become mature under this new proposal. This activity has shown the benefits and practicalities of coordinating and specialising infrastructure operations across countries and has allowed the integration process to begin but it requires time to mature. Full implementation requires new specialist instrumentation – a benefit of the Opticon technology R&D work – and continuing community-building – the goal of the Opticon networking activities. Longer term viability also requires awareness of potential new technologies and technology roadmapping to retain topicality, both aspects of Opticon activity.

The beginning of rationalisation and optimisation of 2-4m telescopes has taken place in recent years and more is expected. The telescope network included in this proposal has been adjusted to take account of these developments, for example the UKIRT has entered survey only mode and is no longer offered under the TNA programme. The telescope suite thus includes all the major (non-ESO) medium sized telescopes which will offer general user access during the contract period. This allows individual astronomers, especially those whose national facilities have been specialised in favour of campaign mode operations, access to a suite of resources which can support a wide range of projects. Crucially, it allows follow up and exploitation of interesting objects discovered in campaigns and surveys using the best possible tools for the job. The successful establishment of an Opticon common time allocation process has made it easier and simpler to apply for time on non-national facilities and crucially, to develop projects which require access to multiple facilities. By developing a process which is clearly not nationally based and applies a common process to all applications, it also encourages proposals from outside the traditional national user groups.

1.2.3 Joint Research Activities

The several JRAs in Opticon cover a wide range of challenges related to development of future astronomical instrumentation – the community contribution to E-ELT and next generation facilities, with complementary approaches including the range from technically challenging developments of systems, which are known to be on the critical path for next generation instrumentation, through investigations of new technologies of high potential impact but as-yet less certain practicality. The balance between these activities has been set in part by the development of the Opticon astronomical technology Roadmap, and in part by critical analysis of the very wide range of possible activities by the national funding agency scientific directors who make up the Opticon Executive Board. For clarity, we briefly consider each JRA area in turn.

Adaptive Optics (WP1)

Adaptive optics (AO) systems, using both natural and laser guide stars, are the key technologies for the next major advances in ground-based optical-IR astronomy in the next 20 years. Significant progress made over the past ten years in the field of AO has brought this observational technique to the maturity level where outstanding astronomical results can be obtained routinely. Astronomers are now looking toward the next generation of AO systems, which will allow them to extend this powerful technique to new observing modes. Current Opticon activity aims to design and develop **Laser Guide Star Adaptive Optics** systems for the existing large telescopes (Large Binocular Telescope, Very Large Telescope, William Herschel Telescope), to upgrade existing Adaptive Optics systems for the large Solar telescope (GREGOR solar telescope) and to upgrade the Very Large Telescope Planet Finder instrument (SPHERE) to maintain its competitiveness in the period 2012-2014. The primary goal of new this proposal is to develop the technologies and the knowledge required to improve the performance and operational efficiency of these existing AO facilities in Europe, as well as to develop the state-of-the-art second generation instrumentation required for the 40m European Extremely Large Telescope (E-ELT).

Fast Detectors (WP2)

The current Opticon activity defines the state-of-the-art in this field. Outstanding performance was obtained from the Opticon developed camera Ocam and its dedicated detector, the CCD220 (which has led to commercial spinoffs – see below). Ocam technology is currently used by the second generation of VLT Adaptive Optics (AO) instruments. Third generation AO instruments will be still more demanding in terms of frame rate and readout noise, and the detectors will be developed in this proposal. This performance update is currently the baseline for the E-ELT AO systems.

Developing smarter, smaller, instruments (WP3, 5 & 6) The global telecommunications industry has invested massively in photonic systems, with many applications available in biomedicine and sensing applications. There are as yet only preliminary investigations of astronomical capabilities. Given the tiny size and mass and relatively low cost of photonic systems, they could revolutionise astronomical spectrographs, if they prove compliant with astronomical requirements. The aim of WP3 is to develop and test possible systems built on integrated photonic technologies. This activity builds on the Astrophotonica Europa Network started in FP6 as an outcome of the Opticon Key Technologies Network and further developed in FP7, including development there of the first integrated waveguide based Photonic Couplers for astronomy. This illustrates the intimate connection between networking and JRA activity in Opticon.

Instruments based on current optical designs tend to get bigger and more complex, leading to increasingly tight requirements on the overall performance [cf. the Opticon technology roadmap]. The goal of WP5 is to reduce the complexity of future instruments by combining two innovative technologies namely: *freeform mirrors and active optics*. This could significantly simplify next generation instruments for the E-ELT and VLT.

The proposed programme of WP6 for novel optical materials is again possible only because of the

successful results of the current Opticon activities. It involves unanticipated discoveries made during those activities, and a successful Opticon-supported effort to recover knowledge and materials following collapse of the sole European industrial supplier. It is focused on enabling technologies (holographic and traditional gratings, innovative fibres, general holographic Optical Elements) that can potentially improve the performance and/or reduce the cost of future instrumentation.

Making optical interferometry a practical astronomical tool (WP4)

Opticon activity in recent years initiated the development of software tools for end-to-end processing of interferometric observations and data from calibration to model fitting. Since then, these tools have been continuously improved by the community and have encouraged more astronomers to make use of interferometry observations. The goal now is to go a step further, as the ability to reconstruct images is essential to exploit the very high angular resolution provided by the next generation multi-telescope instruments such as Matisse, Gravity and Pionier at Europe's Very Large Telescope Interferometer (VLTI), LINC-Nirvana at the Large Binocular Telescope (LBT) or Vega at the Chara interferometer.

1.3 Scientific and Technical methodology and associated work plan

1.3.i) Overall strategy

The Opticon technological strategy is designed to improve the performance of the instruments – cameras, spectrographs, data processing algorithms – which collect and provide science-ready data from Europe's astronomical infrastructures. Enhancing state of the art systems and investigating critical high risk but potentially high-benefit new technologies are involved and will benefit all telescopes of all sizes, extant and planned.

The opportunity to contribute to the ultimate performance of a facility like the E-ELT is a prime motivation for top-talented researchers to come or to stay in Europe. The challenging opportunities also stimulate experts from other disciplines to contribute to the development of innovative technology and design tools and allow industry to demonstrate their capabilities.

The Opticon networking strategy is designed to bring together distributed communities to optimise their participation in planning future capabilities, and train the otherwise disadvantaged parts of the community in state-of-the-art research using state of the art facilities. The Opticon infrastructure strategy is designed to ensure the continuing availability and productivity of medium-sized observatories, by improving their cost-effectiveness and science impact and improving the ease and openness of community access to their use. There is considerable synergy between the networks and the TNA programme. Activities of the training network regularly take place in collaboration with larger telescopes in the TNA programme (e.g. remote access to NOT during training schools) and will do so with smaller ones in the new Time Domain network. The robotic and quick response facilities of the larger telescopes in the Access (TNA) programme will support the activities of the Time Domain programme, a process which is assisted by the linking of the Time Domain and Access programmes through the Telescope Directors' Forum.

All these activities are integrated both through project management (described in Section 2.1), and through close internal communications and mutual decision making. They are planned through careful analysis of the large number of potential activities placed before the Executive, which is made up of leaders of national funding bodies and supplemented by experts from national and ESO strategic planning forums. All strategic planning is informed at the top level by the AstroNet strategic plan, at a local level by the Roadmap, and at a national resource availability level by the national agencies, each of which is of course fully aware of nationally-funded capabilities and activities. There is continuing involvement of senior Opticon participants in strategy forums and in annual review of funding proposals, in national agencies across Europe, ensuring continuing information flow and internal awareness of developments. In essence, Opticon has developed, and maintains, a holistic approach to the

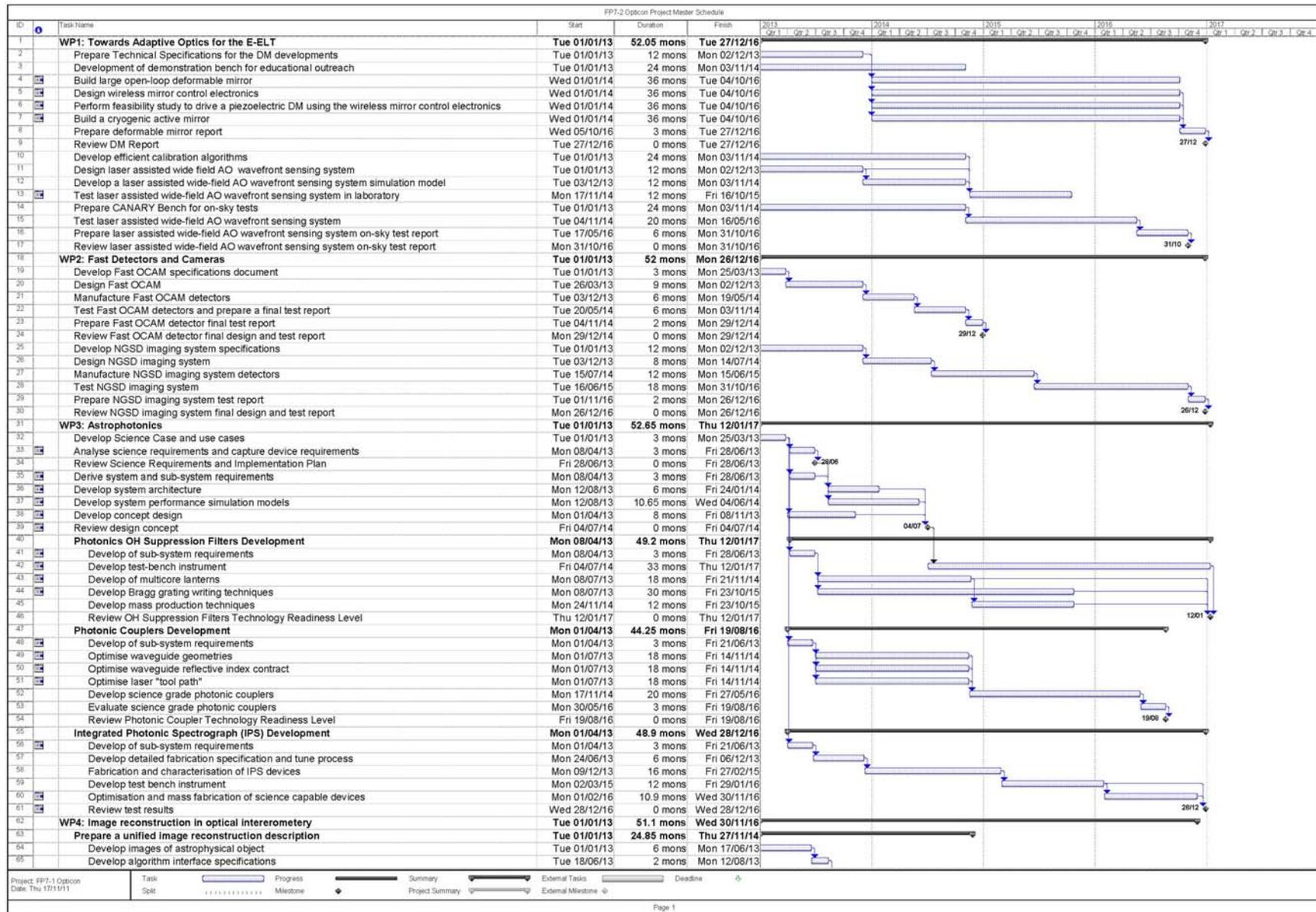
technological, infrastructure, and community challenges facing optical-infrared astronomy, by bringing together all the key players at strategic planning level, and maintains this synergy at implementation level through excellent internal communications.

1.3.ii) Work Package and component timing

A standard Gantt chart showing the duration of each activity is a valuable, though only partial management and review tool for this project. All 14 Work Packages continue through the whole project. While some have internal milestones which affect later work, most involve parallel activities which in turn continue through the whole contract. All activities are designed to maximise synergy, but to minimise risk dependency on each other. There are of course milestones and decision points in some work packages – identified where appropriate.

The primary decision points and down-selects, and major milestone decision points, mostly affect what activities will continue beyond FP7, not how resources are distributed inside this contract. This is the same philosophy adopted, with considerable success, in previous Opticon activities, and in the associated complementary activities supported by the national funding agencies which make up Opticon. Promising developments which arose from those earlier activities form the work packages proposed here.

Throughout the Opticon project, the Opticon Executive Committee will monitor progress in all activities, and where necessary, can and has terminated an activity which was clearly not making progress and proposed re-deployment of the resources through a contract amendment. This review process happens annually, for all activities.



- 1.3.iii) Detailed work description broken down into Work Packages**
This information follows:

Table 1.3 a: Work Package List

Work package	Work package title	Type of activity	Lead partner No	Lead participant short name	Person months	Start month	End month	Indicative Total costs	Indicative requested EC contribution
WP1	Towards Adaptive Optics for the E-ELT	RTD	2	CNRS	257	1	48	2983441	2021890
WP2	Fast Detectors and Cameras	RTD	2	CNRS	72	1	48	1586000	1000000
WP3	Astrophotonics	RTD	19	AIP	86	1	48	1000000	750000
WP4	Image reconstruction in optical interferometry	RTD	2	CNRS	88	1	48	666000	499500
WP5	Development of Active Freeform Mirrors (AFMs)	RTD	9	ASTRON	69	1	48	666626	499970
WP6	Novel Dispersive and Holographic Optical Elements for Astronomy	RTD	3	INAF	85	1	48	1000000	750000
WP7	Trans-national access	SUPP	5	STFC	0	1	48	2003818	2003818
WP8	Management	MGT	1	UCAM	96	1	48	676312	676312
WP9	Innovation Network	COORD	5	STFC	23	1	48	200000	200000
WP10	ELT Science and Tools	COORD	3	INAF	72	1	48	498620	498620
WP11	Time Domain	COORD	20	UNIWARSAW	54	1	48	250000	250000

	Astronomy								
WP12	Medium Sized Telescope Integration	COORD	5	STFC	12	1	48	300000	300000
WP13	Enhancing community skills – Integrating Communities	COORD	2	CNRS	12	1	48	349890	349890
WP14	The European Interferometry Initiative	COORD	15	UPORTO	8	1	48	200000	200000
	TOTAL				934			12380707	10000000

Table 1.3b1: List of Deliverables

Del. No. ⁱ	Deliverable name	WP no.	Nature ⁱⁱ	Dissemination Level ⁱⁱⁱ	Delivery date ^{iv}
1.1	Technical Specifications for the DM developments	1.2	R	PU	12
1.2	Efficient calibration for complex AO systems: theory, simulation and experimental results test report	1.4	O	PP	24
1.3	Outreach demonstration bench (aspiration) plus educational worksheets and report of validation	1.5	D	PU	24
1.4	Adaptive Optics Design and Test Report	1.3	O	PP	48
1.5	Final Report	1.1	R	PU	48
2.1	Fast OCAM specifications and design document	2.2	R	PP	12
2.2	NGSD imaging system specification and design document	2.3	R	PP	18
2.3	Fast OCAM detectors delivery and test report	2.2 & 2.4	P	PP	38
2.4	NGSD imaging system detectors test report	2.3 & 2.4	P	PP	42
3.1	Photonics Spectrographic System (PSS) Specification	3.1	R	PP	9
3.2	System Design Document	3.2	R	PP	24
3.3	Photonics OH-Suppression and Coupler Development Report	3.3 & 3.4	R	PP	48
3.4	Integrated Photonic Spectrograph (IPS) and PSS development report	3.5 & 5.6	R	PP	48
3.5	Networking Report	3.7	R	PP	48
4.1	Unified image reconstruction description	4.2	O	PU	12
4.2	Data reduction tools for Fizeau interferometry	4.3	O	PU	30
4.3	Algorithm interface specifications and Graphical user interface (GUI)	4.4	R	PP	36
4.4	Optical Interferometry Image Reconstruction Test Report and Cookbooks	4.4	R	PU	48
5.1	Active Freeform Optical Critical Component Development Specification	5.1	O	PP	6
5.2	Actuator and Metrology Design Report	5.2	R	PP	12
5.3	Active Freeform System Demonstrator	5.3	D	PP	40
5.4	Active Freeform Mirror Final Report	5.3	D + R	PU	48
6.1	New Materials and Processes for Astronomical Instruments Trade-	6	R	PU	12

Del. No. ⁱ	Deliverable name	WP no.	Nature ⁱⁱ	Dissemination Level ⁱⁱⁱ	Delivery date ^{iv}
	off Study Report				
6.2	Demonstrator Manufacturing Dossier	6	R	PU	30
6.3	Demonstrator Final Test Report	6	R	PU	48
8.1	Opticon Website	8	O	PP	2
8.2	Period 1 Report to EC	8	O	PU	14
8.3	Period 2 Report to EC	8	O	PU	32
8.4	Final Period Report to EC	8	O	PU	50
9.1	Technology Roadmap and Industry Club Website on-line	9	R	PU	9
9.2	Industry Showcase	9	O	PU	28
9.3	Innovation Network Final Report	9	R	PU	48
10.1	Conference Proceedings	10	R	PU	15
10.2	E-ELT Science Conference Proceedings	10	R	PU	42
10.3	Summer School report	10	R	PU	42
10.4	Papers/White paper: Data Analysis Methodologies plus Tools for E-ELT and HTRA	10	R	PU	46
11.1	Web-based interface and software for homogeneous data storage and calibration	11.2	O	PP	9
11.2	Mid-term robotic telescopes network for transients and variable stars follow-up status report	11.1	O	PU	24
11.3	Reports and documentation on developed software and other tools	11.6	R	PU	36
11.4	Final robotic telescopes network for transients and variable stars follow-up status report	11.1	O	PU	48
14.1	Interferometry Web Site	14	O	PU	6
14.4	Working Group "The future of Interferometry in Europe" report	14	R	PU	48

i. In order of delivery dates. Please use convention <WP number> <number of deliverable> (e.g. 4.2 would be 2nd deliverable of work package 4)

ii. R=Report; P=Prototype; D=Demonstrator; O=Other

iii. PU=Public; PP=Restricted to programme participants & EC; RE=Restricted to group specified by Consortium & EC; CO=Confidential, only for members of consortium & EC

iv. Measured in months from Project start date

¹Table 1.3b2: Summary of Trans-National access provision

Participant number	Organisation short name	Short name of infrastructure	Installation		Operator Country code	Unit of Access	Unit cost Euro	Minimum contracted	Estimated number of users	Estimated number of projects
			Number	Short name						
2	CNRS	CFHT	1	CFHT	FR	Night	15588	12	24	4
2	CNRS	OHP	1	OHP193	FR	Night	1893	60	20	11
2	CNRS	TBL	1	TBL	FR	Night	2673	32	14	6
3	INAF	TNG	1	TNG	IT	Night	7171	16	8	5
4	Max Planck	CAHA	1	CAHA 3.5m	DE	Night	9864	30	12	7
4	Max Planck	CAHA	2	CAHA 2.2m	DE	Night	3709	24	8	6
4	Max Planck	La Silla	3	MPG-2.2	DE	Night	2110	12	4	7
5	STFC	ING	1	WHT	GB	Night	9092	10	6	11
5	STFC	ING	2	INT	GB	Night	1906	8	4	5
10	IAC	TCS	1	TCS	ES	Night	1449	16	6	5
11	AAO	AAO	1	AAT	AU	Night	9484	56	24	5
12	NOTSA	NOT	1	NOT	SE	Night	4284	80	20	10
14	LJMU	LT	1	LT	GB	Hour	280	320	20	20

¹ The range in the ratio of “number of users” to “number of projects” reflects the collaborative nature of the relevant science communities.

²Table 1.3b3: Summary of service provision

Summary Provision is not relevant to this proposal, which deliver Transnational Access (cf Table 1.3b2).

Table 1.3 c List of Milestones

Milestone number	Milestone name	Work package(s) involved	Expected date ^v	Means of verification ^{vi}
1.1	Review Deformable Mirror Report	1.2	48	Deformable Mirror Report and Review Meeting Minutes
1.2	Review laser assisted wide-field AO wavefront sensing system on-sky test report	1.3 & 1.4	48	Laser assisted wide-field AO wavefront sensing system on-sky test report and Review Meeting Minutes
2.1	Fast OCAM Design Review	2.2	24	Fast OCAM Design Report and Review Minutes
2.2	NGSD imaging system final design review	2.3	48	NGSD imaging system final design and test report
3.1	Review Astrophotonics Science Requirements and implementation Plan	3.1	6	Astrophotonics Science Requirements, Implementation Plan and Review Minutes
3.2	Design Concept Review	3.2	18	Design Concept Report and Review Minutes
3.3	Review OH Suppression Filters Technology Readiness Level	3.3	48	Review Minutes
3.4	Review Photonic Coupler Technology Readiness Level	3.4	44	Review Minutes
3.5	Review Integrated Photonic Spectrograph test results	3.5	48	IPS Test Report and Review Minutes
4.1	Review object models	4.2	48	Object Models and Review Minutes
4.2	Image reconstruction algorithms design review	4.3 & 4.4	47	Results and Review Minutes
5.1	Review Active freeform Mirror Test Results	5.3	42	Active Freeform Mirror Test Report and Review Minutes
6.1	Review Specification and select best option	6.1 – 6.7	12	Trade-Study Report and Review Minutes
6.2	Review Demonstrator Design and Test Results	6.1 - 6.7	48	Design Dossier, Test Report and Review Minutes
8.1	Period 1 Review	8	12	Period 1 Report
8.2	Period 2 Review	8	30	Period 2 Report
8.3	Period 3 Review	8	48	Period 3 Report
9.1	Innovation Network Year 1 Workshop	9	9	Innovation Network Year 1 Workshop Proceedings

Milestone number	Milestone name	Work package(s) involved	Expected date ^v	Means of verification ^{vi}
9.2	Year 2 Workshop	9	18	Innovation Network Year 2 Workshop Proceedings
9.3	Year 3 Workshop	9	27	Innovation Network Year 3 Workshop Proceedings
10.1	Instrumentation Conference	10	15	Instrumentation Conference Proceedings
10.2	E-ELT Science Conference	10	42	E-ELT Science Conference Proceedings
11.1	Complete survey of robotic telescopes for inclusion in network	11.1	9	Agreed list of telescopes for network
11.2	Review list of standard files and data reduction protocols	11.2	9	Documented agreed file standard and data reduction protocols
11.3	Formal acceptance of improved facilities into network	11.3	24	Updated facilities list and formal acceptance certificates
11.4	Lessons learned workshop 1	11.4	24	Report circulated to network and beyond
11.5	Lessons learned workshop 2	11.5	46	Report circulated to network and beyond
12.1	CTAC Proposal Review Meeting 1	12	4	Ranked list of proposals for approval by telescope directors for 1 st observation period
12.2	CTAC Proposal Review Meeting 2	12	10	Ranked list of proposals for approval by telescope directors for 2 nd observation period
12.3	CTAC Proposal Review Meeting 3	12	16	Ranked list of proposals for approval by telescope directors for 3 rd observation period
12.4	CTAC Proposal Review Meeting 4	12	22	Ranked list of proposals for approval by telescope directors for 4 th observation period
12.5	CTAC Proposal Review Meeting 5	12	28	Ranked list of proposals for approval by telescope directors for 5 th observation period
12.6	CTAC Proposal Review Meeting 6	12	34	Ranked list of proposals for approval by telescope directors for 6 th observation period
12.7	CTAC Proposal Review Meeting 7	12	40	Ranked list of proposals for approval by telescope directors for 7 th observation period
13.1	Annual Observing School - 2013	13.1	12	Observing school 2013 report

Milestone number	Milestone name	Work package(s) involved	Expected date ^v	Means of verification ^{vi}
13.2	AO specific instruments training workshop	13.2	12	AO workshop training material
13.3	Annual Observing School - 2014	13.1	24	Observing school 2014 report
13.4	Eastern EU countries "Awareness"	13.3.3	24	
13.5	Annual Observing School - 2015	13.1	36	Observing school 2015 report
13.6	IFU specific instruments training workshops	13.2	36	IFU workshop training material
13.7	Instrument construction workshop	13.3.4	36	Instrument construction workshop material
13.8	Annual Observing School - 2016	13.1	48	Observing school 2016 report
13.9	Eastern EU countries "Awareness"	13.3.3	48	
14.1	Interferometry Web Site	14	6	Working website
14.2	VLTI Observing School 1	14	24	VLTI Observing School 1 Report
14.3	VLTI Observing School 2	14	36	VLTI Observing School 2 Report

- i. Measured in months from the project start date
- ii. Show how you will confirm that the milestone has been attained. E.g. software released and validated by user group; prototype completed and running flawlessly

Work package number	WP1	Start date or starting event						01-01-2013	
Work package title	Towards Adaptive Optics for the European Extremely Large Telescope								
Activity type	RTD								
Participant number	2	3	4	8	15	17	21	25	
Participant short name	CNRS	INAF	Max Planck	ONERA	UPORTO	UDUR	UL-NOVA	ALPAO	
Person-months per participant	77	36	6	43	24	31	7	33	

Objectives:

Adaptive optics (AO) systems, using both natural and laser guide stars, are the key technologies for the next major advances in ground-based optical-IR astronomy in the next 20 years. The primary goal of workpackage 1 is to develop the technologies and the knowledge required to improve the performance and operational efficiency of existing AO facilities in Europe, as well as to develop the state of the art instrumentation required for the next generation of European astronomical facilities, i.e. the 40m European Extremely Large Telescope (E-ELT).

The significant progress made over the past 10 years in the field of AO has brought this observational technique to the maturity level where outstanding astronomical results can today be obtained routinely. Astronomers are now looking toward the next generation of AO systems, which will allow them to extend this powerful technique to new observing modes (e.g. large field AO-assisted cameras and multi-object spectrographs to study the large scale structures of the Universe together with very high contrast imaging, spectroscopy and polarimetry to search for and characterize extra-solar planets, etc.).

Such ambitious scientific objectives will clearly increase the system complexity of future instruments, which in turn will require further development of critical technologies: higher order deformable mirrors, faster real-time computers, Laser Guide Star wavefront techniques to cope with ELT specific challenges, better calibration/on-line control techniques and more efficient operation. Simulations, laboratory and on-sky demonstrations will be a significant part of the work plan of this WP, with the aim of implementing these new concepts and technologies on existing European facilities: VLT, WHT, etc. The work programme explores both new technology avenues where promising and builds on recognised FP6/FP7 technology highlights and successes.

Description of work.**WP 1.1: Coordination**

WP1.1 will coordinate the activities and the sharing of information amongst partners, organise study and design reviews, prepare the reports to the EC and provide detailed work plans for the OPTICON management. A Scientific Committee (SC) will ensure the scientific coherence of the activities. ESO will be invited to join the SC to reinforce the link between the proposed program and ESO's plans for the E-ELT and instrumentation. This WP will be led by **CNRS/IPAG**, with deputies at UDUR and ONERA.

WP 1.2: Future deformable mirrors

Deformable mirrors (DM) are amongst the essential elements of any AO system. The upcoming systems will require significant improvements in DM technology in several directions: 1-2 mm pitch, 3-5k actuators with in-situ surface control for wide-field AO; 1-2 mm pitch, 30-40k actuators with high reliability drive electronics concepts for extreme AO; operation of DM at low/cryogenic temperature, etc. WP1.2, led by **CNRS/IPAG** with contributions from ALPAO and MaxPlanck Heidelberg, will develop the technological bricks needed to achieve these goals. WP1.2 is sub-divided in four tasks.

Task 1.2.1 - Specification and follow-up of DM development (CNRS/IPAG, CNRS/LESIA, ONERA)

This task will generate the technical requirements based on the AO systems expected to be built in the coming decade and will ensure technical follow-up of the work progress.

Task 1.2.2 - Large open-loop electro-magnetic DM development (ALPAO)

This task will develop the main breakthrough technologies necessary to build large open-loop deformable mirrors, in particular the embedded built-in position sensors within the DM for enhanced open loop operation. The task includes the delivery of a prototype that will be extensively tested in the laboratory and will also be validated on the sky using the Canary instrument (see WP1.4) if the laboratory tests are successful.

Task 1.2.3 - Mini piezo DM development (CNRS/IPAG)

The most demanding high contrast AO system presently under consideration will use a DM with about 40k actuators providing a mechanical actuator stroke of 3-microns peak to valley (PTV) and a fast actuator response with an actuator pitch of the order of 1-2 mm. A feasibility study for a 50x50 actuator mini-DM revealed a number of critical issues that require further R&D to consolidate the design for a future 200x200 actuator DM. This task will in particular focus on the challenge of reliably connecting 40k actuators to the corresponding high voltage (typically 400-500 V) channels.

Task 1.2.4 – Prototyping of cryogenic active mirrors (MaxPlanck/MPIA)

Operation of corrective optics at low/cryogenic temperature will be a requirement for AO systems in the 3-15 micron wavelength range. This task will develop, as a first step, a fast steering mirror operating at liquid nitrogen temperature in preparation for the METIS instrument for the E-ELT.

WP 1.3: Toward Laser and Natural Guide Star wavefront sensing

Wavefront sensing on very elongated Laser Guide Stars (LGS) is a key aspect for the next generation of wide field AO systems on large and extremely large telescopes. Even though preliminary analytical and simulation analysis of LGS spot elongation were recently carried out as part of the E-ELT preliminary studies, experimentation is required to assess these first results. In addition, the LGS measurements have to be complemented by Natural Guide Star (NGS) signals to deal with tip-tilt indeterminations as well as sodium layer profile variations. Hence both low and medium order modes have to be monitored at various temporal frequencies in order to mitigate non-common path effects induced by the fluctuations of the sodium layer structures. This will be done by WP1.3, which will be led by **UDUR** with contributions from INAF-OABO, CNRS/LESIA, CNRS/LAM and ONERA. This WP will be divided in 5 tasks as follows.

Task 1.3.1 - LGS WFS analysis and simulations (ONERA, INAF-OABO, CNRS/LAM, CNRS/LESIA, UDUR)

This task will provide comprehensive simulations and error analysis of the wavefront errors involved with LGS on an ELT, including sensor design, calibration issues and multi-LGS case with tomographic reconstruction. Task 1.3.1 will provide results to assess the laboratory results proposed to be conducted by Tasks 1.3.2 and 1.3.4 and will help to focus on the critical issues which must be validated on-sky.

Task 1.3.2 - LGS WFS laboratory demonstration (INAF-OABO, CNRS/LAM, ONERA)

This task will focus on the experimental validation of the LGS wavefront sensing simulations and analysis performed in Task 1.3.1. To achieve this goal the existing unique European LGS WFS experimental set-up available at INAF-OABO will be upgraded such as to emulate a realistic elongated LGS image with arbitrary sodium layer profile and a realistic turbulence, both in the case of central and edge projection.

Task 1.3.3 - LGS WFS on-sky experiment (UDUR, CNRS/LESIA)

The E-ELT will need to work with unprecedented elongation of its LGS WFS images, typically exceeding 15". An upgrade to CANARY will provide unique capabilities for testing the effects of this phenomenon in actual conditions on-sky and for evaluating proposed mitigations. We shall conduct this experiment using a sodium laser (externally funded), which will be launched far off-axis, OR by emulating the sodium layer effects using modulation of the range gate depth of the existing Rayleigh LGS.

Task 1.3.4 - Efficient NGS wavefront sensing in multi-LGS mode (ONERA)

This task will study and validate a new concept of a low order focal plane wavefront sensor using the full telescope aperture (LIFT standing for Linearized Focal Plane Technique) proposed recently.

Simulations have shown that this type of sensor could be extremely sensitive, allowing the use of fainter NGS and therefore potentially increasing the sky-coverage of the LGS based system or in other words increasing the availability of a given AO performance over a larger fraction of the sky.

Task 1.3.5 - On-sky E-ELT sky coverage optimization using Near IR-NGS sharpening (ONERA, UDUR, CNRS/LESIA, CNRS/LAM)

The concept of using a dedicated correction (specific DM controlled in open loop) in the near-IR NGS wavefront sensing channels is a key concept for providing the sky coverage required for tomographic AO concepts on the E-ELT (and smaller telescopes). This approach, combined with a recently proposed new efficient WFS technique (LIFT, see Task 1.3.4) should ensure unprecedented sky coverage for future Laser assisted wide field AO systems. CANARY, when combined with ONERA's RAPID Near-IR wavefront sensor, will provide a unique opportunity to test these concepts.

WP 1.4: On-sky optimisation and exploitation of AO data

SPHERE (the VLT high-contrast extra-solar planet imager), the Adaptive Optics Facility (AOF) combined with MUSE (3D multi-object spectrograph) and Canary (a Multi-object AO demonstrator on the WHT) are pathfinders for the E-ELT. They all make use of state-of-art AO systems and components. The calibration, on-line optimization and on-sky exploitation of such complex systems represent the most critical challenges for future AO systems on the ELT. These aspects will be addressed by this work package. WP 1.4 will be led by **ONERA** with contributions from UL-NOVA, CNRS/LESIA, CNRS/CRAL, CNRS/IPAG, UDUR and UPORTO. It will be divided in six tasks.

Task 1.4.1 - Optimal tomography Control law (ONERA)

This will investigate some of the critical points of control law design, optimisation and exploitation for wide field AO systems. It mainly consists of the study and the simulation of the optimal tomographic control, the robustness of the optimal control to the AO and telescope parameter changes (pupil shift, rotation...) and on-line optimisation with respect to turbulence statistics evolution.

Task 1.4.2 - Calibration of interaction matrix (UL-NOVA, CNRS/CRAL)

Calibration (interaction matrix and its associated control matrix) of any AO system may evolve significantly during a single night of observations. This task will implement and test new methods based on the on-line estimation of key parameters of the interaction matrix using closed loop data. This new approach will be first tested in the laboratory with the ASSIST test facility and then on-sky at the VLT. The performance of the different methods will be evaluated in terms of residual wavefront error and image quality.

Task 1.4.3 - On-line estimation of tomographic reconstructor (CNRS/LESIA)

This task will establish the best method (trade-off between speed and accuracy) to determine the tomographic reconstructor (a.k.a. control matrix) of either an open loop (MOAO) or closed loop (GLAO and LTAO) system, based on both the in-situ observed environmental conditions (DIMM and MASS data, wind speed, etc), and the specific calibration procedures and data delivered by the AO system itself. Validation of the method will be performed with the CANARY on-sky demonstrator.

Task 1.4.4 - C_n^2 turbulence profile estimation (UDUR, ONERA)

With the implementation of more complex tomographic AO systems on very/extremely large telescopes, the a-priori knowledge of the C_n^2 turbulence profile in the direction of observation becomes critical. The goal of this task is to have a comprehensive analysis of the impact of the C_n^2 knowledge on the wide-field AO performance and to implement and validate two new approaches to retrieve this C_n^2 profile using on-line WFS data. The different methods will be validated using full end-to-end simulation and compared with existing C_n^2 profilers (SLODAR) at the WHT using the Canary experiment.

Task 1.4.5 - PSF reconstruction for wide field AO (ONERA, UPORTO)

This task will estimate the wide field AO response in the particular case of the MUSE-AOF instrument. Using telemetry data coming from both AO Laser and Natural Guide Stars, a Point Spread Function (PSF) will be derived at any location of the field-of-view and for every wavelength of the MUSE spectrograph.

Task 1.4.6 – Lesson learned from the SPHERE high contrast instrument (CNRS/IPAG, CNRS/LAM,

CNRS/LESIA, ONERA)

SPHERE, the VLT high-contrast extra-solar planet imager, will be commissioned at the end of 2012 and will start regular operations by mid-2013. This task will obtain detailed feed-back of some of the most critical design choices made for SPHERE (Kalman filtering of the telescope vibrations, phase diversity for the calibration of quasi-static residual aberrations, pupil control loop, etc.) and validate/improve them in the perspective of EPICS, the proposed high-contrast instrument for the E-ELT.

WP 1.5: Outreach

Teaching, outreach and raising awareness of new techniques is a crucial part of any R&D activities. In the frame of WP1, we propose to use a dedicated demonstration bench that can be used in schools at various levels (secondary, engineering, faculty) to initiate students, pupils, as well as teachers, to the basics of AO. The main objective of the workpackage will be to prepare educational worksheets that will then be translated into all mother languages of the Opticon partners and validated in several teaching institutions. Improvements of the educational material will be implemented as needed. This WP is led by **UPORTO** with contributions from ONERA, UDUR and CNRS/IPAG.

Deliverables

D1.1: Technical Specifications for the DM developments (T0+12, WP1.2, CNRS/IPAG)

D1.2: Efficient calibration for complex AO systems: theory, simulation and experimental results (T0+24, CNRS/LESIA)

D1.3 Outreach demonstration bench (aspiration) plus educational worksheets and report of validation (T0+24)

D1.4 Adaptive Optics Design and Test Report (T0+48)

D1.5 Final Report (T0+48)

Work package number	WP2		Start date or starting event			01-01-2013
Work package title	Fast Detectors and Cameras					
Activity type	RTD					
Participant number	2	2	22	8	6	
Participant short name	CNRS (IPAG)	CNRS (LAM)	e2v	ONERA	ESO	
Person-months per participant	12	12	20	4		

Objectives:

1. Accomplishments during the current FP7contract: the Opticon camera, OCAM

WP2 is dedicated to the development of detectors for future Adaptive Optics (AO) systems using laser guide stars (LGS). The detector control systems are prototypes, which allow testing of the detector in our laboratories, but do not allow development of the production camera which will be used on the telescope itself. During our previous contract, outstanding performance was obtained from the prototype, OCam, and its dedicated detector, the CCD220 by the company e2v. This technology is currently used by the second generation of VLT AO instruments. The third generation of AO instruments will be still more demanding in terms of frame rate and readout noise, and are the basis for the AO systems of the future European Extremely Large Telescope (E-ELT).

Significantly, during our development programme new partners from outside astronomy contacted us to investigate the use of this technology for monitoring civilian airport runways from the control tower, taking advantage of OCam's ability to observe at low light levels and freeze the atmospheric turbulence at high frame rates. A new project, called DROP, is proceeding with the help of civilian aviation partners to explore this possibility and shows the potential societal impact outside astronomy.

2. The FP7 second call: Going beyond what was done before

This WP will be based on the same philosophy as in the past: Define a set of specific goals and engage with partners with world-class know-how. This new proposal is focused on the detector itself, and unlike our previous contract, the testing activity will be performed by the manufacturer who will join the project directly as a beneficiary.

3. Impact on the European industry and job creation in Europe

A Spin-off company, "First Light Imaging", was created in France in July 2011 to commercialise our imaging systems and make this high-level technology available to every European astronomical infrastructure, especially those without strong detector groups with the required in-house skills. Moreover, this spinoff will take advantage of the fast-developing imaging markets outside astronomy. The target in the medium-term is to recruit 10 to 20 staff in the spinoff enterprise.

The worldwide ground-based astronomy detector business has a value of up to £5m per year to e2v, which has a pre-eminent position mainly as a result of these developments. The E-ELT is pushing technological developments in all directions, as exemplified by some Opticon-led programmes, such as the wavefront sensor (WFS) devices. e2v thus expects to sell WFS devices to other markets, notably in the USA. Furthermore, technical developments and new sensors that are developed for ground-based use establish a heritage that is invaluable in enabling e2v to offer similar products to the important space sensor sector. This business has a UK value in excess of £10m per year. High-speed sensors like the WFS devices are also of interest for some defence projects.

Finally, e2v has a UK turnover in excess of £10m per year for medical and science sensors, which are mainly sold to OEM manufacturers worldwide (used in gene sequencing etc). Another

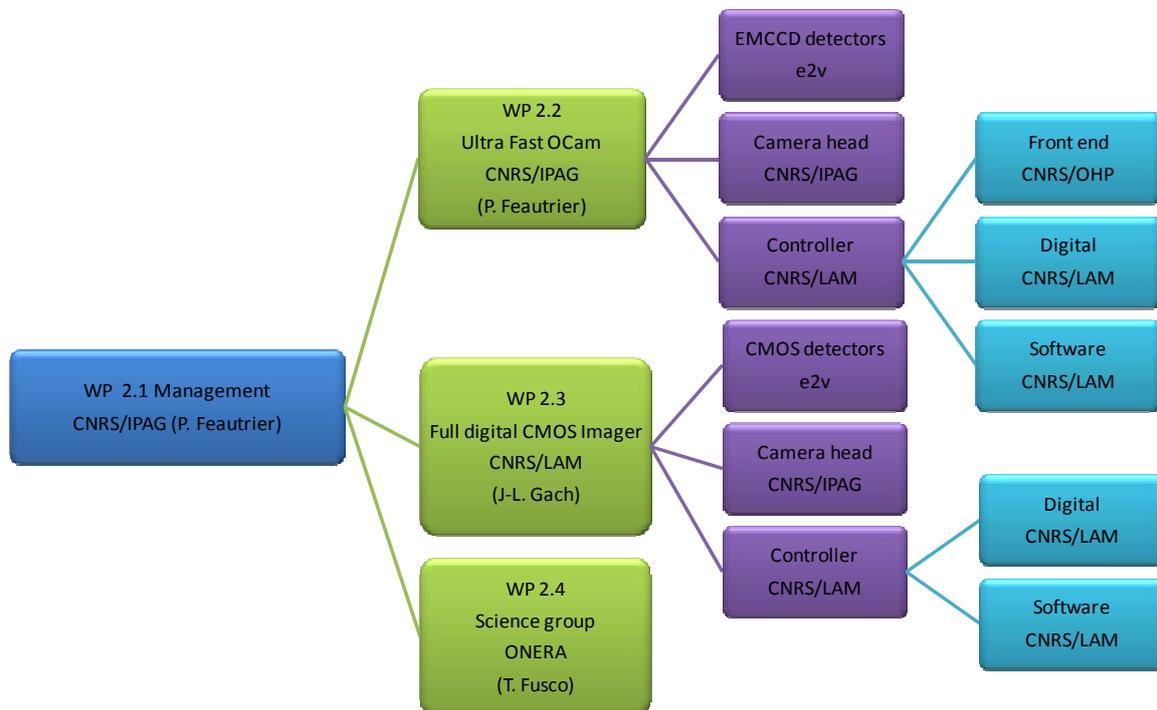
example of a very successful UK company is Andor, who employ 200 staff in a growing and very successful business, much of which is based on e2v sensors. Many of these are derivatives of, or have a direct synergy with, e2v "astronomy" sensors.

So the outputs of this JRA will certainly act as a showcase for future sales and specifically advance e2v's competitive position. The specialized astronomical sensor market in which e2v works is a "small community", but international, so everything that is done in this field has benefits in adjacent fields (i.e. ground and space-based sensing) and in other geographic areas.

e2v employs close to 160 staff at its UK site directly on its imaging business and is recruiting 30 more in 2012 to support its growth. e2v predicts a growth rate of 15-20% per annum over the next 5 years. This is underpinned by the supply of specialised sensors to projects like those of Opticon and E-ELT. The E-ELT is the largest European optical telescope project and will probably be the largest such project worldwide in the next decade. This inevitably means a significant amount of business and technical development will flow from it to the benefit of e2v and its suppliers. e2v global imaging business has a 2011 value of about £60m, with products made in the EU (UK and France). The Opticon developments of CCD220 and Natural Guide Star Detectors (NGSD) CMOS devices could lead to prospective business, especially in the USA and EU, worth up to 5m euro over the next five years merely from astronomy-related markets. If these devices (or derivative ones) are sold to other markets, this value could double or treble. In particular, the company is very active in developing back thinned CMOS imagers for astronomy, space, and industrial markets. The current Opticon NGSD development part of this WP is a key demonstration for e2v.

Description of work.

1. WP2 organization



2. Work Packages description

WP 2.1: Management

CNRS/IPAG will coordinate the activity, prepare the key specifications for the other WPs, monitor the WPs, organize study and design reviews, prepare the regular reports and detailed work plans for the Opticon management. It will be led by CNRS/IPAG – P. Feautrier

WP 2.2: Ultra Fast OCam

WP 2.2 is an upgrade of OCam to increase the speed and noise performance of the device for the 3rd generation of European Instruments and prepare for advanced AO on the E-ELT. We expect to operate the CCD220 detector at a frame rate of 2.5 kHz (goal frame rate 3kHz) for E-ELT instruments such as SPHERE and EPICS, and achieve noise levels below $1e^-$. This will require a complete redesign of the controller using a new generation of low noise pre-amplifiers and will utilise the experience gained during FP6. The outcome will be a completely redesigned and optimised version of the world renowned OCam camera. We will characterize the system and industrialize it. The key partners of the work package will be IPAG (lead): camera head and cooling, camera testing, LAM: controller, firmware, software and e2v technologies: detector development and delivery. WP 2.2 will be led by CNRS/IPAG – P. Feautrier

WP 2.3: All digital CMOS imager

WP 2.3 will develop a production camera system to test and operate CMOS detectors for LGS; the CMOS detector development itself was started during our existing FP7 contract. We will develop this technology for the 3rd generation of European Instruments (VLT, etc) and finalize camera systems for ELT LGS WFS or any other existing European LGS infrastructure. In particular this WP will build and industrialize an all-digital CMOS controller for the new generation of CMOS based WFS detectors dedicated to AO with LGS. CNRS/LAM will lead the electronics design and testing, CNRS/IPAG the mechanical/cooling design and testing, with e2v technologies responsible for detector development and delivery. WP2.3 will be led by CNRS/LAM – J-L. Gach

WP 2.4: Science group

A Scientific Committee including a member of each of the main participating institutes (CNRS/LAM, CNRS/IPAG, e2v and ONERA) will ensure the scientific coherence of the whole project. It will define the scientific objectives of the targeted detector applications. ESO will join this committee to provide advice and reinforce the link between the proposed programme and ESO's medium term plans, especially in the challenging context of the future E-ELT adaptive optics and instrumentation. The committee will issue one specification document for each major development, namely Fast OCam and the NGCD imaging system. This activity will be lead by ONERA – T. Fusco.

Deliverables

Del. No.	Deliverable name	WP no.	Del. Date (month)
2.1	Fast OCAM specifications and design document	2.2	12
2.2	NGSD imaging system specification and design document	2.3	18
2.3	Fast OCAM detectors delivery and test report	2.2 & 2.4	38
2.4	NGSD imaging system detectors test report	2.3 & 2.4	42

Work package number	WP 3	Start date or starting event			2013-01-01		
Work package title	Astrophotonics						
Activity type	RTD						
Participant number	19	17	11	23	24		
Participant short name	AIP	UDUR	AAO	HWU	UBAH		
Person-months per participant	24	18	24	12	8		

Objectives:

The Astrophotonics work package will build on the massive worldwide investment in Photonic technologies for telecom, biomedical and sensing applications to develop complementary enabling photonic technologies for astronomy [1] and related applications.

The overall aim is to develop a completely new Photonic Spectroscopic System [2] based on optical fibre and integrated photonic technologies. By integrating optical fibres and photonic dispersers into a single package, many of the problems imposed by the sheer size of the E-ELT can be overcome [3]. The difficulty of providing a stable optical interface between telescope and instrument is addressed to deploy systems with arbitrarily large multiplex gain. This will benefit observations that require very large statistical samples of objects, such as observational cosmology, which is currently dominated by the need to determine the equation of state of the universe through the study of very large samples of galaxies to very faint limits.

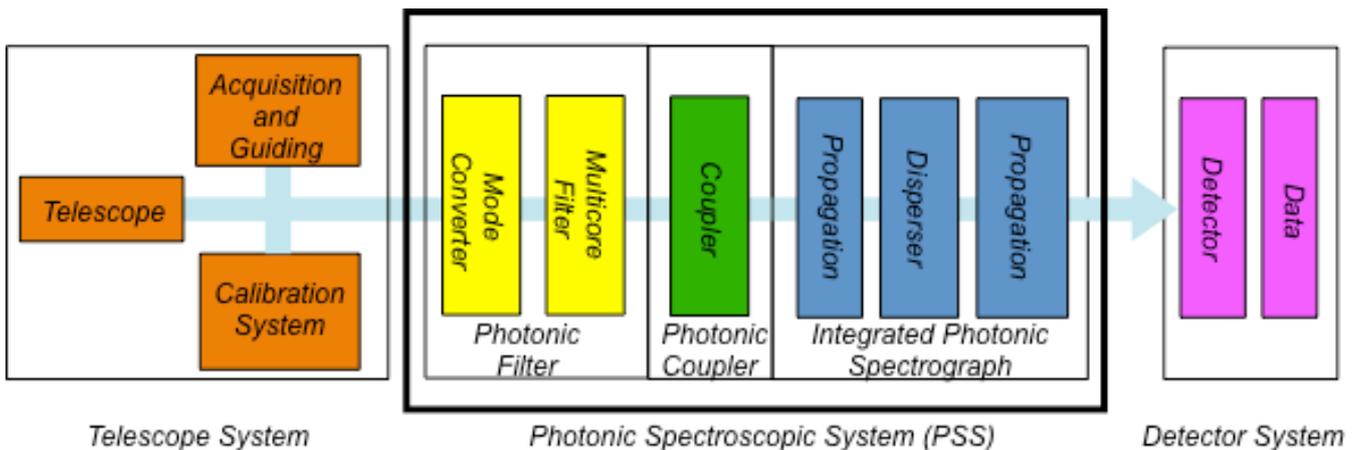


Figure 3.1: Schematic diagram of the Photonic Spectroscopic system incorporated into an observing facility.

The Astrophotonics work package will concentrate on three main components of the Photonic Spectroscopic System (PSS): (i) the Photonic OH-Suppression Filter [4]; (ii) Photonic Coupler; and (iii) Integrated Photonic Spectrographs [5]. The first technology is a low-cost, compact, robust and high efficiency photonics filter for OH-Suppression that will improve the sensitivity of ground-based near infrared observations by factors of >30 . The second technology uses ultrafast laser inscription (ULI) techniques [6] to transform the 2D waveguide structure of a multicore optical fibre used in the photonic OH-Suppression filter into the 1-D linear array required to couple light into the spectrograph. The third technology builds on the successful initial development of integrated photonic spectrographs (IPS) based on Arrayed Waveguide Gratings (AWGs) started under our existing FP7 contract.

When operated in conjunction with conventional instrumentation each device can provide great benefits to astronomy in their own right. However, a combination of the OH-Suppression filter, coupler and integrated photonic spectrograph would completely revolutionise spectroscopic instrumentation and capabilities.

The intrinsically diffraction-limited nature of the photonic principles on which the technologies are based are complementary to the Adaptive Optics and Interferometry techniques addressed by Opticon WP1 and WP4.

We will leverage extensively from the existing regional programmes already pioneering the research

within the Astrophotonica Europa partnership, in particular those led by AIP, Durham University, AAO, University of Sydney, University of Bath and Heriot Watt University as well as the current FP7 programme. We also intend to further complement this with a proposal for a Marie Curie Initial Training Network for Astrophotonics in the next round.

Description of work:

Photonic OH-Suppression filters

The goal is to remove the bright atmospheric OH emission lines using a simple, small, robust and cost-effective optical fibre based device.

A device demonstrating the current state of the art (Figure 3.2), based on photonics lanterns and individual Fibre Bragg Gratings (FBGs; Figure 3.3), has completed commissioning at the AAT (Oct 2011). The filter provides very large S/N gains, but is expensive and bulky. This development aims to massively reduce the size and cost of the filter unit by incorporating the whole system within a multicore optical fibre $\sim 0.3\text{mm}$ in diameter (Figure 3.4). The multicore and FBGs also have possible application in Interferometry (WP4) and time domain spectroscopy (WP10.2) respectively.

Figure 3.2: Blue - OH emission line spectrum, Black – Filtered OH emission line spectrum. Filter cut off @ $1.7\mu\text{m}$.

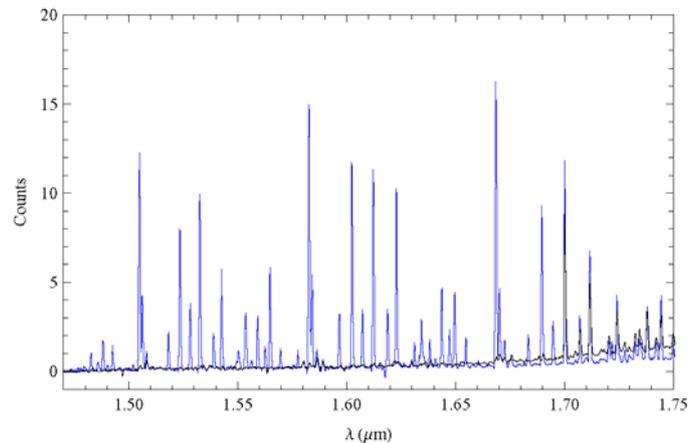


Figure 3.3: Current filter ($\sim 1000 \times 300 \times 50\text{mm}$)



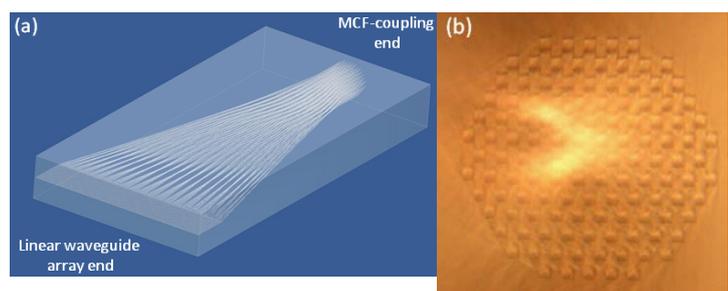
Figure 3.4: Multicore fibre filter ($\sim 200 \times 0.3 \times 0.3\text{mm}$).



Photonic Couplers

The goal is to develop a waveguide coupler to make the transition from the 2-D multicore fibre to the 1-D input of the IPS. Only Ultrafast Laser Inscription has the ability to inscribe the necessary 3-D structures in appropriate glass substrates (Figure 3.5 & Figure 3.6) [3]. The basic technique has been successfully demonstrated and reported in the literature. Further development is required to optimise the system to reduce insertion losses to maximise system efficiency.

Figure 3.5: Linear waveguide array to multicore fibre coupler of Multicore coupler. Figure 3.6: End-face array to multicore fibre coupler of Multicore coupler.



Integrated Photonic Spectrographs

The goal is to build on the IPS development of a “spectrograph on a chip” started in FP7, with the aim of producing a complete spectrograph system with a massive reduction in size, cost and risk.

The first device was demonstrated on-sky at the Anglo-Australian Telescope (AAT) in June 2009 based on a COTS device for telecommunications. This development will concentrate on the development of the next generation devices, which require significant modification for optimisation to astronomy.

Work Packages:

The work strongly compliments and furthers the current regional and FP7 funded activities of each of the partners, including significant participation from the University of Sydney (USYD) led and managed by the AAO.

3.1 Science requirements and science implementation plan

This work package will define the top-level requirements for each of the photonic technologies and that of the integrated Photonic Spectroscopic System (PSS). This includes the science case development, the device requirements and development of the implementation plan with end users, such as ESO. The requirements and implementation plan will be based on “use case scenarios” for applications of the individual technologies and combine system in astronomy. The lead institution for WP3.1 will be UDUR in partnership with AIP, AAO, HWU and UBAH.

3.2 System Design

The work package will develop and optimize the integrated system design of the PSS and provides the overall system architecture for the combined technology developments. This includes the detailed system and subsystem requirements, developing and modelling of the system architecture, and system performance simulations and estimates. The lead institution for WP3.2 will be AAO in partnership with AIP, UDUR, HWU and UBAH.

3.3. Photonics OH-Suppression Filters

WP3.3 will develop multicore photonic OH-Suppression fibre Bragg grating (FBG) filters to minimise the night sky background in the astronomical *J* and *H* bands (approx. 1.0-1.8 μ m wavelength region). It will include: the development of multicore lanterns optimised for FBG imprinting, tuned to the specific wavelength regions and optimised for efficient telescope coupling; the development of multiple emission line notch Bragg grating writing techniques in multicore fibres; the development of the FBG writing technique for mass production of multicore based OH-Suppression filters; and the development of an OH-Suppression test-bench instrument efficiently removing over one hundred of the brightest night sky emission lines in the near-IR. Components of the test-bench will be adapted and developed into the PSS prototype (WP3.6). The lead institution for WP3.3 will be AIP in partnership with AAO and UBAH.

3.4 Photonic Couplers

The work package will develop low loss photonic couplers allowing integration of multicore fibre filters with IPS devices for applications in the astronomical *J* and *H* bands. This includes: developing the photonic coupler requirements (e.g. insertion loss, inter-waveguide variation and cross-talk); optimisation of the waveguide curvature and profile geometries; development and optimisation of the refractive index contrast within the waveguide substrate; optimisation of the laser written “tool path”, system stability and production engineering processes required for minimal loss in each of the required wavelength regimes; and the development of science-grade photonic couplers for the PPS development prototype (WP3.6). The lead institution for WP3.4 will be HWU in partnership with UDUR, AIP AAO and UBAH.

3.5 Integrated Photonic Spectrograph

The scope of WP3.5 is to build on FP7 and regionally funded activities by developing devices specifically designed and optimised for *J* and *H* band astronomy. This will involve: the development of detailed requirements for the astronomically tailored integrated photonic spectrograph (IPS) devices; development of the detailed device fabrication specifications and process tuning in close collaboration with the fabrication partners; fabrication and detailed characterisation of the IPS devices; optimisation and mass-fabrication of science capable devices for the on-sky test-bench; detailed development of science-capable test bench IPS prototype system. The test bench will eventually be developed into the fully integrated PPS prototype (WP3.6). The lead institution for WP3.5 will be AAO in partnership with

AIP.

3.6 System prototype development

Work package 3.6 will build on the other WP3 activities by developing a science-capable Photonic Spectrograph System prototype integrating the technologies produced in WP3.3, WP3.4 and WP3.5 and targeted at the high priority science requirement identified in WP3.1. This includes: the detailed design of the system, based on the architecture developed in WP3.2; manufacture, assembly and laboratory testing of the prototype system prior to shipping; integration, commissioning and initial science verification at the telescope (e.g. the AAT or other telescope included in WP7). The prototype PSS will combine the signal to noise gains of OH-Suppression via the Photonic Filters, with efficient 2-D multicore to 1-D IPS transition from the Photonics Couplers and the benefits of compact and robust “spectrograph on a chip” provide by the IPS. The lead institution for WP3.6 will be AIP in partnership with UDUR, AAO, HWU and UBAH.

3.7 Outreach, Innovation and Dissemination.

This work package builds on the Astrophotonica Europa Network started in FP6 under the Key Technologies Network and further developed in FP7. The aim is to provide continued logistic support, maintaining community interaction and joint collaborative activities. This will include an Astrophotonics ITN proposal in the next round. In addition activities will expand to include enhancing links with; the Telescope, Adaptive Optics, Interferometry and Time Domain Astronomy communities.

The lead institution for WP3.7 will be UDUR in partnership with AIP, AAO, HWU, UBAH, IAC, LAOG, UKATC, Malvern Instruments, University of Jena, University of Macquarie, University of Porto, University of Southampton, University of Sydney; the Adaptive Optics (WP3), Interferometry (WP4), Telescope (WP7), Innovation & Outreach (WP9) and European Wide Science (WP10) communities.

References:

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Deliverables:

Del. No.	Deliverable name	WP no.	Del. Date (month)
3.1	Photonics Spectrographic System (PSS) Specification	3.1	9
3.2	System Design Document	3.2	24
3.3	Photonics OH-Suppression and Coupler Development Report	3.3 & 3.4	48
3.4	Integrated Photonic Spectrograph (IPS) and PSS development report	3.5 & 5.6	48
3.5	Networking Report	3.7	48

Work package number	WP 4	Start date or starting event	01-01-2013	
Work package title	Image reconstruction in optical interferometry			
Activity type	RTD			
Participant number	2	1	4	15
Participant short name	CNRS	UCAM	MaxPlanck	UPORTO
Person-months per Participant	54	13	14	7

Objectives:

Optical Interferometry (OI) provides an important complement to the other large telescope projects of the next 10 years in Europe: its ten times higher angular resolution (compared to the more sensitive E-ELT and JWST) and its different wavelength (with respect to ALMA) provide a unique astronomical microscope to peer into the innermost regions of planets, stars and black holes formation. The linear scales resolved by optical interferometry offer for the first time the possibility to directly image transient astrophysical processes, like the formation and destruction of circumstellar material during planet formation as well as motion under the gravitational pull of a supermassive black hole. During the previous FP6, we initiated the development of software tools to prepare interferometric observations and process interferometric data in an end to end way from calibration to model fitting. Since then, these tools have been continuously improved by the community and have encouraged more astronomers to make use of interferometric observations. We now need to go a step further as the ability to reconstruct images is essential to exploit the very high angular resolution provided by next generation multi-telescope instruments such as Matisse, Gravity and Pionier at Europe's Very Large Telescope Interferometer (VLTI), LINC-Nirvana at the Large Binocular Telescope (LBT) or Vega at the CHARA interferometer. Image reconstruction algorithms from interferometric and variable point spread function (PSF) data are now mature (le Besnerais *et al.*, 2008; Thiébaud 2009; Berger *et al.*, 2011; Desider *et al.*, 2008), but they remain difficult for non-specialists to use and do not exploit all the capabilities of the new instruments (notably hyper-spectral imaging). This work package will provide user-friendly image reconstruction algorithms to make the high angular resolution imaging possible with today's interferometers withing the reach of the whole community

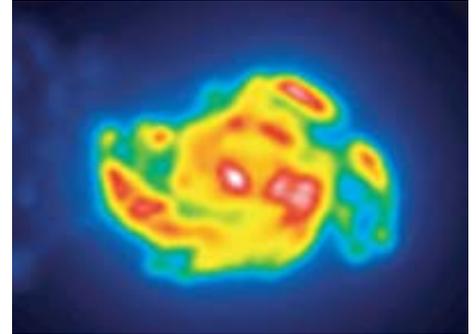
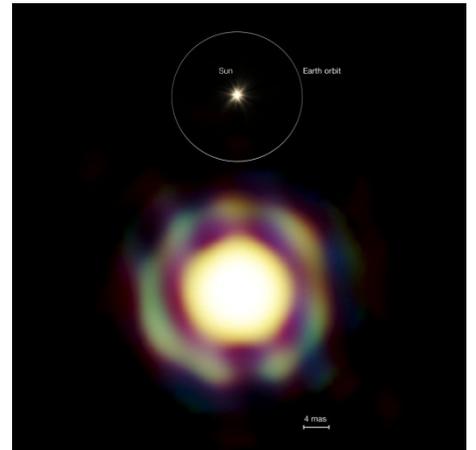


Image of the galaxy NGC 3504 at the resolution of a 23m telescope. The image was reconstructed by the *Building Block* algorithm from simulated interferometric LBT/LINC images (Hofmann *et al.* 2005, A&A **444**, 983).



Multi-color image of the Mira-type star T Leporis showing the molecular layer around the star. Image reconstructed with the MiRA algorithm from VLTI/AMBER data (le Bouquin *et al.*, 2009, A&A **496**, L1).

Description of work.

WP 4.1: Coordination

WP 4.1 will coordinate the activities of the partners and the sharing of information, and prepare reports and work plans for the Opticon management.

WP 4.2: Scientific cases and input data

WP 4.2 will produce simulated data or provide real data (for Pionier, LINC-Nirvana and Vega) in a common file format. These data will serve as inputs for testing and comparing the algorithms and, later, for training end users of the image reconstruction software. At least part of these data files will be made available to the partners in the early stages of the project (about T0+6m) to allow for algorithm developments. According to the science cases of the instruments, synthetic brightness distributions of astrophysical objects will be computed for a number of relevant cases, e.g. circumstellar and AGN environments (jets, dust and protoplanetary disks, clumpy environments, etc.). These models will serve to simulate realistic data for Gravity, Matisse and LINC-Nirvana. However, for thorough testing of the algorithms, nothing replaces real data so sample datasets will be obtained from existing instruments such as Pionier, Vega/CHARA and, (after late 2014), LINC-Nirvana.

These data files will follow astronomical standards and use the FITS-based format expected by the image reconstruction software: OI-FITS for the interferometric data and multi-dimensional FITS for the images. For the simulated data files, in order to establish the performance of the image reconstruction methods, the specific brightness distribution (x,y,λ) of the true object will also be delivered. A scientific document based on published papers will be written and provided to WP4.3 to describe the conventions used for the data format and the specific characteristics of the data generated by different instruments. We expect that, as it will take into account the characteristics of the new instruments for the first time, this document will be useful to propose a revised OI-FITS standard to the community.

WP 4.3: image reconstruction algorithms

This sub-WP will adapt the best of the existing image reconstruction methods to the new types of data provided by the multi-telescope interferometers. To make the algorithms more user-friendly, specific R&D will be undertaken to simplify the control of the algorithms.

Whatever the on-line help provided by a software interface, a minimum level of knowledge is required to choose the most appropriate algorithm parameters and perform the best reconstruction for a given data set. We will therefore start by writing a background document describing the work flow of image reconstruction to explain its fundamental principles to the users. This document will serve to unify the methodologies being used and help to specify interfaces and to schedule the algorithm developments.

Means to account for the new types of data will be studied and implemented based on the description of the data generated by WP4.2. These studies will include: hyper-spectral image synthesis from multi-wavelength interferometric data which will take into account off-axis and on-axis phase referenced data and image reconstruction with a variable PSF. The deliverables will be either modified algorithms based on the existing state of the art (BSMEM, MiRA and Wisard) or recipes and case studies using existing algorithms (such as Airy-LN) can best be used to obtain useful images from instruments such as Matisse, Gravity, LINC-Nirvana, VEGA/CHARA and Pionier.

To fully exploit the know-how of each partner (some of them are the authors of the above-mentioned algorithms), it is not sensible to work on a single implementation so a few different algorithms will be developed or improved. We will however pool as much work as possible. In particular, the tools

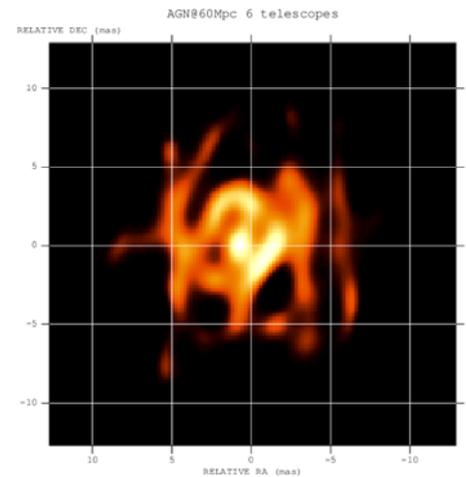
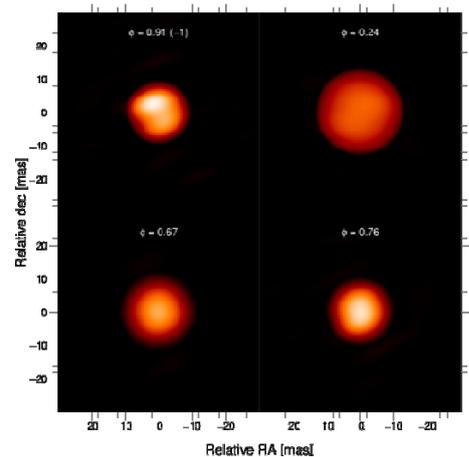


Image of a clumpy AGN torus (model by Schartmann *et al.*, 2008, A&A **482**, 67) reconstructed by BSMEM algorithm from synthetic 6-telescope MROI data (Young *et al.*, 2011, conf. "Resolving the future of astronomy with long-baseline interferometry", Socorro).



The Mira-type star Chi Cygni at several epochs. Images reconstructed with the MiRA algorithm from IOTA data (Lacour *et al.*, 2007, A&A **707**, 632).

produced will deal with the same input and output file formats (OI-FITS for the interferometric data and multi-dimensional FITS for the multi-wavelength images and other data) and use similar parameters to drive the reconstruction (e.g., pixel size, regularization method and hyper-parameters). Finally whatever the programming language used for their implementation, the different algorithms will have a similar command line interface to allow them to be driven with a common graphical interface. The specifications of this interface are part of WP4.4.

WP 4.4: user interface and user guides

For maximum flexibility and efficiency in the development of the algorithms, we propose to deliver image reconstruction methods implemented in various high level languages with a common command line interface and using common formats for input and output files. The first task of this sub-work-package is to study and specify this low level interface for driving the algorithms.

The second task is the development of a high level graphical user interface (GUI) applying the specifications of the simplified interface to at least one of the algorithms (like the one developed at JMMC to wrap LITpro, a model fitting package). This GUI will allow the user to set the image reconstruction parameters, launch the reconstruction method and provide the user with feedback (a view of the reconstructed image(s), error bars, etc.).

Using their low level interface, it will be possible to write batch scripts for extensive tests of the image reconstruction methods (provided by WP4.3) on the different data sets (provided by WP4.2). These tests will be used to compare the different methods for the same inputs and for a number of realistic cases. Such comparisons and tests will also be exploited to derive general guidelines for reconstructing images given combination of instrument and scientific target (thus generalizing the work of Renard et al., 2011). Finally the GUI will be used to demonstrate the use of image reconstruction software on realistic interferometric data and to write cookbooks for the general user. The results of the tests and the cookbooks will be part of the deliverables.

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Deliverables

Del. No.	Deliverable Name	WP No.	Del. Date (month)
4.1	Model images of astrophysical objects	4.2	6
4.2	Unified image reconstruction description	4.3	12
4.3	Synthetic data for Gravity	4.2	18
4.4	Synthetic data for Matisse	4.2	18

Work package number	WP 5	Start date or starting event			01-01-2013
Work package title	Development of Active Freeform Mirrors (AFMs)				
Activity type	RTD				
Participant number	9	2	5	21	
Participant short name	ASTRON	CNRS	STFC	UL-NOVA	
Person-months per participant	14	25	11	5	

Objectives:

Future extremely large ground based telescopes like the E-ELT require an increase in sampling density that drives the scale of the optics and their requirements. Instruments based on current designs tend to get bigger and more complex, leading to increasingly tight requirements on the overall performance [cf. the Opticon technology roadmap; Cunningham et. al.]. We aim to reduce the systems size and thus the overall instrument weight, size and cost, while increasing performance in terms of spatial and spectral resolution. This can be realised by the introduction of Active Freeform Mirrors (AFMs). In the current FP7 contract we have developed optical design tools and evaluated possible manufacturing processes to produce AFMs. The team has also successfully designed an active and highly aspherical optical component (Freeform Mirror). At this stage, the technology appears to be very promising and justifies further development.

Our objective now is to reduce the complexity of future instruments by combining two innovative technologies namely: *freeform mirrors and active optics* to produce AFMs. By making use of well produced AFMs it will be possible to reduce the cost, size and mass of complex multi-object spectrographs (MOS) such as EAGLE or OPTIMOS. This will be made possible by reducing the number of mirrors in the optical train, while maintaining the instrument performance and stability by using an active structure.

The successful freeform optical design funded by our existing FP7 contract will be further utilised and a complete prototype will be produced and fully tested. Comparing to existing active mirrors technologies, the primary goal of this development is to design components which are inherently stable over a wide range of environmental conditions.

These issues will be addressed in this work packages by using two complementary methodologies namely:

- Reducing the number of optical component in the optical trains using *freeform mirrors* (extremely aspheric mirrors), this increases the transmitted flux, reduces the integration time and improves the overall signal-to-noise ratio of the instrument.
- Using *active optics* within the instrument to improve the overall quality and stability of the system.

Under this work package both methodologies will be evaluated in terms of performance, cost effectiveness and ease of production.

Freeform Mirrors:

Using extremely aspheric mirrors (Freeform Mirrors) instead of more conventionally shaped optics in spectrographs can significantly reduce the number of optical components required. This reduction facilitates:

- Reduction of the loss of the flux transmitted.
- The possibility of wider fields of view.
- Larger spectral bandwidths.
- Easier access to UV band (fewer optics, only reflective).
- Reduced mechanical integration complexity.
- A reduction of the overall instrument mass and volume envelope.
- Increased reliability and operational availability.
- Reduction of optical component cost.



First models for active structure development in FP7

We aim to demonstrate that by the end of 2016 it could be possible to adopt this technology in the

designs of the proposed multi-object ELT instruments. To date the broad introduction of freeform optics has been inhibited because:

- a. Tools for designing and analysing optical systems are not suited for free form components.
- b. Production methods and metrology to create an accurate shape with high surface smoothness do not fit the requirements for optical/Infrared instruments.

Active Optics:

Present day large telescopes and future extremely large telescopes rely on active optical components. The E-ELT will be an *active and adaptive* telescope, using these complementary technologies throughout the design to optimise telescope performance. Active optical components are already used at instrument level, controlling optical components such as beam steering mirrors (X-Shooter, MATISSE) and VCMs (VLT-PRIMA star separators). The VLT-SPHERE instrument combines the advantages of *active mirrors* and Extreme Adaptive Optics (XAO) to reach the highest possible angular resolution and contrast for exoplanet imaging and the VLT interferometer delay lines using variable curvature mirrors (VCMs) to keep the pupil in position and stable. These technologies make the instruments stable and also tuneable.

In this work package these technologies will be further developed by combining the active control elements with that of freeform optics to build on the promising results, solutions and tools already available.

Description of work:

The following main tasks are planned:

WP 5.1: System studies, E-ELT instrument optimisation

WP 5.2: Conception, simulations and preparatory tests of models

WP 5.3: Manufacturing, assembly, integration and performance characterisation of the Active Freeform Mirror

The first two work packages will kick-off in 2013 while WP5.3 will commence in 2015, once the components from WP 5.2 are available.

WP 5.1: System studies, E-ELT instruments optimisations (lead (LAM))

One of the current Phase A E-ELT instruments will be selected and parts of the optical path will be modelled making use of AFMs. By comparing the initial design with the new design it will be possible to assess the usefulness of such devices. A numerical trade-off study methodology will be used and the trade-off parameters will be defined early in the project. By performing comparison studies, the impact of the proposed novel architecture can be evaluated in terms of the most important performance parameters such as optical image quality, signal-to-noise ratio and throughput; improved alignment and calibration, reduced effort to perform instrument alignment and calibration; field of view; spectral bandwidth; etc.

One likely target for the study is that of EAGLE. For both the design study and the performance analysis the Zemax plug-in tools developed in the present contract are essential. During the trade-off study the detailed requirements for the freeform shape of the mirror will be derived. The limitations in the manufacturing process as well as tolerances in the design will determine the range and accuracies required from the active and adjustable structure.

WP 5.2: Development of Active Freeform Optical Component Building Blocks (lead STFC)

We will extend the existing design to a real complex "active freeform mirror". This task aims at validating the design by developing and verification of an active prototype. The prototype will be characterised. The final goal of this task will be to produce a fully tested complex aspherical freeform face sheet using the novel hydro-forming manufacturing method developed in our existing FP7 contract. An adjustable and active array structure will also be developed and integrated with the freeform mirror. The adjustable active array will be used to make small adjustments to the surface form of the face sheet. Detailed design constraints and limitations for the demonstrator will be defined as part of this WP.

The following activities will be undertaken:

Actuators will be selected and integrated with the active and adjustable array. A system to sense the actual shape will be included. A test model will be produced to validate the design and to verify the performance characteristics of the support structure.

We will integrate the face sheet with the active and adjustable array (bonding).

We will optimise the spatial resolution and accuracy of the AFM.

We will test and characterise the interaction between face sheet and array. The results of the finite element model will be used to validate the design and will be compared with the actual measured data. As a baseline, the adjustable and active array structure will be designed to work in a cryogenic environment, but will not be verified for cryogenic operation as part of this WP.

WP 5.3: Manufacturing, Assembly, Integration and Performance characterisation of an Active Freeform Mirror (lead NOVA-ASTRON)

The following tasks will build on the deliverables of our existing FP7 WP5.1 and WP5.2. The aim of this WP is to produce a fully functional Active Freeform Mirror and will consist of:

- a. Production of components: active array, actuators and control electronics, freeform facesheet
- b. Integration
- c. Verification
- d. Characterization at ambient and recommendations for cryogenic testing.

Furthermore we will explore the options for industrial manufacturing of AFM components and/or entire systems by industry in Europe in order to develop an understanding whether the overall objectives can be achieved in an economic way and transfer knowledge to European Industry.

Publications from FP7-1 WP5:

- [1] "A new basis of polynomials for off-axis highly aspheric surfaces" Gray M. et al, SPIE Optical system design 2011
- [2] "Modeling highly aspherical optical surfaces using a new polynomial formalism" Vivès S. et al, SPIE Optical system design 2011
- [3] "Extremely aspheric surfaces- toward a manufacturing process based on Active Optics." Challita Z. et al, SPIE Optical system design 2011

Deliverables

Del. No.	Deliverable name	WP no.	Del. Date (month)
5.1	Active Freeform Optical Critical Component Development Specification	5.1	6
5.2	Actuator and Metrology Design Report	5.2	12
5.3	Active Freeform System Demonstrator	5.3	40
5.4	Active Freeform Mirror Final Report	5.3	48

Work package number	WP 6			Start date		01-01-2013	
Work package title	Novel Dispersive and Holographic Optical Elements for Astronomy						
Activity type	RTD						
Participant number	3	10	2	16	5		
Participant short name	INAF	IAC	CNRS	POLIMI	STFC		
Person-months per participant	28	24	23	12	7		

Objectives:

We will investigate selected topics in the area of Novel Dispersive and Holographic Optical Elements for astronomical instrumentation.

Description of work:

Under the auspices of previous EC contracts, we have achieved important goals in transferring new technologies into the field of astronomical instrumentation. This is widely demonstrated by published papers, manufactured devices and the application of concepts into the design of current and future astronomical instruments already produced. This programme moves forward from these achievements in the framework of the new challenges such as the design and construction of the E-ELT and its instrumentation. The workpackage will be structured as follows :

WP 6.1:Management (Filippo Maria Zerbi INAF-OABr

This will co-ordinate and monitor the overall progress of the research. It will maintain the link between the WP and the Board of Opticon by delivering the required reports, attending and contributing to the Board meetings etc. It will coordinate the dissemination of the results of the research in line with the intellectual property bylaws agreed upon contract signature. The WP-office at Brera Observatory will utilize a dedicated project engineer (half time position).

WP 6.2 Photopolymer-based VPHGs manufacturing (Andrea Bianco – INAF/OABr

Traditional (DCG-based) VPHGs are currently the baseline element for numerous astronomical instruments under design or construction, but the number of vendors of astronomical VPHGs in the world has recently fallen dramatically. Europe has lost its only VPHG producer, leaving us dependent on the single US producer remaining active in this market. This situation represents a risk for instrument development in terms of reduced variety and quality of the available devices as well as increased cost. It is vital to the European astronomical community that we establish new and reliable European suppliers. We will address this problem as follows:

Replacing the DCG: DCG post-processing is very difficult and is the principal reason why companies are not interested in investing in this market. We obtained in the original FP7 contract science grade VPHGs based on a specifically tailored photopolymer. Such photopolymers are candidates to replace the DCG in a wide range of astronomical applications, but their chemical synthesis and film deposition technique requires further study. For instance in order to widen the spectral range the polymer needs to provide large refraction index contrast (Δn). This requires a larger concentration and mobility of the monomer in the photopolymer, the chemical composition of which must thus be specifically tailored. A suitable film preparation tailored on the specific chemical product, must then be invented and applied. This activity, in synergy with WP6.5 for the chemical aspects and with WP6.3 for the tests, is central to this programme.

Injecting the new technology in the market: The selected and optimized process needs to be injected into the market in order to set-up possible suppliers for the Astronomical Community. This requires a pre-prototyping and process standardization activity to allow industrial partners to take over the production using well understood recipes with adequate control over product quality and cost.

Follow-up of new potential producers: Due to the state-of-the-art nature of the components, e.g. photopolymers of new composition, and of the novelty of the process, the potential vendors will need

follow-up assistance after the industrial activity has kicked-off. This will be provided by this WP in association with WP6.4 and WP6.5 depending upon the specific support needed.

Accurate Simulations: Particular attention will be paid to generating accurate simulations of the behavior of the VPHGs according to its construction parameters. This will be done in synergy with the equivalent activity in WP6.3

WP 6.3 Advanced Ruled Gratings for Astronomy (Marc Ferrari – CNRS/LAM)

VPHGs represent a great step-forward in Astronomical Instrumentation. Nevertheless the field also requires ruled gratings for a number of cutting edge applications. This activity is aimed at providing European astronomers with generic tools and manufacturability options for the design of high efficiency ruled grisms and gratings for common instrument applications. This will be done through the following:

Revisiting the ruling process: the classical and historical approach of ruled gratings will be revisited, taking advantage of new techniques in industry and recent grism developments let by LAM for Galex in the UV and EMIR in the near infrared. The techniques used for these applications rely on direct ruling onto the glass, using transfer of the groove profile by ion etching, leading to high efficiency dispersive systems.

Test Cases: test cases will be considered, in particular for E-ELT instruments and wide field multi-object instruments. High-level specifications will be derived for these test cases. Design tools will be developed allowing the users to design efficient grism or gratings, relying on industrial solutions. Prototypes may be developed.

Accurate Simulations: Particular attention will be paid to generating accurate simulations of polarization-dependent efficiency and scattered light. This will be done in synergy with the equivalent activity in WP6.2

WP 6.4 VPHGs and Gratings testing (Francisco Garzon Lopez – IAC).

VPHGs developed by WP6.2 or ruled gratings from WP6.3 will be the result of day-by-day R&D activity. Any improved performance or the parameter space of applicability must be validated through proper test campaigns. During the FP6 and existing FP7 programmes the IAC set up a laboratory facility for the complete testing of ruled gratings and VPHGs. Exploiting this existing investment we will:

Assess the quality of the product and the production technique: An assessment of the level of quality and performance reached by each technique is necessary to understand its range of applicability to astronomical Instrumentation.

Feed Back: The results of the complete testing are expected to feed-back useful information to improve, via modification in the material or the process, the performance of the gratings studied in WP6.2 and WP6.3.

Market exploration: VPHGs and ruled gratings are regularly manufactured for applications other than astronomy (analytical chemistry, telecommunications, military industry, laser, etc.). Monitoring of these markets, through the acquisition (by donation or purchase) of samples to submit to complete and rigorous tests, will allow us to keep track of the industrial market achievements and identify possible synergies with astronomical needs.

WP 6.5 Photochromic-Based Holographic Optical Elements for Astronomy (Chiara Bertarelli POLIMI).

This programme has produced some outstanding and innovative results. It opened up the study of the application of photosensitive and photochromic materials to astronomical Instrumentation and continued through the definition and production of performance-representative prototypes. The application of these materials to astronomical instrumentation is diverse and covers the area of gratings, masks, Fresnel Lenses, etc. These materials have been found to have interesting properties for devices indirectly linked to Astronomical Instrumentation such as Computer Generated Holograms (CGH) used for the characterization of free-form optical surfaces. The step forward proposed for this programme consists of:

Synthesis of new chemical species: the origin of the successful development obtained during the past phases of this activity has been linked to the possibility of synthesizing chemical species with specific characteristics. This has allowed rapid synergic tailoring of the chemical compound to the specific need of the astronomical application. This activity must be continued during the further

phases to support the design and realization of new devices.

HOE realization: as an inheritance of the past phases of this activity, the technology is now mature enough to enter the phase of realization of a science-level or market-level device. During this phase the type(s) of HOE candidate to be converted into the final device, will be selected. A demonstrator will be defined, designed, built and characterized. CGHs are the most natural candidate, but also others will be explored.

Polymer-Based VPHGs: This activity will cooperate with other parts of this WP for the chemical aspects related to the realization of polymer-based VPHGs. Photochromic polymers proved to be applicable to the realization of VPGHs in a restricted area of parameters, e.g. wavelength range. Nevertheless the intimate knowledge of the link between grating characteristics and final performance, obtained during the study of photochromic-VPHGs can further contribute to this activity. The search will be mostly carried out in the area of photosensitive materials, already applied to Holography in other areas of application.

WP 6.6 Polymer Fibres for Astronomy and Metrology (Favio Bortoletto INAF- OAPd)

A new factor which emerged during our existing FP7 activity is the existence of polymer fibres close to astronomical science-grade qualification. Fibres were obtained with extraordinary low internal absorption over very long lengths and wide wavelength range. A number of samples of this type of fibre have been studied as part of our existing activity looking at those aspects related to astronomical application such as FRD, Scrambling, etc. The results are controversial but promising and certainly prompt further study of these devices.

Polymer Fibres for Astronomical Applications: Telescopes have increased tremendously in size in the last decade and this trend will continue with the E-ELT. Longer fibre lines are thus required and this conflicts with the poor internal transmission of commonly used fibres. Polymer fibres with very high and broad-band internal transmission are good candidates to replace glass in these applications. Astronomical instruments also require fibres manufactured in non-traditional shapes (rectangular, octagonal, etc.). Polymers are by nature suited to be extruded in any shape and have far better bending properties than the limited radii possible with glass fibres.

Polymer Fibres for Metrology: Bragg fibres are in common use for thermo- mechanical metrology of complex mechanical structure. They have however known drawbacks that prevent them from being applied to certain configurations. Fibres fed with semi-coherent light are also used to measure stress and strain in mechanical structures. The latter method is less demanding in terms of quality of fibres and could be done with suitable polymer fibres. The advantage of polymer fibres is their easy bending that allows them to be embedded in complex structures.

WP 6.7- Advanced DMD-based Holographic Techniques (Line lead by Frederic Zamkotsian LAM)

The use of Digital Micro-mirror Devices (DMD) in hologram recording is a well known practice in the anti-counterfeit precaution industry. They make it possible to obtain holograms with very complex characteristics. The photochromic HOE studied in WP 6.5 and particularly the CGH obtained in our earlier contract are limited in their application by the relatively simple figures that can be inserted in the hologram due to the standard holographic techniques in use. This WP is designed to work in synergy with WP6.5 as follows

DMD-based Holography in Astronomy: study to what extent DMD holography can be ported into fields of interest for the astronomical instrumentation such as the measuring and characterization of complex-form optics via CGHs.

DMD-based CGH writing device: Design and realize a laboratory level prototype of a CGH writing facility based on DMD, followed by the production of CGH samples and their characterization.

WP 6.8 – Ultrafast laser inscription of volume phase grating structures (Line lead by David Lee, STFC)

Ultrafast laser inscription (ULI) is a process commonly used in Astrophotonics (see WP3) to generate complex three-dimensional structures in glass. Recently ULI has been used to manufacture volume phase gratings (VPGs) in glass substrates. Theoretically ULI can be used to manufacture VPGs in a variety of materials including those with good infrared transmittance (e.g.

ZnSe). The ULI process is also able to generate complex grating structures such as tilted fringes or irregular groove spacing. ULI gratings are incredibly robust as the refractive index change is permanently recorded into the glass. They can therefore be used in harsh environments such as cryogenically cooled spectrometers. This work package will investigate the exciting prospect of using ULI VPGs for infrared astronomy (wavelengths greater than 2 microns) as follows:

A selection of prototype gratings will be manufactured in infrared transmitting glasses. These gratings will be characterised to determine their diffraction and efficiency and scattered light performance using test facilities at STFC's UK Astronomy Technology Centre.

The ULI process will be studied to develop the optimum manufacturing parameters. The final deliverable will be a small prototype infrared transmission grating for use in future astronomical spectrometers and a technology road map for the manufacture of large ULI gratings.

Deliverables

Del. No.	Deliverable name	WP no.	Del. Date (month)
6.1	New Materials and Processes for Astronomical Instruments Trade-off Study Report	6	12
6.2	Demonstrator Manufacturing Dossier	6	30
6.3	Demonstrator Final Test Report	6	48

Work package number	WP7			Start date			01-01-2013
Work package title	TRANS-NATIONAL ACCESS						
Activity type	SUPP						
Participant number	2	3	4	5	10	11	12
Participant short name	CNRS	INAF	MaxPlanck	STFC	IAC	AAO	NOTSA
Person-months per participant	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Participant number, contd.	14						
Participant short name, contd.	LJMU						
Person-months per participant, contd.	N/A						

Common Description of work for all Participants

The access programme to European 2-4m telescopes is one of most successful Opticon activities in FP6 and FP7. Its role has evolved enormously during this period, from simply funding projects submitted and evaluated through independent national channels to a fully European pool of observing time, accessed via a common multi telescope proposal tool and, unique in global astronomy, a common multi-national, multi-observatory peer-review process. This process ensures uniform, high-quality peer review and equal treatment of all proposals and directs projects to the most appropriate facilities. The programme is highly regarded by the community, vastly oversubscribed, and unquestionably the model to adopt for the future. Our experience to date has been applied to adjust the TNA request in Table 1.3b2 for each infrastructure based on this real world experience in the first few calls of the present contract.

This achievement has paved the way for a truly historic breakthrough in European optical-infrared astronomy: The owner agencies for the telescopes in the network have agreed on the principle of rationalising the operation of all these telescopes according to a coordinated plan - the *ASTRONET Infrastructure Roadmap*. The aim is to specialise each of them for greater scientific and financial effectiveness, notably enabling the wide-field spectroscopic surveys that are a necessary complement to impending ESA space missions. As an unavoidable consequence, all observing time must be allocated via a single European allocation process. The time scale on which this will happen is 4-5 years, as needed to construct a new generation of optimised instruments, and commensurate with the next Opticon contract period.

The Opticon TNA programme in 2013-2016 will thus serve the double purpose of (i) further broadening European access to the existing 2-4m telescope, and (ii) to prepare the community ethos and develop the common time allocation tools for a future in which all time on all telescopes will be accessed by all on an equal basis. Implementing this vision successfully will be a daunting task for the community and telescope operators alike, but we are on the right course and are accumulating experience from the Opticon *Call for Proposals* each new semester. The goal of a achieving a long-term coordination and structuring effect is finally in sight.

Modality of access under this contract,

Calls for proposals will be made twice a year, at a time optimised to dovetail with existing proposal deadlines. The call, which will include details of those facilities offering observing time, and the amount of access available, will be posted on the TNA webpage. This page has a well-known URL and is also linked from the websites of the telescopes offering access. Potential users will be advised via the web-page, e-mail exploders and national points of contact. Proposals will be made via the NORTHSTAR software, developed by RADIONET under FP6 and adapted for Opticon in FP7. This is a web based application which uses drop-down menus and has built-in help screens to guide users

through the application screens. TNA users are expected to request fairly typical projects requiring between 1-7 nights of access, usually involving physical presence at the telescope but sometimes supportable in remote/service mode.

Users allocated time will be advised by the project office, and will be supported at each telescope in the same way as all other users. Travel costs will be refunded via WP12.3 staff located in the project office. Although the ESO 4m telescopes cannot join the CTAC process, qualifying EU users who gain time via the ESO process will receive travel support from the TNA budget on a case by case basis.

Review procedure:

Each member of the review panel will rank all the proposals by scientific merit (except any in which there is a significant personal or institutional interest). As noted under WP12, this panel will comprise international experts, from different national communities and with a range of skills tuned to the full range of typical projects (solar system, extra-solar planets, stellar astrophysics, galaxies and cosmology). They will usually be individuals with direct experience of national proposal review mechanisms. External experts will be invited to comment on each proposal, after which a physical meeting of the TAC (see WP12.2) will finalise the grades and define a scientific quality threshold. This process can also be efficiently administered using the review part of the NORTHSTAR package. The highest ranked proposals will be allocated time until resources (either physical time available or financial) are exhausted. No projects below the quality cut-off will be allocated even if resources remain, but we note that to date the quality of proposals is such that this threshold has never been reached. The ranked list will be approved by a sub-committee of the Telescope Directors' Forum as a final quality check. Nominally 7 calls will be announced during the 4 year contract. (The final call must be well ahead of the contract end date, so an 8th call is impractical).

Outreach to new users:

In addition to the specific announcements of each call, the programme will be promoted in a wider sense by the project scientist and others, who will present suitable talks and presentations at meetings and seminars across Europe (eg JENAM, IAU and national meetings) and in newsletters and conference proceedings.

The TNA process will be managed by the Project Scientist, who has direct personal experience with all aspects of the process, has set up the FP7 CTAC procedure, and is fully committed to making its continued operation a success.

Description of the Infrastructure
<u>Name of the infrastructure:</u> CFHT (Canada-France-Hawaii Telescope)
<u>Location (town, country):</u> Kamuela, Hawaii, USA
<u>Web site address:</u> www.cfht.hawaii.edu
<u>Legal name of organisation operating the infrastructure:</u> Canada-France-Hawaii Telescope Corporation
<u>Location of organisation (town, country):</u> Kamuela, Hawaii, USA
<u>Annual operating costs (excl. investment costs) of the infrastructure (€):</u> 5.3M (at 1€=1.3US\$)
<u>Description of the infrastructure</u>

<p>The Canada-France-Hawaii Telescope is an international facility located at the summit of Mauna Kea, a 4200-m high dormant volcano in the middle of the Pacific. Operated by the French Agency Institut National des Sciences de l'Univers (INSU) for the Centre National de la Recherche Scientifique (CNRS). In spite of its modest size (3.6-m diameter), CFHT is at the forefront of modern astronomy, thanks to its unique and powerful instrumentation. With 50 employees operating and maintaining the facility, CFHT operates 100% in service observing mode and provides pre-processed data to its users, who in return are extremely productive scientifically, thanks to the quality of the data delivered. CFHT is highly competitive with other medium-sized telescopes in terms of publications and impact factor.</p> <p>The three main instruments used at CFHT are:</p> <ul style="list-style-type: none"> • MegaCam is the largest digital camera in operation on a telescope (340MPixels), with a 1-square degree field of view (equivalent to 2x2 full moons). This instrument delivers images of superb quality over the whole visible spectrum, including the near-UV. • WIRCam, with a mosaic of four infrared detectors of 4Mpixels each, is equivalent in size to the largest near-infrared cameras available in the world. This instrument is an excellent complement to MegaCam, with a good compromise between field size (20°x20°) and image resolution (0.3"/pixel). • ESPaDOnS is a spectropolarimeter covering the whole visible spectrum with a spectral resolution of 70,000 and allowing the measurements of all the linear and circular polarisation for all the lines available in the spectra observed, giving access to the magnetic field of stars up to magnitude 15. <p>CFHT's wide field instruments have been used with great success for cosmology, especially the distribution of dark matter, the study of dark energy through and the evolution of large scale structure along the history of the universe. MegaCam is also used to study our own galaxy and its various components, and our own solar system (distribution of the asteroids from close to Earth to the Kuiper</p>

belt in the outskirts of the solar system). Thanks to ESPaDOnS, astronomers now have access to the magnetic field of stars much beyond our own sun, opening a new era of stellar physics.

As CFHT is part of the Mauna Kea Observatories, it plays an important role for its 8 to 10-m neighbours. Many of the observations made at CFHT, like the discovery of distant supernovae, are followed up at the Gemini or Keck telescopes. As one of the pioneers in Adaptive Optics, CFHT maintains a close relationship with Gemini, Keck and Subaru. All observatories share a common meteorology centre providing unique seeing predictions for the mountain, and collaborate for site-wide seeing monitoring.

Services currently offered by the infrastructure

CFHT observing time is offered in service observing mode all year long, with tools for observation submission provided to the users. Data are pre-processed by the observatory and accessible in a ready-to-use clean format and through the Internet. Recent highlights include

- Dark-energy constraints and correlations with systematics from CFHTLS weak lensing, SNLS supernovae Ia and WMAP5 (*Astronomy and Astrophysics* **497**, 677, 2009)
- The discovery of a new class of gravitational lenses, the groups of galaxies, in the CFHT Legacy Survey.
- Gravitational lensing in the supernova legacy survey (SNLS) (*Astronomy and Astrophysics*, **514**, 44, 2010)
- UKIRT, CFHT, and Chandra team up to unveil what could be the most distant galaxy cluster ever (*Astronomy and Astrophysics*, 507, 147, 2009)
- Andromeda caught devouring another galaxy: The remnants of galaxy formation from a panoramic survey of the region around M31 (*Nature* **461**, 66, 2009)
- Searching for star-planet interactions within the magnetosphere of HD189733 (*MNRAS* **406** 409,2010)
- Elliptical galaxies found to be much younger than previously thought (*MNRAS* **417**,863,2011)
- Near-infrared Thermal Emission from WASP-12b: Detections of the Secondary Eclipse in Ks, H, and J (*Astronomical Journal* **141**, 30, 2011)
- Discovery of the first Trojan asteroid of the Earth (*Nature* **475**, 481, 2011)

Under the Opticon access programme CFHT has already provided observations to, or hosted, groups led by PIs mainly from Spain, Switzerland, UK and Germany. It should be noted that the pressure on the telescope is high, thanks to the uniqueness of the instrumentation offered.

Description of work

Support offered under this proposal:

PIs submit their proposals through an on-line tool. Once they are awarded time, they submit their request for observation in a Phase-II process that is offered by CFHT, with assistance given by the observatory staff astronomers when needed. The observations are later carried out by the CFHT staff so that the observing conditions match those requested by PIs, who can follow the progress of their programme on line.

Data are then pre-processed at the observatory and controlled by staff astronomers, before being made available with a set of ancillary data to the PIs through the Internet.

Description of the Infrastructure
<u>Name of the infrastructure: Observatoire de Haute-Provence, 193cm telescope</u>
<u>Location (town, country): Saint Michel l'Observatoire, France</u>
<u>Web site address: www.obs-hp.fr</u>
<u>Legal name of organisation operating the infrastructure: CNRS</u>
<u>Location of organisation (town, country): Paris, France</u>
<u>Annual operating costs (excl. investment costs) of the infrastructure (€):3100000€</u>
<p><u>Description of the infrastructure:</u></p> <p>The Observatoire de Haute Provence 193cm telescope (OHP193) is a 1.93m telescope located at in Southern France, St Michel l'Observatoire. It is operated by the Institut National des Science de l'Univers (INSU) for the Centre National de la Recherche Scientifique (CNRS). The OHP 193cm is equipped with one of the world's most stable echelle spectrographs, SOPHIE, with a resolution of 70000, and an accuracy of 2m/s for radial velocity. Data reduction is fully automated with SOPHIE and the result is available both on DVDs and over the net as spectra and radial velocity curves. The other instrument, CARELEC, is a low-medium resolution spectrograph for faint objects (5000). OHP can also accommodate visitor instruments.</p> <p>SOPHIE, a correlation spectrograph, is unique in the Northern hemisphere. It is heavily used for the detection and study of extrasolar planets, and is able to accommodate long term searches. Among its recent successes are the confirmation of several superwasp planets, the follow-up of COROT candidates, and the spectroscopy of a planetary transit. SOPHIE is also heavily used for stellar studies as planetary atmospheres. More recently SOPHIE has been used for asteroseismology, and has discovered the oscillations of 51Peg.</p> <p>CARELEC is a long slit spectrograph and is used for stellar studies, high energy sources, and extragalactic sources as AGNs.</p> <p>We have recently made a major effort to refurbish the 193cm, making it semi-automated, enhancing its throughput and performance. We have just refurbished the bonnette and the fibre system, the calibration, and provided better instrument management. With the new bonnette we reach accuracies in the range 1m/s for SOPHIE.</p> <p><u>Services currently offered by the infrastructure.</u></p> <p>The OHP193 is used all the year around, and time is allocated on a semestrial basis by independent committees. In the recent years access has been granted to astronomers from all over Europe including Spain, U.K., Switzerland, Italy, Bulgaria, Portugal, Germany, Israel, etc. We have now implemented a service mode, which will be facilitated when the telescope control will be upgraded to a semi-automated mode by 2012.</p>
Description of work
<p><u>Support offered under this proposal:</u></p> <p>The service offered by OHP193 is a complete support at all stages of the observing process from proposal management, handled by a centralized proposal software installed under FP6 Opticon Access Programme; NorthStar, to archiving of the data. Since 2007A, a service mode is offered where observations are performed by service observers under prior guidance of the Principal Investigators. Scheduling has been gradually evolving from a static scheduling to a full dynamical scheduling by 2012. OHP193 services include observations, data reduction with a state-of-the-art pipeline, quality control and release at the end of each night. WWW Interfaces are being developed to</p>

allow astronomers a full control on their programme observations on a semester basis.

Astronomers have the support of a night assistant. They can prepare the run with a local support scientist. Data reduction pipeline is automated for SOPHIE. The reduced data from SOPHIE and the previous ELODIE spectrograph is also freely accessible, depending on the status of the data.

Description of the Infrastructure

Name of the infrastructure: TELESCOPE BERNARD LYOT

Location (town, country): PIC DU MIDI DE BIGORRE, FRANCE

Web site address: wwwtbl.bagn.obs-mip.fr

Legal name of organisation operating the infrastructure: Institut des Sciences de l'Univers (INSU)

Location of organisation (town, country): Paris, FRANCE

Annual operating costs (excl. investment costs) of the infrastructure (€): 635563

Description of the infrastructure:



The Telescope Bernard Lyot (TBL) is a 2.13-m telescope operated by the French Agency Institut National des Sciences de l'Univers (INSU) for the Centre National de la Recherche Scientifique (CNRS) and the Observatoire Midi-Pyrénées for the Université de Toulouse. TBL located in the French Pyrenees Mountains at the summit of Pic du Midi de Bigorre (2877m), renowned for its image quality and sky darkness.

TBL comprises a team of 15 technicians and engineers working all year round. The instrumentation includes a unique instrument: Narval, an echelle spectropolarimeter yielding a resolution of 65000/80000 in the range 370-1000nm, optimized for measurement of QUV stokes parameters in spectral absorption lines. TBL/Narval is the only telescope in the world to provide long term follow-up capabilities of stellar magnetic fields. Associated with the combination of CFHT/ESPaDoNS, TBL/Narval allows observers to make continuous follow-ups of dedicated objects. The telescope is offered to the French community, to third countries under one-to-one agreements and to the European community as part of the Opticon Programme.

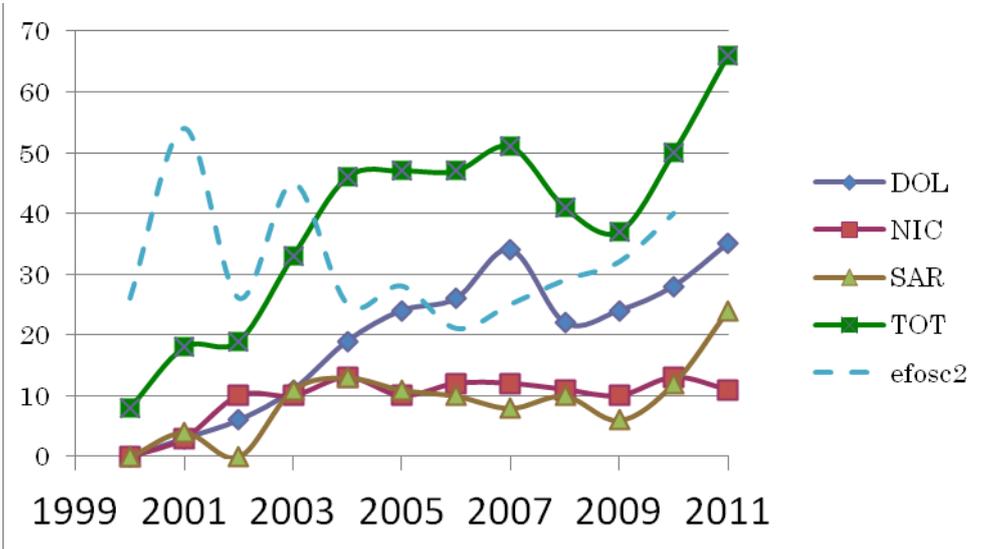
Services currently offered by the infrastructure:

The service offered by TBL/Narval is complete support at all stages of the observing process from proposal management, handled by a centralized proposal software installed under FP6 Opticon Access Programme; NORTHSTAR, to archiving of the data. Since semester 2009B, TBL has been operated in full service mode. Observations are performed by service observers under prior guidance of the Principal Investigators (through PH2 www interface). Scheduling is fully dynamical, optimizing each night to the weather and astronomical constraints of each programme. The process started in 2007 has already proven to be both scientifically rewarding with pioneering discoveries published soon after the observations, and very successful among observers with a pressure factor of ca. 3 or more in all recent TBL/Narval calls for proposals.

TBL/Narval services include observations, data reduction with a state-of-the-art pipeline, quality control and release at the end of each night. WWW Interfaces are available to allow astronomers a full control on their programme of observations on a semester basis.

Services currently offered by the infrastructure:

This proposal offers time at TBL to the European community, including all the support and services described in the previous section.

Description of the Infrastructure																																																
<u>Name of the infrastructure:</u> Telescopio Nazionale Galileo (TNG)																																																
<u>Location (town, country):</u> Observatorio del Roque de Los Muchachos, La Palma, Spain																																																
<u>Web site address:</u> http://www.tng.iac.es																																																
<u>Legal name of organisation operating the infrastructure:</u> Istituto Nazionale di Astrofisica (INAF)																																																
<u>Location of organisation (town, country):</u> Rome, Italy																																																
<u>Annual operating costs (excl. investment costs) of the infrastructure (€):</u> 2,054,975																																																
Description of work:																																																
 <p>The 3.58m telescope is an Italian facility located at the Roque de Los Muchachos Observatory in La Palma (Spain). It is dedicated to astrophysical observations at visual and near infrared wavelengths and offers a remarkably complete set of instruments for imaging and spectroscopic observations. The main peculiarity, and advantage relative to other telescopes of the same class, is that all the instruments are always on-line and quickly selectable by the users who may, therefore, organize their observations in a very flexible mode.</p> <p>TNG is a very productive and successful facility. The oversubscription rate (i.e. the ratio between requested and available time) is, on average, a factor 1.5, with about 1/3 of the requests coming from international (i.e. non-Italian, non-Spanish) teams. The scientific production of TNG has been increasing and half is due to the Dolores instrument.</p>  <table border="1"> <caption>Estimated data from the oversubscription rate graph (1999-2011)</caption> <thead> <tr> <th>Year</th> <th>DOL</th> <th>NIC</th> <th>SAR</th> <th>TOT</th> <th>efosc2</th> </tr> </thead> <tbody> <tr><td>1999</td><td>0</td><td>0</td><td>0</td><td>8</td><td>25</td></tr> <tr><td>2001</td><td>5</td><td>10</td><td>5</td><td>18</td><td>55</td></tr> <tr><td>2003</td><td>10</td><td>10</td><td>10</td><td>33</td><td>45</td></tr> <tr><td>2005</td><td>25</td><td>10</td><td>10</td><td>48</td><td>28</td></tr> <tr><td>2007</td><td>35</td><td>12</td><td>10</td><td>52</td><td>22</td></tr> <tr><td>2009</td><td>25</td><td>10</td><td>10</td><td>38</td><td>30</td></tr> <tr><td>2011</td><td>35</td><td>10</td><td>25</td><td>65</td><td>40</td></tr> </tbody> </table>	Year	DOL	NIC	SAR	TOT	efosc2	1999	0	0	0	8	25	2001	5	10	5	18	55	2003	10	10	10	33	45	2005	25	10	10	48	28	2007	35	12	10	52	22	2009	25	10	10	38	30	2011	35	10	25	65	40
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2001	5	10	5	18	55																																											
2003	10	10	10	33	45																																											
2005	25	10	10	48	28																																											
2007	35	12	10	52	22																																											
2009	25	10	10	38	30																																											
2011	35	10	25	65	40																																											
TNG has been part of the EU access programme since FP5.																																																

Services currently offered by the infrastructure:

The focal plane instruments of TNG which account for most of the scientific publications are

- DOLores: a multi-mode imager/spectrometer at visual wavelengths with a field of view of 9'x9' and spectral resolving power from R=300 to R=7,000
- NICS: a multi-mode imager/spectrometer at infrared wavelengths (0.9-2.5 microns) with a field of view of 4.2'x4.2' and spectral resolving power from R=40 to R=2,500
- SARG: a high resolution (up to R=160,000) spectrograph at visual wavelengths

A fourth instrument, planned to become operative during 2012, is

- HARPS-N: a high resolution high stability visible spectrograph for the discovery of exoplanets, down to Earth-like planets.

Another instrument is programmed for the near future:

- GIANO, a high resolution IR spectrograph, covering the 0.9-2.5 microns range in a single shot.

All the above instruments are permanently mounted, maintained and made available to all observers. TNG intends to offer this service throughout the whole period covered by the contract.

Description of work

Support offered under this proposal:

TNG will provide and guarantee all the maintenance work on telescope and instruments, as well as the calibration and quality-control operations necessary to achieve the best possible scientific outcome from the data.

Logistic, technical and scientific support will be made available to the visiting observers who will be also invited to give seminars and exchange information with the all the research staff of La Palma.

Description of the Infrastructure
<u>Name of the infrastructure:</u> Calar Alto
<u>Location (town, country):</u> Almeria, Spain
<u>Web site address:</u> www.caha.es
<u>Legal name of organisation operating the infrastructure:</u> Centro Astronómico Hispano-Alemán
<u>Location of organisation (town, country):</u> Almería, Spain
<u>Annual operating costs (excl. investment costs) of the infrastructure (€):</u> 4.7 M€
<p><u>Description of the infrastructure</u></p> <p>Calar Alto Observatory (Centro Astronómico Hispano-Alemán) it is joint institution between the German MPG and the Spanish CSIC. The observatory is located in the Sierra de Los Filabres (Andalucía, Southern Spain) north of Almería. It is operated jointly by the Max-Planck-Institut für Astronomie (MPIA) in Heidelberg and the Instituto de Astrofísica de Andalucía (IAA) in Granada and its role is to provide world-class observing facilities to Spanish and German optical and infrared astronomers as well as to the international community. Calar Alto currently provides two telescopes with apertures of 2.2m, and 3.5m together with state-of-the-art instrumentation. The Calar Alto Observatory is the largest astronomical observatory in continental Europe and has a staff of about 50, comprising technical staff, engineers, and PhD astronomers. The observatory has guaranteed funding until at least 2018.</p>  <p>The quality of the Calar Alto sky was characterized recently (see Sanchez et al. 2007, PASP 119, 1186; and Sanchez et al. 2008, PASP 120, 1244) and the main findings indicate that Calar Alto is a particularly dark site, specially good for spectroscopy, on similar terms with the best observatories in the world, like Mauna Kea in Hawaii, and Paranal in the Atacama desert in Chile.</p>  <p>Calar Alto offers an impressive array of 10 very competitive instruments to its users, covering the optical and near-infrared wavelengths with imagers and spectrographs, with both low and high-resolution. The currently most popular instrument is <i>the world's largest Integral Field Unit</i> PMAS. This unique instrument consists of a lens array and a fibre-coupled spectrograph working in the optical (350-900 nm) and has a field-of-view of about one square arcmin. The newest acquisition has been an optical echelle spectrograph (CAFÉ) in 2011. Calar Alto instrumentation will be complemented in</p>

2012 with PANIC, a Panoramic Near-Infrared camera offering a 30 arcmin x 30 arcmin field of view. Calar Alto has started the process of procuring of a new instrument for its flagship telescope, the 3.5m. Therefore, after 2014, we will offer to the community a high-spectral resolution spectrograph, CARMENES, which will work both in the optical and near-infrared.

Calar Alto is used by astronomers from all areas of research, from Solar System science to Cosmology. Most of the observations (60%) are now carried by staff astronomers in Service Mode. Surveys, target of opportunity, and monitoring programmes are being carried, together with normal programmes. A fast response Director Discretionary Time observations, available for all 10 instruments) is currently in place and used by a growing number of researchers.

A new programme for Master and PhD students (Calar Alto Academy) is now in place. Under this programme, students can now do short or long term visits to the observatory and get hands-on experience with observatory work and data reduction and analysis techniques.

Data from Calar Alto Observatory generates about a 100 refereed publications per year.

Services currently offered by the infrastructure.

Observing time for both telescopes and their instruments is open to the entire community via a Call for Proposals. German-Spanish time allocation follows strictly the recommendation of an international TAC and is solely based on scientific merit. Currently, about 20% of Calar Alto time goes to international proposals (i.e. proposals not from Spain or Germany, whether applied for via the Opticon CTAC or not). There are two Calls per year (15 September for the Semester January-June, and 15 Feb for July-December). A team of 11 astronomers is responsible to support the visiting astronomers (Visitor Mode) or to carry out the observations in the case of Service Mode.

Since July 2011, we have an archive open to any researcher worldwide. The data became public after one year proprietary period. The gate to the data is at: <http://caha.sdc.cab.inta-csic.es/calto/index.jsp>

Description of the Infrastructure
<u>Name of the infrastructure:</u> MPG 2.2m telescope, LaSilla, Chile
<u>Location (town, country):</u> ESO LaSilla Observatory, Chile
<u>Web site address:</u> http://www.mpia.de/Public/menu_q2.php?MPIA/ESO22/index.html
<u>Legal name of organisation operating the infrastructure:</u> Max-Planck Society, Germany
<u>Location of organisation (town, country):</u> Munich, Germany
<u>Annual operating costs (excl. investment costs) of the infrastructure (€):</u> 625.000,00
<p><u>Description of the infrastructure:</u></p> <p>The MPG/2.2m telescope is located at the La Silla observatory of the European Southern Observatory in Chile. The design of the telescope as a Ritchey-Chretien system provides for excellent image quality over a very wide field of view of 33 arcmin free of vignetting. The telescope was built by Zeiss, and is characterised by an encircled energy of 80% within the central 0.3 arcsec of each point source image..</p> <p>The telescope is equipped with three permanently installed state of the art instruments. The Wide Field Imager (WFI) is a focal reducer-type camera which is permanently mounted at the Cassegrain focus.. It offers excellent sensitivity from 350 nm to the near IR, with more than 40 filters simultaneously available, many of them specifically selected to support the determination of photometric redshifts of distant objects. The focal plane is filled with a 4 x 2 mosaic of 2k x 4k CCDs and has a filling factor of 95.6%.</p> <p>FEROS is a state-of-the-art fibre-fed Échelle spectrograph. It covers the 360 – 920 nm wavelength range in one shot and provides a spectral resolution of about $R = \lambda / \Delta\lambda = 50,000$. FEROS is fed by two fibres providing simultaneous spectra of OBJECT plus either SKY or one of the two CALIBRATION lamps (wavelength calibration and flat-field). Switching from the WFI to FEROS is achieved by moving the M3 third mirror and accomplished in about 8 sec.</p> <p>The third instrument is GROND, an imaging instrument designed to investigate Gamma-Ray Burst Afterglows and other transients simultaneously in seven filter bands. Several dichroic beamsplitters feed light into three NIR channels and four visual channels, each equipped with its own detector. GROND became operational in 2007. The field of view in each of the near-infrared channels is 10' x 10', and 5' x 5' each in the four visible bands. Observations with GROND can be activated via a rapid response mode (RRM) which can be fed automatically into the system, thus minimizing the delay between a GRB detection by a satellite.</p> <p><u>Services currently offered by the infrastructure:</u></p> <p>Because of its versatile set of instruments, a number of highly visible scientific projects have been carried out, ranging from extragalactic work such as the COMBO-17 survey which has imaged 1 square degree of sky in 17 optical filters, or the spectacular discovery of the youngest extrasolar planet in TW Hya. Since April 2009 the telescope has been operated as a semi-national facility, with 9 months/yr of the observing time owned by MPIA. International access to the telescope via ESO is thus significantly reduced and the number of eligible users in the transnational access programme has greatly increased. This is a significant change from the arrangements that existed in FP6. MPG will offer up to 100 nights to the programme.</p> <p>Description of work</p> <p><u>Support offered under this proposal:</u></p> <p>Technical support from ESO and support to visiting astronomers has been significantly reduced by ESO. MPIA has hired two local support astronomers, Dr. T. Anguita and Dr. R. Lachaume, who are based at the PUC in Chile. Support to visiting astronomers from the TNA will be provided by one of the two support astronomers.</p>

Description of the Infrastructure
<u>Name of the infrastructure:</u> Isaac Newton Group of Telescopes
<u>Location (town, country):</u> Santa Cruz de la Palma, Spain
<u>Web site address:</u> http://www.ing.iac.es/
<u>Legal name of organisation operating the infrastructure:</u> Science and Technology Facilities Council
<u>Location of organisation (town, country):</u> Swindon, United Kingdom
<u>Annual operating costs (excl. investment costs) of the infrastructure (€):</u> € 3.8M
<p><u>Description of the infrastructure</u></p> <p>The Isaac Newton Group of Telescopes (ING) operates the 4.2-m William Herschel Telescope (WHT) and the 2.5-m Isaac Newton Telescope (INT), located at the Roque de los Muchachos Observatory at an altitude of 2400-m on the island of La Palma. Both telescopes are equipped with state-of-the-art instruments and allow a very wide range of scientific projects to be conducted.</p> <p>The INT provides capability for wide-field optical imaging and intermediate resolution spectroscopy. This combination makes the telescope particularly suited for research of stars and stellar systems, as well as for nearby galaxies; it complements well the capability of other telescopes within the OPTICON framework.</p> <p>The WHT offers a wide range of instruments covering optical and near-IR imaging and spectroscopic capability. There are a number of unique and highly competitive instrument available. For example, the multi-object fibre spectrograph, WYFFOS, is a powerful tool for surveying the physics of stellar systems and galaxy clusters. Our near-IR spectrograph, LIRIS, offers the highly competitive option of multi-object spectroscopy besides its more common long-slit imaging and spectroscopic capability. Recently commissioned on the ISIS optical spectrograph is the high-speed spectroscopic capability using novel L3CCD technology, providing virtually zero dead time and zero read noise capability that is ideal for measuring rapidly-varying objects in the universe.</p> <p><u>Services currently offered by the infrastructure.</u></p> <p>The telescopes are operated year-round in order to optimally profit from the excellent weather conditions on La Palma. Common-user instruments are freely available to all applicants. ING is well-equipped and set up to provide a high-quality service to its users.</p> <p>Scientists may also bring their own instrument, and observatory personnel will assist in the successful execution of these experiments. This service is rather unique and popular with university groups to fast-track scientific experiments.</p> <p>The ING telescopes see a wide interest from astronomers around the world. The high oversubscription of telescope time implies that only the very best scientific projects are awarded time.</p> <p>Recent science highlights include:</p> <ul style="list-style-type: none"> • The WHT obtained first observational evidence that outflows from active galaxies originate as disk winds from rotating accretion disks around a super-massive black hole. • The INT and WHT were among the telescopes used to discover the accelerated expansion of the Universe. This research received the 2011 Nobel price in physics. • Publication of two major survey catalogues carried out with the INT Wide Field Camera: the IPHAS Hα survey of the north galactic plane, and the millennium galaxy catalogue.
Description of work
<p><u>Support offered under this proposal:</u></p> <p>The service offered by the ING under this proposal is identical to that offered to our normal user community, including transport on site, accommodation, computing and network infrastructure, consumables, data reduction software, data archival facilities etcetera. For the scientific support</p>

the visiting astronomers are assisted by a team of support personnel, including astronomers, technical assistance on the night, a telescope operator on the WHT, and administrative support. The support team ensures that the instrumentation is set up and tested in order that the available observing time be used as efficiently as possible. ING also provides training and advice for those astronomers that are less familiar with the equipment. This makes the ING particularly suitable to reach out to new science communities in Europe. ING's infrastructure includes extensive web tools and documentation to plan observations prior to arrival at the observatory and during the observations, as well as the standard data reduction tools for on-line analysis of the scientific data.

Description of the infrastructure	
<i>Name of the infrastructure:</i> Telescopio Carlos Sánchez	
<i>Location:</i> Tenerife, Canary Islands, Spain	
<i>Web site address:</i> http://www.iac.es/telescopes/pages/en/home/telescopes/tcs.php	
<i>Legal name of organisation operating the infrastructure:</i> Instituto de Astrofísica de Canarias	
<i>Location of organisation (town, country):</i> C/ Vía Láctea s/n. 38205 – La Laguna. Tenerife, Spain	
<i>Annual operating costs (excl. investment costs) of the infrastructure (€):</i> 399826.4 €	
<i>Description of the infrastructure:</i>	
<p>The 1.52-m Telescopio Carlos Sánchez (TCS), installed at the Observatorio del Teide and is mainly devoted to night-time infrared observations, with excellent image quality over a wide field of view.</p> <p>The TCS's common user instrumentation includes one near infrared and one optical instrument. These instruments were developed and built at the IAC with the particular strengths of the telescope and site in mind. The IR camera, CAIN-3, consists of a mosaic of 256x256 HgCdTe photoelectric elements with sensitivity in the 1-2.5 micron range. It has two different optical devices: narrow field with a field of view of 100x100 arcsecond and wide field with a field of view of 256x256 arcsecond. There are four readout modes in CAIN-3: simple, fowler, correlated and ramp. The available filters cover the whole range over which the instrument is sensitive and they include broad and narrow band filters. The limiting magnitude is around 18.5 in the J band and 17.1 in the K band.</p>	
<p>The other instrument, FastCam, is the most recent technological development for the TCS. This consists of a L3CCD lucky imaging 512x512 camera with very fast readout (several hundreds of images per second) that allows the diffraction limit of the telescope to be attained. The observations with FastCam offer spectacular results, even under poor atmospheric conditions, with a seeing of 0".12 in the Johnson-Bessell I band, something never before witnessed at the OT. A special software package has been developed to extract, from cubes of tens of thousands of images, those with better quality than a given level defined by the user. This is done in parallel with the data acquisition at the telescope.</p> <p>In addition to the Opticon CTAC research teams have the opportunity twice a year to apply for time at the TCS through the Spanish Time Programme (CAT). The CAT brings together reputable astronomers from different fields of research in astrophysics so that each line of research is well represented, and in the most independent way.</p> <p>The TCS is suitable to observe "cold" objects, like stars in the first or last stages of their evolution. Some of its milestones are the first infrared images of the impact of the Shoemaker-Levy9 comet on Jupiter, images of sub-stellar objects like G196-3B, a deep multi-colour NIR survey of the galactic plane, photometric surveys of the Sigma Orionis cluster, the confirmation of the Milky Way long-bar hypothesis or the creation of a catalogue of galaxies with stellar formation in the H band of emission – first of this type. Sometimes, the TCS operates together with other telescopes, mainly in the OT (OGS and IAC80), for complementary observations in different wavelengths or for investigations of the atmospheric structure.</p>	
Description of work	
<i>Support offered under this proposal</i>	
<p>All users receive technical engineering support, including electronics and mechanical workshop, software support, and support and assistance for user-owned instruments. Computing facilities, such as the provision of private accounts, media for data storage, technical assistance, internet access, library, office space, administrative support for dealing with transport and accommodation. A car is made available for transport on site for use of each research group. Astronomy support, covering introduction, assistance and professional advice in the use of the equipment and for optimal execution of the research programme. Night-time support staff such as telescope operators (6</p>	

operators), support astronomers (4 support astronomers and the Head of the Spanish Telescopes at OT and ORM) and engineering duty staff. Health and safety procedures and equipment to ensure a safe working environment, including trained first-aid staff, alarm systems, on-call night guard and medical emergency room. Office space is made available, in case a longer stay is required.

Astronomers observing at the TCS wishing to perform preliminary reduction of the data at IAC HQ in La Laguna will clearly benefit from the research facilities, computer capability and scientific/technical environment at this Headquarters. We will encourage external users to carry out this preliminary data reduction at IAC HQ. They will have also free access to an specialised library with more than 9,000 reference books and subscriptions to 300 journals, modern computing facilities (with a wide range of computers and 300 work-stations which are interconnected and have wide band links with the observatories and the national and international networks), meeting rooms, etc.

Description of the Infrastructure
<u>Name of the infrastructure:</u> Anglo-Australian Telescope
<u>Location (town, country):</u> Siding Spring Observatory, Australia
<u>Web site address:</u> http://www.aao.gov.au
<u>Legal name of organisation operating the infrastructure:</u> Australian Astronomical Observatory (AAO) - a Division of the Department of Innovation, Industry, Science and Research
<u>Location of organisation (town, country):</u> Sydney, Australia
<u>Annual operating costs (excl. investment costs) of the infrastructure (€):</u> 7815000 (AAO)
<p><u>Description of the infrastructure:</u></p> <p>The Anglo-Australian Telescope (AAT), the largest optical/infrared telescope in Australia, has a 3.9m mirror on an equatorial mount, with prime, Cassegrain, and coudé foci. It is situated at Siding Spring Observatory, at an altitude of 1154m.</p> <p>The AAT is operated by the Australian Astronomical Observatory, which has its headquarters in the Sydney suburb of Eastwood. Approximately a dozen astronomers and 25 technical staff provide observing support to visiting observers. A night assistant, support astronomer and technical support staff are always provided at the AAT.</p> <p><u>Services currently offered by the infrastructure:</u></p> <p>The common user instruments on the AAT are: (i) the AAOmega dual-beam optical spectrograph, fed by either the Two-degree Field (2dF) multi-fibre system, allowing simultaneous spectroscopy of up to 392 objects within a two-degree field, or by the SPIRAL integral-field unit with a 22" x 11" field of view; (ii) IRIS2, a 1–2.5 micron imager and spectrograph offering broad-band and narrow-band imaging over a 7.7' x 7.7' field, as well as R=2400 spectroscopy in long-slit or multi-object mode using multi-slit masks; and (iii) UCLES and UHRF, for high-resolution (R=50k–100k) and ultra-high resolution (R=300k–900k) optical échelle spectroscopy. UCLES now has an optional image slicer fibre feed (CYCLOPS) that doubles the effective resolution and throughput. Visitor instruments are also supported, as are Target of Opportunity override programmes using the currently mounted instrument. Instruments coming on-line in the next 3 years include the GNOSIS OH-suppression fibre feed for IRIS2 (which will reduce the sky background in the H band by a factor of about 40) and HERMES (an R~30000 spectrograph that can be fed by 2dF and can obtain up to 392 simultaneous spectra).</p> <p>Major science programmes currently under way on the AAT include the WiggleZ dark energy survey at redshifts up to $z \sim 1$, the GAMA survey of galaxy and mass assembly in the local universe, and the Anglo-Australian Planet Search, which has been in operation since 1998 and has discovered in excess of many extra-solar planets. A diverse range of smaller programmes is also supported.</p>
Description of work
<u>Support offered under this proposal:</u>
Like other AAO observers, Opticon users can receive assistance with proposal preparation and submission. Due to the complexity of the instrument, 2dF/AAOmega observers have an AAO staff astronomer provided for each scheduled night; users of other instruments receive training on their first night, and on-call support thereafter. Data reduction pipelines are provided for 2dF/AAOmega, SPIRAL, and IRIS2, and post-observing assistance with data reduction is also available.

Description of the Infrastructure	
<u>Name of the infrastructure:</u>	Nordic Optical Telescope
<u>Location (town, country):</u>	Roque de los Muchachos Observatory, Garafia, La Palma, Spain
<u>Web site address:</u>	http://www.not.iac.es
<u>Legal name of organisation :</u>	Nordic Optical Telescope Scientific Association
<u>Location of organisation (town, country):</u>	Lund, Sweden
<u>Annual operating costs (excl. investment costs) of the infrastructure (€):</u>	1.7 M€
	<p><u>Description of the infrastructure:</u></p> <p>The NOT is a fully modern 2.5m telescope, operated at the world-class site of Roque de Los Muchachos Observatory, La Palma, Spain. It is in strong demand as a reliable, highly efficient, user-friendly facility giving the best natural image quality of the site, down to 0.3" under optimum conditions. A wide range of on- and off-site educational services is also offered. In the future, NOT will be optimised for studies of transient and variable sources as part of the future European 2-4m telescope facility.</p>
<p>The present NOT instrument suite is tailored to capitalise on its strengths: Versatile optical and NIR direct imaging and low-resolution spectroscopy with filters, grisms, and polarimetric options are offered with the focal-reducer instruments ALFOSC (2Kx2K CCD) and NOTCam (1Kx1K Hawaii NIR array). The 4Kx4K CCD camera MOSCA offers the highest UV sensitivity of any telescope+ camera at the observatory. The fibre-coupled optical échelle spectrograph FIES ($R = 60,000$), located in a stabilised room off the telescope, yields radial velocities with errors below ~ 10 m/s and will also offer precise spectropolarimetry from 2012 (see http://www.not.iac.es/instruments/).</p> <p>The standby CCD imager StanCam and FIES are can be deployed at any time, which is especially valuable for Target-of-Opportunity and synoptic projects. Following priorities set by its Nordic user community, the operation of NOT is being tuned for even better flexibility and performance on such projects: Our goal for the period 2013-2016 is equip the NOT with a single optical-NIR instrument - the <i>NOT Transient Explorer (NTE)</i> - modelled on the highly successful Xshooter at the ESO Very Large Telescope and offering instant access to direct imaging and échelle spectroscopy throughout the entire spectral range 300 nm - 1.6 μm. The NTE and FIES will then form the fixed complement of instruments at the NOT in the future. In the interim, our operating and data management procedures are being further optimised to capitalise on the potential of this powerful combination.</p> <p>NOT is currently delivering world-class science in a wide range of fields: Gamma-Ray Bursts and Type Ia and Type II supernovae; gravitational lensing as a tool to "weigh" the most massive galaxy clusters in the Universe; studies of the surface structure on Solar-like active and other magnetic stars; and physical properties of extrasolar planets. Results from NOT are published in <i>Nature</i>, <i>Astrophysical Journal</i>, <i>Astronomy & Astrophysics</i> and other prestigious journals (~ 420 refereed papers in 2005-2010 - see http://www.not.iac.es/news/publications/).</p> <p>The competition for observing time at NOT is keen: Over 45% of the observing proposals over the past 5 years had non-Nordic PIs, and the time offered to Opticon is greatly oversubscribed, so the NOT user community is already fully international. User satisfaction is also very high, as documented in the End-of-Run reports. The interest in and value of access to NOT for the European user community is abundantly documented.</p>	
<u>Services currently offered by the infrastructure:</u>	
<p>In addition to the Opticon and NOT proposal submission and peer review procedures, NOT offers a 'fast-track' option by which smaller programmes can be submitted, approved, and executed rapidly in service observing mode by NOT staff. Service mode is also offered when the science goals require special scheduling. On-site visiting observers are hosted at the observatory in the common Residencia, benefiting from the scientific environment and services offered there. At the telescope, visiting scientists are instructed in the use of the telescope and accompanied by staff at the start of their run; most visitors manage well on their own already after 2-4 hours, but staff is always on call in</p>	

case of problems. Quick-look processing is available for all instruments to allow immediate quality assessment by the observer. Finally, user feedback is collected every night, entered into our data base system, and used to further optimise our services. Observers under the Opticon access programme receive exactly the same level of service as Nordic observers.

The data obtained are delivered to the observer on DVDs at the end of the run, and archived at the observatory. For Targets of Opportunity, the data are made available by ftp for inspection by the PI immediately after the observation. For some instruments, standard processing software is also made available; more will be added in the near future.

Description of workSupport offered under this proposal:

The NOT access offer includes complete support for users, from proposal submission through the common Opticon proposal interface to support at the observatory and data delivery at the end of the project, whether conducted on-site or by staff observers in remote mode. Complete up-to-date information on all instruments and facilities is maintained at the NOT web site. Staff are always available for consultations and may help with local travel arrangements.

Description of the Infrastructure
<u>Name of the infrastructure:</u> Liverpool Telescope
<u>Location (town, country):</u> Observatorio del Roque de los Muchachos, La Palma, Spain.
<u>Web site address:</u> http://telescope.livjm.ac.uk/
<u>Legal name of organisation operating the infrastructure:</u> Liverpool John Moores University
<u>Location of organisation (town, country):</u> Liverpool, UK.
<u>Annual operating costs (excl. investment costs) of the infrastructure (€):</u> 726,392
<p><u>Description of the infrastructure:</u></p> <p>The Liverpool Telescope is a fully robotic 2 metre aperture optical and near IR telescope. It is the largest robotic telescope in the world, and offers unique rapid-response capabilities for studies of transient sources and follow-up of sources detected at other wavelengths. The instrumentation offered consists of two optical CCD cameras (one optimised for high time-resolution studies), an IR camera, an imaging polarimeter and an optical, fibre-fed spectrograph.</p> <p><u>Services currently offered by the infrastructure:</u></p> <p>We offer the facility for repeated monitoring of astronomical objects at any frequency from minutes to months; target-of-opportunity observations of transient sources; moving solar system objects; sources which flare; or observations scheduled to be simultaneous with observations at other facilities (usually spacecraft). Such observations can be optical or infra-red imaging photometry; spectroscopy; or polarimetry. Recent science highlights that are based wholly or in part on LT data include:</p> <ul style="list-style-type: none"> • The measurement of the earliest every spectrum of a Type Ia Supernova (Nature, 2011, in press) • The discovery that the Xmas Day 2010 GRB101225A is a new class of burst resulting from the merger of a neutron star and a helium star (Nature, 2011, in press) • The first measurement of the size and albedo of Eris, a Pluto twin (Nature, 2011, 478, 493) • The first discovery of a red-shift 7 quasar (Nature, 2011, 474, 616) • Early-time polarimetric observations of Gamma-Ray Burst counterparts, constraining the strength of magnetic fields in the jet (Science 315, 1822, 2007; Nature 462, 767, 2009) • Detection of the Yarkovsky-O'Keefe-Radzievskii-Paddack effect in near-earth asteroids, a change in the rate of spin due to the torque caused by sunlight warming the surface of the asteroid, and the subsequent recoil as heat is emitted (Science 316, 272, 2007) • Observations of a low-energy core collapse supernova without a hydrogen envelope (Nature, 459, 674, 2009) • Observations of a link object between supernovae and GRBs/Hypernovae (Science, 321, 1185, 2008)
<p>Description of work</p> <p><u>Modality of access under this proposal:</u></p> <p>Successful applicants define their observations using a java web based application, an automatic scheduler optimises the sequence of all observations, and users are notified by email the day after any of their observations are carried out. They are then able to retrieve their data at their home institution using standard internet protocols. Observations for a project are not carried out in a single block, but at user-defined intervals. The data are made available to the user within 10 minutes via website.</p> <p><u>Support offered under this proposal:</u></p>

Support is via a dedicated electronic helpdesk and a support astronomer via email. Queries relating to specification of observations and data products are answered within one working day. Observers do not travel to the LT, and support at the telescope is not applicable.

Implementation Plan

Short name of installation	Unit of access	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
CFHT	Nights	15588	12	24	12	4
OHP	Nights	1893	60	20	60	10
TBL	Nights	2673	32	14	32	8
TNG	Nights	7171	16	8	16	5
CAHA 3.5	Nights	9864	30	12	30	7
CAHA 2.2	Nights	3709	24	8	24	4
MPG 2.2	Nights	2110	12	4	12	7
WHT	Nights	9092	10	6	10	3
INT	Nights	1906	8	4	8	2
TCS	Nights	1449	16	6	16	2
AAO	Nights	9484	56	24	56	14
NOT	Nights	4284	80	20	80	20
LT	Hours	280	320	20	0	20

Work package number	WP8	Start date or starting event	01-01-2013				
Work package title	Management						
Activity type	MGT						
Participant number	1	5					
Participant short name	UCAM	STFC					
Person-months per participant	48	48					

Objectives:

Ensure the smooth running of the consortium, ensure the programme is delivered on time and budget, modifying plans and rebalancing resources as required. Liaison with other structures (eg ASTRONET), reporting to the commission

Description of work.

The consortium management methodology will use the same basic structure as has been successful in delivering the FP6 and FP7 Opticon contracts. Strategic direction will be provided by the Opticon board, on which all the beneficiaries will be represented. It will be chaired by one member of the board who is not the co-ordinator. Representatives from the other EC-funded astronomy activities are invited to attend. This body will meet approximately once per year to receive reports from the work package leaders, review the progress and plans in the light of overall developments in both technology and the evolution of the European astronomical community and, should they be required, approve recommendations from the Executive committee on re-allocation of resources, admission of new beneficiaries and other top level decisions required by the consortium agreement. Each board meeting will be held in a different location and will be open to observers from the local communities except where a closed session is required to discuss complex or confidential matters. Wherever possible the meeting organisers will work with the local organising agency to provide one or more technical seminars and/or outreach activities (e.g. a public lecture or support to school or university careers events).

Since a large annual meeting is not optimised for making rapid decisions, especially since some issues may be financial with direct impacts on some of the work-package leaders, beneficiaries or be related to national agency policies, a smaller executive committee comprised of representative of each major national agency will have delegated authority to deal with such matters. This committee will normally meet at least twice per year and will be chaired by the project co-ordinator.

Day to day management of each work package will be invested in individual work package leaders. These will be individuals with a proven track record of project management whose positions will be confirmed by the board. These WP leaders will report progress to the executive and board on a regular basis, usually in the form of written reports which will form the basis of the project's reporting to the commission.

The whole structure will be co-ordinated by a project office distributed between the office of the co-ordinator (presently UCAM) and the project scientist (presently STFC). The co-ordinators office will be primarily responsible for financial and strategic matters, such as distribution of EC funds and organisation of board and executive meetings. The co-ordinator will also ensure regular interaction with other European structures such as ASTRONET, RADIONET and the solar astronomy community, where joint board membership is implemented. The project scientist will ensure regular monitoring of, and communication between, the work-packages and will report issues and successes to the co-ordinator (and more formally to the board and executive as required). The project scientist's office will monitor progress towards our contractual milestones and ensure all deliverables meet both project and wide EC needs, including suitable publically accessible reports. This office will also deliver the common TAC process required for the TNA described in WP7 and WP12. This combined project office will collate papers for board and executive meetings (including monitoring spending) and prepare the periodic reports to the commission.

The project office will also be responsible for promoting the project to the wider European community. This will be done in a number of ways building on the experience already obtained. For example presentations will be made at large pan-European meetings such as the annual JENAM/EWASS and,

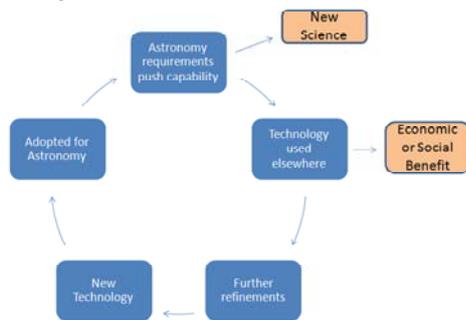
as appropriate IAU meetings. In parallel to these, targeted visits and talks will be made to national and regional events in communities who are not yet fully engaged with the Opticon programme. Regular columns will be offered to newsletters and the Opticon web-pages will be maintained. Wider outreach opportunities will be monitored and exploited when this can be done in a cost effective manner, normally in collaboration with programmes which are already in place

Deliverables

Del. No.	Deliverable name	WP no.	Del. Date (month)
8.1	Opticon Website	8	2
8.2	Period 1 Report to EC	8	14
8.3	Period 2 Report to EC	8	32
8.4	Final Period Report to EC	8	50

Work package number	WP9	Start date or starting event	01-01-2013				
Work package title	Innovation						
Activity type	COORD						
Participant number	5						
Participant short name	STFC						
Person-months per participant	23						

Cycle of Innovation



Objectives: Optical and Infrared Astronomy has both fed off new technologies coming from industry and acted as a stimulus for industrial innovation. An example of this 'cycle of innovation' is the adoption of infrared detectors developed for military applications for the first array-based IR cameras and spectrometers in the 1980's. The strong push for higher performance in astronomical applications, particularly for wavefront sensing in adaptive optics, has recently stimulated Selex-Galileo to improve the performance of these detectors, thereby improving their competitiveness for other markets. Within the Opticon programme, there is an

excellent example of the application of the OCAM high-speed camera, developed for adaptive optics, but now being evaluated for debris detection on airport runways. The proposed 'Innovation Network' will build on the success of the previously funded Opticon Key Technology Network (KTN), but will extend the remit to include much more direct knowledge exchange with industry. The existing KTN has been an important factor in the innovation process, examples being: the outcome of workshops on Infrared Detectors which encouraged ESA to fund new developments in European industry; and the bringing together of the Astrophotonics groups into a unified community. This Innovation Network will be coordinated by the UK ATC Innovations Group (STFC), which has many years experience of engaging with industry, both for economic and scientific benefit. It will also access skills in similar organisations, such as ASTRON in the Netherlands and the IAC in Spain.

Our objectives will be to facilitate this process, by:

- Running technology focussed workshops that will bring together scientists, engineers and technologists from the astronomy community and in particular the Opticon R&D work packages with their peers from industry, knowledge transfer professionals and other relevant science sectors
- Further developing the technology roadmap that has been a fundamental tool of the previous Key Technology Network, and using this to encourage academic/industrial consortia to bid for further technology development funding
- Setting up an Industry Club to bring together companies that wish to bid for contracts and develop technology in Optical and Infrared Astronomy, and to exploit our technology in other fields

Description of work.

WP 9.1: Roadmapping

The Opticon Technology Roadmap has evolved through the life of the project, as should be expected. The primary aim of such a roadmap is to get people to think about what new technologies could do for the field, and then plan how they can be developed to a sufficient Technology Readiness Level so that they can be adopted in instruments, telescopes and systems. The roadmap is driven by foresight of the scientific needs and facility requirements from one end, and the emerging technologies from the other. The Innovation Network will update the Roadmap throughout the period, by a process of consultation, on-line collaboration tools and workshops. We will involve industry experts in this process, and make connections with technology planning exercises in related fields, in the same way that the KTN has involvement in the ESF/ESA Techbreak project. The outcome will be published through the SPIE

conference proceedings.

WP 9.2 Technology workshops

Technology workshops that bring together the astronomy technology community with industry specialists are our key mechanism for encouraging innovation. We will use a combination of focussed physical meetings with a small number of participants with a breadth of expertise, alongside virtual meetings and consultations using social networking tools. We will build on the topics explored in the Opticon KTN, but put more emphasis on potential spin-out of technology from astronomy for economic and societal benefit.

WP 9.3 Industry Club

On top of the workshops which can only have a limited industrial reach, we will broaden the connections by publicising our activities through an Industry Club, where companies can sign up in order to get access to an interactive website, learn about results of workshops, provide input to the technology planning and knowledge exchange process, and get information about future workshops. We will also run a technology showcase, probably coincident with one of the large European optical instrumentation conferences or large facility exhibitions, highlighting the Opticon developments, and providing an opportunity for further connections to take place.

Participants

Key Opticon Participants: STFC, UL-NOVA, IAC, CNRS, AIP, INAF

Associated organisations: SPIE, EOS, ESO, ESA, CERN

Funding arrangements:

STFC will hold the budget for the network, and fund participants to attend workshops and functions. We expect industry participants to be self-funding.

Deliverables

Del. No.	Deliverable name	WP no.	Del. Date (month)
9.1	Technology Roadmap and Industry Club Website on-line	9	9
9.2	Industry Showcase	9	28
9.3	Innovation Network Final Report	9	48

Work package number	WP 10	Start date or starting event				01-01-2013
Work package title	European Extremely Large Telescope Science and Tools					
Activity type	COORD					
Participant number	3	18	6			
Participant short name	INAF	NUIG	ESO			
Person-months per participant	60	12				

Objectives:

To strengthen the connection between the astronomical community and the European Extremely Large Telescope (E-ELT) project in general. To connect the developers of technology for future E-ELT instruments with the scientific community of future users. To develop tools needed by the community to analyse E-ELT data.

Description of work:

The European Extremely Large Telescope is a 40m-class telescope that will be the largest ground-based optical-infrared telescope in the World. Opticon has played a key role in connecting the project with the community of future users. We have held a series of community workshops focused on various aspects of the science case (e.g.

“Astronomy with Megastructures: Joint Science with the E-ELT and SKA, and workshops shown in Figs 1 and 2). These workshops were aimed at informing the community of progress, obtaining input and preparing the community for the use of E-ELT. The meetings were very well attended (combined attendance of over 200 people) and have resulted in a set of reports and proceedings. This work has been carefully coordinated with the E-ELT project office at ESO.

Recent developments in the E-ELT project as a whole include selection of the site at Cerro Armazones in Chile and successful completion of external technical and cost reviews. A recent risk and cost reduction exercise resulted in some redesign and reduction in size of the primary mirror to 39m diameter. The construction proposal will be submitted to ESO Council in December 2011.

The instrumentation of the telescope is the key link with the scientific community. Two first light instruments have been selected: a diffraction-limited infrared imaging camera (based on the MICADO concept) and an optical-IR integral field spectrograph (based on the HARMONI concept). A roadmap for the first generation instruments is now being developed, which will result in new instruments arriving at the telescope at the rate of one every two years. In addition, the roadmap will include a route for new instrumentation ideas. Instrumentation choices will therefore continue to be made in the next 10 years and indeed throughout the lifetime of the telescope. The scientific community needs to be informed and have input to these choices.

We therefore propose to continue our role of community engagement in the E-ELT, coordinating with, but not duplicating, the E-ELT project office at ESO. Opticon’s role will continue to focus on community preparation and scientific input to the project but with increased emphasis on new instrumentation concepts, in particular those emerging from other Opticon activities such as fast detectors, VPH gratings and astrophotonics.

One such area, High-Time Resolution Astrophysics [HTRA], is a rapidly developing field astronomy due to advances in detector technology and the availability of 8-10 metre class telescopes. In the ELT era HTRA science should come into its own – the available fluxes will be higher enabling observations on shorter timescales. As with any new observing paradigm this is likely to be associated with unexpected discoveries and new avenues for research.

Under previous Opticon funding we have developed the community by bringing together both the main HTRA instrument developers and HTRA observers. In part this was achieved through workshops, short



Figure 7. Session at the meeting “Feeding the Giants, ELTs in the era of Surveys”, Ischia, Italy, Sept 2011.



Figure 8 Participants at the workshop “High Time Resolution Astrophysics IV - The Era of Extremely Large Telescopes”, Crete, May 2010

conferences and a summer school.

HTRA Science will come of age when 30-40m class telescopes become available. In the context of this proposal it made sense to merge the previous HTRA network with the E-ELT science network. Consequently we shall continue the HTRA activity albeit with our main emphasis on the E-ELT. Our HTRA work clearly depends upon detector development and consequently there are strong synergies with WP2 on Fast Detectors and Cameras. The latter, although mainly focussed on fast-detectors for adaptive optics, provides a basis for fast science detectors. Part of the HTRA component will include working with the MICADO instrument team

on the development of an HTRA capability within the 1st light E-ELT imaging camera.

Finally, we stress that E-ELT data will be different – the telescope will routinely deliver adaptive-optics corrected data, which will be unusual compared to that from current large telescopes (for the E-ELT the diffraction limited core will be about 100 times smaller than uncorrected seeing disk). Furthermore the PSF changes rapidly, which must be taken into account in fast photometry applications. There is a need to prepare the community. Therefore we propose to develop tools for AO photometry data analysis and HTRA analysis. This work is not under the remit of ESO or the instrument teams.

The work is broken down into the sub-workpackages below

WP 10.1: Network Coordination

This sub-WP is concerned with coordination of the network’s activities including reporting and recruitment. As previously, there will be close coordination with ESO, which will be achieved through continuation of weekly telecons with the ESO E-ELT Science Office.

This sub-WP includes network meetings on HTRA, aimed at strengthening the existing collaboration between HTRA experts and the MICADO team for the E-ELT first light camera and developing its HTRA capability. The network will also develop further the HTRA science case, concentrating upon the near-IR, for the E-ELT and strengthen collaborations with teams observing at other wavelengths including LOFAR, ALMA and Fermi for multi-wavelength HTRA.

WP 10.2: Workshops and Talks

This sub-WP involves organisation of workshops and talks focussed on E-ELT science and ideas for future instrumentation. Options under consideration include, subject to agreement with ESO:

- Organisation of a conference on Long-range E-ELT instrumentation, to be held in 2013. The meeting will highlight HTRA and links with other technology developments from the Opticon JRAs
- Organisation of an E-ELT science conference, to be held in 2015. This will be organized in collaboration with ESO
- Organisation of a summer school with training sessions on observing techniques that are most relevant for E-ELT. This will be held in parallel and co-located with the science conference in 2015.
- Giving presentations on E-ELT and its instrumentation at European institutes and national astronomy meetings
- Preparing and giving talks for the general public on E-ELT and its instrumentation

WP 10.3

This sub-WP is concerned with development of the tools that are required by future users of the E-ELT. The work includes the following components.

- Developing analysis tools for Adaptive optics photometry data, relevant for current facilities (such as VLT, GTC), and future use of E-ELT. Such tools are needed in order to deal with point spread function that varies with time and with position within an image.
- Developing software tools for reducing, analysing and archiving massive HTRA data sets, relevant for current facilities as well as E-ELT.

We aim to hire one full-time post-doctoral researcher to work on development of these tools, starting with the photometry data and moving on to the related issue of HTRA data. This person will also assist in organisation of the workshops described above.

Deliverables

Del. No.	Deliverable name	WP no.	Del. Date (month)
10.1	Conference Proceedings	10	15
10.2	E-ELT Science Conference Proceedings	10	42
10.3	Summer School report	10	42
10.4	Papers/White paper: Data Analysis Methodologies plus Tools for E-ELT and HTRA	10	46

Work package number	WP 11	Start date or starting event				01-01-2013
Work package title	Time Domain Astronomy					
Activity type	COORD					
Participant number	20	14	1			
Participant short name	UNIWARSAW	LJMU	UCAM			
Person-months per participant	3	27	24			

Objectives:

New and upgraded European facilities such as OGLE-IV (operating now), LOFAR (from 2012) and Gaia (from 2013) will discover many thousands of new, transient objects corresponding to a wide range of astrophysical phenomena from solar system objects through new types of stellar variability and signatures of exoplanets to Supernovae and orphan Gamma Ray Bursts. However without proper ground based follow-up observations, much of the scientific potential of these new discoveries will be lost. As well as rapidly observing the new phenomena using small and medium size (0.5 – 2.0m) robotic telescopes, it is crucial that astronomers can quickly (within minutes) analyse the data obtained and distribute the knowledge obtained to other users who can then trigger follow-up activity on other facilities. This WP will coordinate and develop the capabilities of existing small and medium robotic telescopes to enable them to follow-up new transient phenomena in an efficient and timely fashion. In order to deliver this the following objectives must be achieved:

1. Coordinating the development of scientific programmes in time domain astronomy related to specific targets, e.g. supernovae, microlensing events, variable stars.
2. Matching of the facilities available (in terms of location, aperture, instrumentation etc.) to the various scientific programmes and identifying simple, low cost improvements that could be made to enhance capability.
3. Developing common software and tools for time domain data to facilitate the interactions between observers and to allow a homogenous data analysis of data from heterogeneous telescopes.
4. Providing a platform for experience exchange between time domain astronomers, enabling both young and established astronomers to cooperate in optimizing the operation of robotic telescopes and establishing systems for the rapid analysis and reduction of data.

Description of work.

WP 11.1: Scientific Coordination and overall project management. Based on the experience of Gaia Science Alerts Working Group and the workshops organised in 2010 and 2011, in this task we will conduct a coordination of the network focusing on potential scientific outcomes of the follow-up of transient events. The network activities will be monitored and annual workshops will be organized to report on the progress and outcomes. Main Activity T=0-6 months, with occasional progress monitoring after that.

WP 11.2: Identify and assess the capabilities of exiting robotic telescopes. Based on the list compiled by Gaia Science Alerts WG a standardized set of information will be collated and new partners will be identified. As well as self-assessment, this process will require potential network members to carry out standardised observing programmes in order to measure their efficiency. T=0-9 months.

WP 11.3: Standards, software and tools for individual telescopes. In order to ensure that the telescopes identified by WP 11.2 can be used to deliver the science of WP 11.1 it is necessary that they deliver data to a certain quality standard within the necessary timeframe. This task will therefore consider items such as choice of filters for ease of cross-calibration, standardising on data reduction and analysis packages etc... T=3-12 months.

WP 11.4: Enhance the facilities: By leveraging existing software tools for telescope automation and astronomical data reduction identified in WP 11.3, this WP will provide support such that each facility can obtain data and remove instrumental signatures in a timely fashion. This would be achieved by small "tiger team" visits of a dedicated scientist and software expert to the facility for periods of 1-2 weeks to

assist in setting up the software and training local staff. The team will also identify the potentials and needs of the facility and suggest/undertake relevant actions, including recommendations for hardware purchases. T=12–24 months

WP 11.5: Software and tools for managing the network. Identify and deploy tools needed to better manage the network and interact within it, e.g. wikis, alerts, etc. Develop software to support observers to easily upload their observations to a central server and allow easy cross-calibration. T=6–36 months.

WP 11.6: Crystallising the experience. The people involved in these networks may also be transient. In this task we will take care of preserving and spreading the knowledge and memory of experience gained. It will be achieved through detailed documentation and publications as well as during the annual workshops with presentations of lessons learned, stimulated discussions and brain-storming sessions revealing the holes in the process that need to be filled. T=12-36 months.

WP 11.7: Outreach and public engagement. Transient events, especially supernovae, are of great public interest and small and medium robotic and remotely controlled telescopes have huge potential for engagement with young people. In this task we will extend the telescope, data and tools availability for general public, schools, amateur astronomers, universities. This task will be performed in cooperation with the “Discover the COSMOS” FP7 network (grant agreement 283487). T=0-48 months.

Deliverables

Del. No.	Deliverable name	WP no.	Del. Date (month)
11.1	Web-based interface and software for homogeneous data storage and calibration	11.2	9
11.2	Mid-term robotic telescopes network for transients and variable stars follow-up status report	11.1	24
11.3	Reports and documentation on developed software and other tools	11.6	36
11.4	Final robotic telescopes network for transients and variable stars follow-up status report	11.1	48

Work package number	WP12	Start date or starting event	01-01-2013			
Work package title	Medium Sized Telescope Integration					
Activity type	COORD					
Participant number	5					
Participant short name	STFC					
Person-months per participant	12					
Objectives:						
<p>Improve communications between existing facilities to enable the most effective use of resources and subsequent integration.</p> <p>Operate a European process to allocate time across the Opticon telescope suite.</p>						
Description of work.						
<p>WP 12.1 A Telescope Directors Forum: The Directors of all European medium-size (2-4m) night-time telescopes will meet approximately once a year to coordinate their strategies for the development of their facilities etc. This forum will not be restricted to facilities providing TNA, but may include ESO, observatories in Central Europe and operators of robotic telescopes. A key action item for 2013-2016 will be to prepare specific, coordinated plans for improving and rationalising the instrumentation and operation of all the telescopes to maximise cost-effectiveness. Obvious opportunities for co-operation exist in such areas as exchanges of observing time, sharing software, common use of laboratories and expensive facilities such as coating plants, synergy in upgrading telescope control systems and instrument and detector electronics, and better common use of human resources for the operation. The Forum will also provide oversight of the TNA programme (WP7) and endorse the results of the Common TAC process. Leaders of WP 11(Training) and 13 (TDA) will attend. Links with ASTRONET will be maintained by either the forum chair or the project scientist.</p> <p>WP 12.2 A Common Time Allocation Committee (CTAC): The CTAC will meet twice per year to rank TNA proposals in order of scientific merit. The committee members, initially a single panel of 7, will be drawn from nominations by national TACs to ensure two-way communication and a good understanding of the standards of national proposals. External scientific experts will be consulted during the peer review process. Feedback will be provided to all applicants, especially unsuccessful ones, in order to raise the overall standard of the applications. This system shall have the flexibility to expand to multiple panels to support a much larger pool of nights as the ASTRONET rationalisation process develops. A full report of the progress of the TNA programme will be made to each Opticon board meeting in order to ensure that the programme remains consistent with Opticon's strategic goals.</p> <p>WP12.3 Support to the TNA process. This will include promoting and advertising the calls (via newsletters, web and e-mail exploders); allocating and administering travel support to observers; and hosting, maintenance and development of the NORTHSTAR software. These tasks will all be supported at the same location as the project scientist to maximise communication efficiency and minimise overheads. This WP will also maintain the EU database of TNA user information.</p>						
Deliverables						
<p>There are no physical deliverables associated with this networking activity. Trans-National Access delivery actions are listed as Milestones.</p>						

Work package number	WP 13	Start date or starting event				01-01-2013	
Work package title	Enhancing community skills - Integrating Communities						
Activity type	COORD						
Participant number	2	17	4	5	6		
Participant short name	CNRS (IAP)	UDUR	Max Planck	STFC	ESO		
Person-months per participant	12 + (12)	(2)	(1)	(1)			
<p>Objectives</p> <p>The objective of this Network is to collect expertise and transmit the skills necessary to efficiently use state-of-the-art European astronomical infrastructures, to develop the user community widely over Europe and to enable new communities to participate in the development of the new Large Scale Facilities.</p> <p>More specifically, it intends to:</p> <ul style="list-style-type: none"> -Train young researchers in observing techniques and data reduction early in their careers -Provide a “Life long training” opportunities in new instrumentation for already established astronomers -Exchange experience and good practice among the participants (individuals and observatories), and ensure the participating observatories offer front-line instrumentation for training. -Address the concerns about scarcity of skills in specific technical and scientific areas - Enable the integration of new, or less favoured, European communities. <p>Training, and Education are, by their very nature, activities where continuity and repeatability are essential, as every year, a new generation of students has to be trained. While introducing some innovations can always be beneficial and is considered here, it is nevertheless normal that this WP builds on previous experience, and thus incorporates the key-features which have proven so successful in the past.</p>							
<p>Description of work</p> <p>This network organises activities bringing together experienced astronomers from major observatories and new users (young scientists who have just graduated from the Universities, or scientists from the new member states). These activities take the form of technical schools or workshops organised in leading institutes or observatories; short term exchanges of engineers or scientists; and conferences organised in the new member states to raise awareness of the new techniques and topics which underlie the construction of the new Large Scale Infrastructures.</p> <p>We will ameliorate the lack of systematic training in observational astrophysics in most universities and the progressive disappearance of “training at the telescope” which has resulted from the increasingly widespread deployment of large scale surveys or “service observing”.</p> <p>The programme we will deliver builds on previous experience with the NEON schools, which has shown a huge demand for such activities, it implements previous recommendations and includes a range of new activities. It will work in close coordination with the activity of the Opticon Telescope Director’s Forum (WP12), as well as with the ASTRONET roadmapping exercise, and its engagement with new EU communities, to ensure coherence between the training delivered and the scientific/technical needs and developments. It will also see that enough resources remain available for training at "medium-sized" telescopes.</p> <p>The overall activity will be managed by a Steering Committee comprising experienced astronomers from leading institutes and observatories, and representatives from the “targeted” communities. It will work in coordination with the SREAC (Sub-Regional European Astronomical Committee, gathering all countries from South-Eastern Europe and their neighbours), the EAS (European Astronomical Society), and the ASTRONET network, to ensure appropriate communication with, and feedback from, the user community at large , and in particular from the new EU member states.</p>							

WP 13.1 Organisation of observing schools

This task addresses mainly the first objective: “to train young researchers in observing techniques and data reduction early in their careers”.

We will organise “Observing schools” hosted by observatories equipped with modern instrumentation, where medium-size telescopes (1-2m) will be used to conduct a genuine research programme.

The training will be conducted in small groups (typically 4 students) under the supervision of an experienced astronomer (“tutor”). The process will include preparation of the observations, set-up of the instruments, observations, data reduction and presentation of the scientific results, all within a two week long school (this is the paradigm developed by the NEON scheme). Introductory lectures will cover the necessary areas (e.g. telescope optics, photometry, spectroscopy, detectors, etc...). Complementary lectures will cover new instrumentation and the future Large Scale Facility Projects, the job market and include a module on how to write a proposal for telescope time. Very few countries organise such training at national level and many do not even have the necessary infrastructure for it. The increasing complexity of modern instrumentation, and the high oversubscription factor of modern facilities, require an efficient training model, as “trial and error” and the potential waste of resources by inexperienced observers is clearly no longer acceptable. Furthermore, a sound understanding of an instrument’s performance and of appropriate data reduction techniques is now a prerequisite to be successful in winning observing time. An additional societal benefit of such schools is to bring together young researchers from many EU countries, developing contacts and collaborations.

With the development of large databases and virtual observatories, and the increasing importance of multi-wavelength studies, specific training is also required to optimally extract, evaluate, and then exploit data from various sources, ground or space. This will be done also along the NEON scheme, by simply replacing the newly obtained telescope data by archive data, all other organisational details being similar. Such a school can easily be held in places where no telescopes are available, provided sufficient computer resources and Internet connections are available: it is therefore a good scheme to involve some less economically favoured countries.

The core of this programme is organised by the observatories in the NEON consortium: Asiago (Italy); Calar Alto (Spain); ESO (Germany); Haute-Provence (France); LaPalma (NOTSA, Spain, UK),

many of which are also included as partners in the Trans National Access Programme (WP7). It is lead by CNRS/IAP. Further events will be organised in collaboration with some other observatories (e.g. Rozhen (Bulgaria); Skinakas (Greece); Moletai (Lithuania)) and also Universities (e.g. Porto, Belgrade, Malta).

WP 13.2 Organise training workshops on new types of instruments

This task addresses the second objective: “to provide a “Life long training scheme” for established astronomers”, targeting both young researchers and senior ones with little experience

in new instrumentation. New, more complex observing techniques are being developed all the time

(e.g. Adaptive Optics, Integral Field Spectroscopy, High-Stability spectroscopy for radial velocity measurements, Interferometry, etc...) which require a good understanding of their characteristics for optimal use, and a specific data reduction methodology. They are furthermore of prime importance for the next generation of telescopes (ELT’s). Yet with the increasing complexity of modern observatories, astronomers are usually not allowed to “touch” the instruments and more and more observations are conducted in service mode. So learning directly at the telescope is no longer possible and basic observing skills are getting lost. Many potential users are thus reluctant to use these powerful, new instruments, even if the observations are conducted in service mode. In addition, the complexity of the data reduction is often a barrier for those astronomers not working directly in collaboration with the instrument-building teams. A particularly striking example concerns Adaptive Optics: the E-

ELT will be unable to achieve its expected performance without it, yet very few systems are operational on smaller telescopes today, so training in this technique remains a challenge.

We will therefore conduct specific workshops/training schools covering these key techniques, based on the model of the NEON Archive school, where participants will work in small groups on data sets provided by the various instrument builders and become acquainted with these specialised techniques. Proposed topics are: Photometry with Adaptive Optics; Integral Field Spectroscopy; Multi-object spectroscopy; high-accuracy radial velocity measurements, etc. The partners involved are the same as for the observing schools, but additional expertise will be provided by the JRA's, particularly for the Adaptive Optics. A training workshop on the latter topic will be organised together with the ELT Network (WP 10).

WP 13.3 Raise interests and skills in modern instrumentation technology and forefront topics in astrophysics.

This task addresses the following objectives:

- The concerns about scarcity of skills in specific technical and scientific areas
- Exchange experience and good practice among the participants.
- Ensure adequate instrumentation remains available for training purposes.

Instrument building institutes are increasingly concerned by the difficulties in finding/attracting scientists in this domain, while needs are increasing due to the new Space (ESA's Cosmic Vision) and Ground (ELT's) projects. Furthermore, the management of such projects is also more complex, requiring specialist skills. Similarly, the development of new scientific areas (e.g. extrasolar planets, high-z galaxies, etc...) is not well distributed over Europe, increasing the integration difficulty for some countries. Particularly in the East of Europe, the diversity of topics being taught is restricted by the presently available staff and their skills and experience.

Finally, observatories are operating and evolving independently, creating unnecessary duplication of procedures and solutions in many areas (detectors, control software, maintenance tools, etc..) and some of them are much less advanced than others. Similarly, uncoordinated evolution could lead to the disappearance of some of the tools needed for training and education. Increased contacts and exchange of experience can help reduce the gaps and standardise practices.

The following tools are proposed:

WP13.3.1 Network of European 1-2m class telescopes for research training. Telescope owners and directors will meet to exchange their experience and coordinate the development of instrumentation. This is crucial as resources for "smaller" telescopes are becoming scarce due to the pressure from the Large Scale Facilities, but where it remains fundamental to still offer front-line instrumentation in those facilities, both for research and training. This will be coordinated with the forum of the Directors of those telescopes also offered in the Trans National Access programme.

WP13.3.2 LaCaille exchange grants, funding short visits (typically one month or less) of engineers or scientists to leading institutes all over Europe, with emphasis on development of modern instrumentation or observing techniques, and the science cases of the next generation of space or ground-based large scale facilities. Announcements will be periodic, selection made by peer review, but with a time scale flexible enough to allow rapid response to emerging needs. This scheme will be extended to allow some individual PhD students to participate in observing runs lead by foreign senior scientists, to help alleviate the high pressure existing on the NEON schools (pressure factor of about 4...).

WP13.3.3 Organisation of "Awareness" conferences given by a small team of expert scientists and instrumentalists (assembled by Opticon) at Universities or National Observatories. These events of a few days duration would address students ready to engage on a PhD programme, young researchers or even more senior scientists gathered in a single place from all over a country or wider. They would present the top-level existing facilities in Astrophysics, their scientific capabilities, as well as the future facilities with their science cases,

thus covering a broad range of subjects. This should help astronomers in new EU countries to broaden their horizons, appreciate what are the hot-topics in Astrophysics, raise their interest in the Access programme, and attract new researchers into leading topics in astrophysics. These conferences could be coupled with a local observing school.

While usually organised at a regional level (one country plus neighbours), we will also try to organise one larger conference at a pan-European level (with help from the International Astronomical Union).

WP under the responsibility of Durham (+ IAP)

WP13.3.4 Workshop “Design of an instrument for ground-based telescopes”.

This workshop follows the model of the Alpbach school in Space instrumentation, but applied to ground-based instrumentation. Participants will work in small groups, to design an instrument starting from the scientific drivers up to the definition of a Phase A study, under the supervision of engineers and instrument scientists. A module on “project management” can be added also. WP under the responsibility of STFC, together with NEON.

Deliverables

There are no physical deliverables associated with this networking activity. The main outputs of this activity are conferences and workshops, etc, which are listed as Milestones.

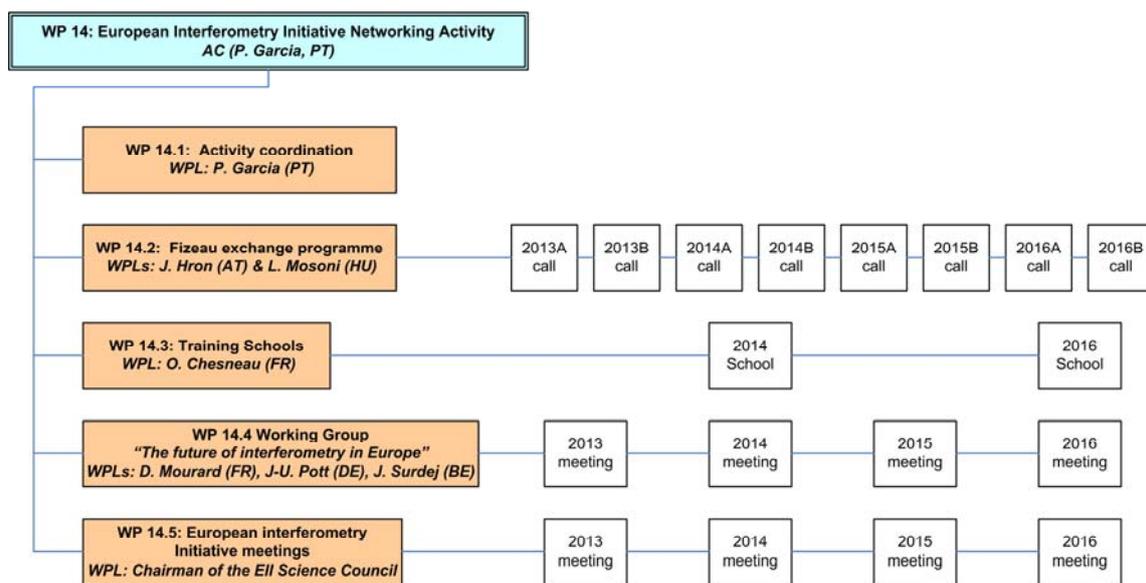
Work package number	WP 14	Start date or starting event	01-01-2013				
Work package title	The European Interferometry Initiative						
Activity type	COORD						
Participant number	15						
Participant short name	UPORTO						
Person-months per participant	8						

Objectives:

Enhance the access and the scientific exploitation of the European flagship infrastructure – the Very Large Telescope Interferometer – the world’s top optical interferometer as well as the European-USA alliances in the CHARA array, MROI and LBT-Interferometer. Exchanges of individuals across European institutes will be competitively funded and a new generation of, mostly young astronomers, will receive hands-on training.

Define a strategy for the future of optical interferometry in Europe in the next decade, taking into account the global landscape shaped by the operation of the ALMA array and construction of the E-ELT. This will be achieved via an inclusive working group with members from the scientific community, service infrastructures and emerging countries.

Reinforce a shared vision for the field with meetings of representatives from established and new countries (infrastructure organizations, instrument building countries, scientific user countries and countries with emerging communities).



Summary of the activity

The European Interferometry Initiative

The Very Large Telescope Interferometer is unique as the world premier optical interferometer and in offering telescope time to the community via a competitive allocation and common user instruments. During the 2013-2015 timescale this interferometer will evolve by the deployment of PRIMA (allowing not only precise astrometry but also faint science with existing AMBER and MIDI instruments) and by the construction of the new common user instruments GRAVITY and MATISSE and the associated fringe tracker. In parallel, European researchers are involved in European-USA alliances in the context of the CHARA array, LBT-Interferometer and MROI.

This work package brings together researchers from across Europe structured in the European Interferometry Initiative alliance of countries (ESO and non-ESO members). This work-package was funded in the first FP7 Opticon call: <http://www.european-interferometry.eu/>. Its main achievements were the expansion of the Fizeau Exchange Programme with over 50 exchanges funded to now (a scheme resembling the Exchange Visit Grants offered by European Science Foundation Networks). The creation of working groups on “Circumstellar disks and Planets”, on “AGNs and the Galactic Centre” and “Science

cases for a 2nd generation facility” who have met and have/will deliver reports.

In the present proposal most resources are allocated to the highly successful Fizeau Exchange Programme and to training. The following sub-workpackages/activities are proposed:

WP 14.1 Coordination is concerned with coordination of the network’s activities including reporting.

WP 14.2 Fizeau exchange programme competitively awards funding for exchanges of individuals (students, researchers and technical staff) across Europe on optical interferometry activities (from training to technical/research collaborations). The exchanges can have a duration of up to one month. The grants are awarded twice a year, after public calls, by a selection committee mainly composed of researchers from institutions not participating in Opticon. Although the focus is on European institutes, applications from outside Europe (e.g. BRIC countries) will be accepted if deemed essential to the objectives of the programme. This work package continues the previous highly successful FP7 activity.

WP 14.3 Training schools The widening of access to the worlds leading optical interferometric infrastructure, the ESO Very Large Telescope Interferometer, strongly relies on continued training. This is due to the combination of: a) lack of advanced training in this complex technique across Europe; b) instrument building for the infrastructure being done by localized expert laboratories in Europe; c) continuous evolution of the facility with new instruments and modes.

Training on scientific design and preparation of measurements with the infrastructure and on data reduction is therefore essential. The schools will have mainly a hands-on component using the respective software, complemented by theory classes explaining the fundamentals, seminars illustrating front-line applications and complementary skills courses. The attendance will be of around 30 participants (as in previous editions, with priority to young students from non-expert institutes/countries). The schools are tentatively scheduled for 2014 and 2016. The innovation dimension will be addressed by including in all schools seminars and open discussions on this topic.

WP 14.4 Working Group “The future of interferometry in Europe” The future of interferometry in Europe in the next decade will be addressed in the context of other European and worldwide ground infrastructures such as ALMA, the E-ELT/TMT and SKA and space infrastructures such as the GAIA satellite as well as emerging optical interferometers in the USA such as the Large Binocular Telescope Interferometer and the CHARA and MROI arrays. This working group will involve major players in optical interferometry as well as members from the community at large. This new working group will build on the scientific reports delivered by the previous working groups focused on circumstellar disks and planets and on the galactic centre and extragalactic science.

WP 14.5 European Interferometry Initiative meetings The work package will organise meetings of the scientific council of the European Interferometric initiative which joins representatives of Austria, Belgium, Czech Republic, France, Germany, Hungary, Italy, Israel, Netherlands, Poland, Portugal, Spain, Switzerland, United Kingdom, ESO and ESA. Face-to-face meetings will take place every two years. This activity is a continuation of a previous FP7 work package; its goal is to maintain a common vision of the field by established and new countries and of oversight of the other activities.

Deliverables

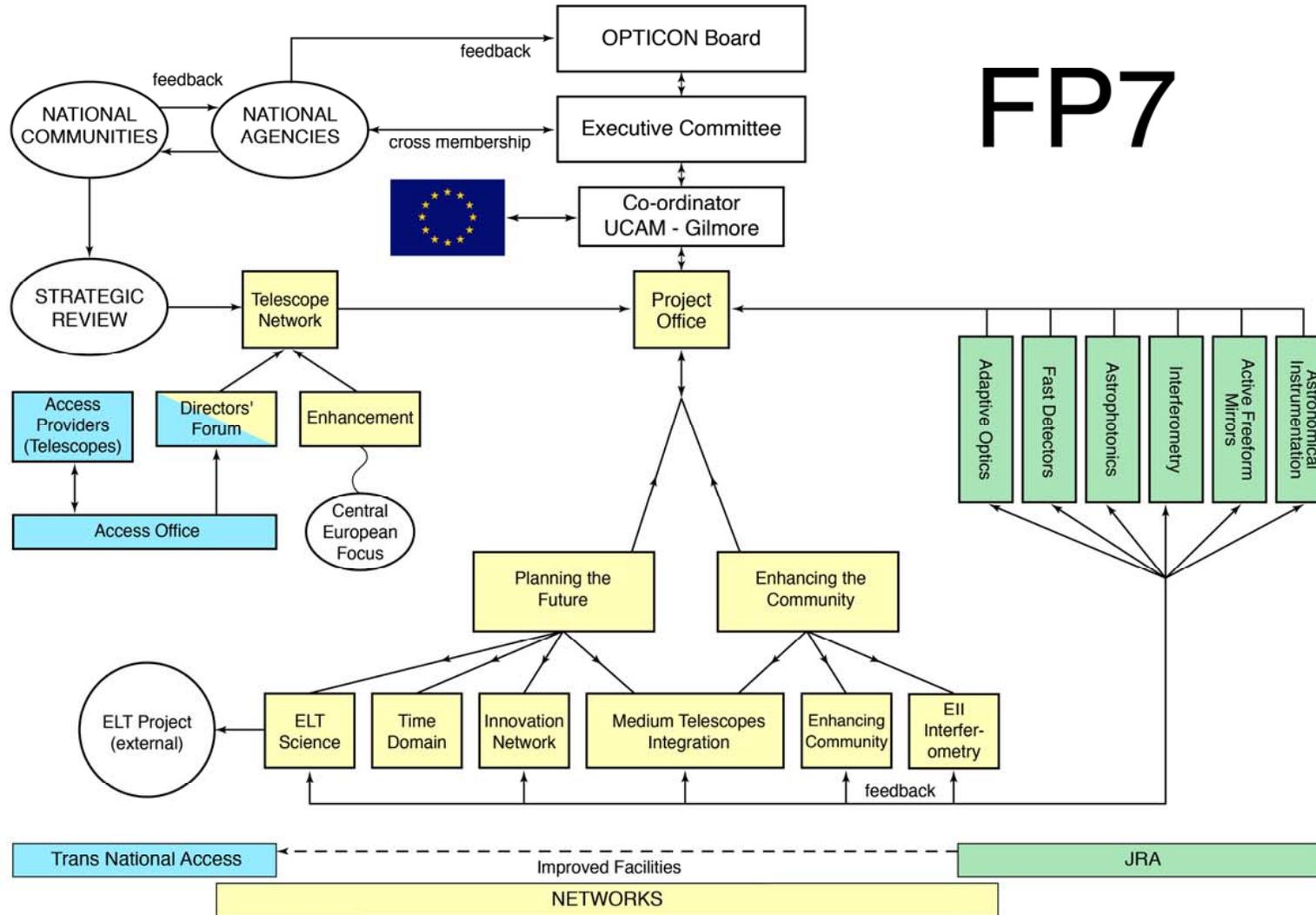
Del. No.	Deliverable name	WP no.	Del. Date (month)
14.1	Interferometry Web Site	14	6
14.4	Working Group “The future of Interferometry in Europe” report	14	48

Table 1.3e: Summary of Staff Effort

Participant no/short name	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10	WP11	WP12	WP13	WP14	Total person months
1/UCAM				13				48			24				85
2/CNRS	77	48		54	30	20							12 + (12)		229
3/INAF	36					25				60					121
4/MaxPlanck	6			14									(1)		20
5/STFC					16	10		48	23			12	(1)		109
6/ESO		(2)								(3)			(1)		0
7/CSIC															0
8/ONERA	43	4													47
9/ASTRON					15										15
10/IAC						15									15
11/AAO			24												24
12/NOTSA															0
13/NoAthens															0
14/LJMU											27				27
15/UPORTO	24			7										8	39
16/POLIMI						15									15
17/UDUR	31		18										(2)		49
18/NUIG										12					12
19/AIP			24												24
20/UNIWARSAW											3				3
21/UL-NOVA	7				8										15
22/e2v		20													20
23/HWU			12												12
24/UBAH			8												8
25/ALPAO	33														33

Months listed in brackets () indicate effort spent but not charged to the project

iv) Pert-like diagram: Opticon is not a single project, so we illustrate the global structure and connections here



1.3. v) Significant risks and associated contingency plans

Once the final budget is known, and the work plan has been negotiated an early activity of the management team will be to work with the WP leaders of all funded activities to produce a detailed risk register. This register appears as an activity for WP8 and will be the responsibility of our systems engineer. The resulting risk register will be assessed by the first management board meeting 'the project Kick-off meeting' and appropriate contingency measures will be identified. Detailed preparation of this register with respect to the JRAs cannot be done until the contract details are finalised as some workpackages may have to be re-scoped if the budget falls short of expectation.

The risks in the TNA programme are low. Each call allows the operator agencies to vary the amount of time they wish to offer in the light of national circumstances at the time and the telescope suite is robust to temporary loss of one or more facilities provided it does not drop below critical mass. The proposal and allocation software has a wide user and support base and will be hosted at a national laboratory with professional IT support. Apart from its international nature, the TAC process itself is conventional and is robust against the loss of any individual, indeed gradual rotation of the panel is planned. If the number of high quality proposals drops below that which fills the allocation (this is considered *extremely* unlikely) unused resource can be carried forward to future rounds. If this were to occur twice a review of the TNA programme would immediately be held and the activity possibly de-scoped or stopped.

Networking activities are low risk. By their nature they involve many individuals and while some are identified as workpackage leaders, in practice there will be considerable redundancy. Monitoring of progress by the project office against milestones will identify any problems early in time for corrective action by the Opticon board.

The management team is distributed between two respected national institutions each with their own procedural safeguards ranging from professional finance and legal teams to IT support ensuring regular data backups. The close relationship between the four key members of this team, two at each site, ensures that group memory is distributed and mitigates against the loss of one individual.

Significant risks are typically associated with the Opticon Joint Research Activities (JRAs). This is mainly due to the cutting edge nature of these research activities. Although many unknowns will occur, some problems or opportunities can be anticipated and their effects managed to the advantage of the project. The Opticon programme will make use of a systematic risk management process. The objective of the risk management process is to improve the probability of project success by anticipating possible problems, identifying opportunities and by taking cost effective actions to improve the current situation, margins and working efficiency.

The key activities in the risk management process are:

- a. Risk management planning.
- b. Risk and opportunity identification.
- c. Qualitative assessment and quantitative scoring of the identified risks and opportunities.
- d. Risk response planning and identification of cost effective Risk Reduction Actions (RRAs).
- e. Risk monitoring and control.

A risk register will be created and maintained for the duration of the programme. All WP leaders will be responsible for managing the risks of their work package. A crucial element is the appointment of "risk owners" whose responsibility it to ensure that:

- a. The qualitative (and if appropriate quantitative) risk analysis is performed on the risk.
- b. Mitigation actions are identified and carried out.
- c. Triggers that may exacerbate the risk marking or indicate the termination of the risk are monitored.
- d. the Project Support Office is notified of all outputs from these activities so the register is maintained

A scoring system shall be used to assess the impact and probability of each risk identified. In conjunction with the risk register each WP shall also create an issue list. Realised risks shall be transferred to the issue list and it shall be the responsibility of each WP manager to make sure that these issues are addressed and resolved where possible.

The “impact” score assess the effect a particular risk might have on the project in terms of schedule, cost and performance. The proposed risk impact table definition is given in Table 1.

Table 1 Risk Impact table

Impact	Qualitative Description	Quantitative Implications for Project			
		Cost	Time		Performance
			Work Package Slip	Critical Path Slip	
1 (Low)	Insignificant or Minor	<€50k	Up to 6 weeks	Nil	Minor change to functionality requiring remedial action.
2 (Medium)	Moderate	€50k to €150k	6 to 12 weeks	>1 month	Minor loss of performance (change to Specification) or functionality.
3 (High)	Major problem	€150k to €500k	12 to 24 weeks	> 2 months	Major loss of performance (change to specification) or functionality.
5 (Severe)	Catastrophic problem	>€500k	>24 weeks	> 4 months	Unacceptable loss of performance or functionality

Note: There is no ‘4’ marking to ensure that ‘severe’ impacts are properly captured
The risk probability definition in Table 2 will be used to score the probability that a risk will occur.

Table 2: Risk Probability Definitions

Level	Qualitative Description	Definition	Equivalent probability
1	Rare	Occur in exceptional circumstances	10% (1 in 10)
2	Possible	Might occur	20% (1 in 5)
3	Likely	Quite likely to occur	50% (1 in 2)
4	Highly likely	Will almost certainly occur	75% (3 out of 4)

Finally the risk expose will be calculated which is the product of the risk impact and probability of occurrence. The thresholds for risk exposure are:

- a. <3 Low
- b. 5-8 Medium
- c. >8 High

2. Implementation

2.1 Management structure and procedures

The Opticon management structure is based on standard methodology and involves an experienced administration team which has proven robust, effective and efficient over the whole duration of the Opticon activities through FP6 and currently in FP7. It has been consistently highly rated in Mid-Term Reviews and consistently delivers all the necessary reporting and financial management requirements to the EC. The structure has proven robust enough to identify, review and change the resource allocation for an activity which was not meeting internal review standards and to terminate a network activity when it was clear that it could not achieve its objective due to circumstances beyond its control (in FP6). It has managed to retain support inside the Opticon partnership during the robust selection process when very many excellent ideas had to be reduced to a viable balanced sub-set for this proposal. It has shown sufficient strength that two new industrial partners, the detector specialist e2v, and the startup SME Alpao have been enthusiastic to join the consortium for this proposal. Equally importantly, it meets the requirements of the Opticon partners and is that management system which they wish to implement.

The top level of the management system is the Opticon Board, with a representative from each partner, and a Chair, elected from the partners and independent of the management team. Representatives of all the astronomy-related EC-funded activities are invited. All Opticon WP leads are expected to attend. The Board meets approximately annually. This meeting receives progress reports on all activities – partly to ensure progress is being maintained at the expected rate and partly to ensure optimal communications across all activities. The Board receives the Opticon reports to the EC, the budget progress and a detailed analysis by the project scientist on the state of the activities. Any significant modifications in Opticon activity to be proposed as contract amendments for EC approval must be agreed and authorised by the Board. The Board approves all WP leads. The Board is also responsible for initiating regular reviews of the performance of the management team.

More urgent business and detailed financial monitoring, is delegated to an Executive Committee. This Executive is made up of representatives of all the key national funding agencies, whose roles as members is arguably the greatest strength of the Opticon management. The agencies involved include all the largest agencies which fund optical-infrared astronomy in Europe: CNRS (France), CSIC (Spain), INAF (Italy), NOVA (Netherlands), Max Planck (Germany), STFC (UK), and ESO (International). The individuals who attend the Opticon Executive are the senior directors of research funding and strategy for those national funding agencies. Thus the Opticon Executive is not only made up of very senior and experienced research managers, it is inevitably fully informed of national complementary funding capabilities and relevant strategic development opportunities and constraints. The Executive monitors work package progress, reporting and decides on any modifications required. It also monitors the Consortium Agreement, IPR issues and outreach. The Executive meets as required, at minimum twice per year.

A special feature of such a senior membership of the Executive is that the Executive also functions as an Opticon Advisory Committee. In practise the Executive members consult senior advisory groups within their agencies on an *ad hoc* basis as appropriate, and report the corresponding advice to the Executive. There is considerable overlap of the Executive membership with other European and Global level astronomy projects, including ESO, ASTRONET, and the Boards of the national 2-4m observatories which are involved in the TNA activities. This further ensures maximal knowledge of and responsiveness to all the political and financial factors which are involved in major infrastructural developments. We have carefully considered the issue of external reviews. Given the overheads of recruiting a suitably qualified external advisory panel who would have the same depth of experience as this executive, and the likelihood of a comprehensive commission mid-term contract review, we see no added value in conducting parallel external reviews of the programme. We do however plan a full external review of the performance of the CTAC system, after year two. Since this is so new, we feel such a review could be of benefit.

Coordination, coherence and integration of these complementary activities occur at every level of Opticon. The several technical JRA activities have many cross members and many coordinated activities. The JRA work is of considerable potential importance to current and future telescopes (4-m, 8-m, E-ELT) and instruments, so national and international (ESO) facility planning involves the same team leaders as do Opticon activities. At the management level, the Opticon Executive consists of the same people and organisations that lead national strategic development and investment programmes and fund the infrastructures. Comprehensive and timely information flow is thus assured. As examples, the Chair of the ESO E-ELT Science team coordinates the Network on community involvement in the E-ELT, several leading participants in JRA developments are leading participants in planned or proposed next generation instruments, the coordinator of the training schools is in attendance at Telescope Directors' Forum meetings considering lessons learned from observing proposal cycles, the Time Domain Astronomy coordinator leads the work package inside the Gaia consortium delivering time-domain discoveries, and the European Interferometry planning group is represented on the Executive of the European Interferometry Initiative.

Day-to-day responsibility for activity management is delegated to WP leaders. Every leader is both highly motivated and of proven competence. They are chosen for their personal interest in the relevant activity, as well as for competence, on the nomination of relevant national (and ESO) agencies. The TNA activities are coordinated by the dedicated Project Office, discussed below. The networks are built round dedicated teams, used to collaboration, and mostly manage with informal internal management, supplemented by regular (typically quarterly) progress reporting to the Project Scientist and Coordinator. The exception is the European Interferometry Initiative, which involves many people and institutions, and organises itself formally with its own Board and Executive. The JRAs involve large distributed teams and so each requires a formal internal management structure. Each activity has its project manager, responsible to the Opticon Executive. The JRAs each have one full team annual meeting (which the project scientist normally attends), to ensure good communications, technical review and budget progress monitoring. The several sub-WPs provide formal internal reporting (and project deliverables) at relevant deadlines, with in each case the external projects to which the specific work is contributing being the immediate technical performance assessment system. This provides the design and study reviews in the most objective and expert way practical.

Specific sub-WP progress meetings are held as appropriate for each activity – in practise this ranges from several times per year to once per year. Day-to-day communications are managed through telecons and email. This process minimises duplication of reporting, micro-management, and ensures clarity of decision making, and responsibility. It has proven to work extremely well over the past several years.

The management team is small but dedicated and experienced. At its heart is the Project Scientist, who has a double role. He leads the implementation of the Access programme, manages the Calls for Access, the Allocation Review process, the implementation and funding of successful applications, the feedback to unsuccessful applicants, the complementary feedback to the Training Networks, to learn from and respond to lessons learned, and the interface to the Telescope Directors' Forum. His second role is to attend regularly the JRA and network team meetings. Through these attendances information transfer between activities is assisted and an objective assessment of the actual state of progress in each WP is made available to the management team. The second key aspect of the management is the Coordinator's PA. She manages the reporting and communications between the EC and the Consortium, especially the Periodic Reports, and organises Board and Executive meetings. Both the Project scientist and the Coordinator's PA have been in post for several years, and have considerable proven experience. Importantly, they have built robust personal relationships with the very many administrative and technical management groups involved in Opticon. This structure leaves the Coordinator to focus on strategy, top-level communications with agencies and financial monitoring. In this last he is supported by the UCAM Finance Team.

The formal remit of the central management team will continue as at present, with the following (continuing) remit:

The project office will undertake the following tasks:

- Provide secretariat support for the Opticon Board and the Opticon Executive Committee – prepare and/or commission papers, reports, etc; organise meetings; take minutes, etc.
- Commission from the various elements of the Opticon programme the reports, forward projections and other documentation required for EU reporting.
- Receive financial and progress reports from the various elements of the Opticon programme.
- Assemble and collate the commissioned reports and provide any covering or overview documentation for EU reporting and submit to the Opticon Co-ordinator for approval and submission to the EU.
- Ensure that plans, schedules and forward projections for the various elements of the Opticon programme are reviewed annually.
- Create and maintain the central Opticon Web page and presence.
- Promote the activities of Opticon in international forums.
- Receive reports for the Executive Committee from the Access programme, including the financial reports and reconciliation of expenditure against advances.
- Receive annually proposals and cost estimates outlining the planned programme of networking activities.
- Prepare the Coordinator papers for the Executive Committee for decisions on which programmes and activities will be supported.
- Receive progress reports, financial reports and forward projections of activity and financial requirements from the Network Chairpersons.
- Receive details (schedules and documentation) of Project Management Committees from the Principal Investigators of each Work Package.
- Attend Work Package meetings as appropriate.

In summary, the Opticon management structure applies proven best-practise, has been successfully in operation for several years, is regularly reviewed by national agency representatives, minimises duplication of effort and maximises efficiency and robust review of performance. The key feature is that the proven management structure is matched, by experience, to the complexity and scale of the project.

2.2 Individual participants

Partner 1: UCAM: Cambridge University, UK

Cambridge University is a large teaching and research University with a high international reputation. Cambridge has a significant involvement in scientific research leadership, and in technological developments. Managerially, a central Research Support Division provides legal, financial management and transfer services, and management support as needed to support proposals and projects. This specific activity is based in the Institute of Astronomy (IoA), a large research and teaching institute with a very high international reputation, and its own management support team. The relevant staff include the project Coordinator, Prof Gerry Gilmore, Professor of Experimental Philosophy and Opticon Coordinator through FP5 and FP6, and Suzanne Holland, Opticon PA. Both have experience in coordinating and managing Opticon, and delivering EC reports and audited accounts as required. The technical involvement in Interferometric image reconstruction involves the very strong research group in the Cavendish physics department. This group has been in place since the first applications of interferometry in astronomy (under Sir Martin Ryle) and leads Europe's participation in the Magdalena Ridge interferometer.

Partner 2: CNRS: Centre National de la Recherche Scientifique, France

Since CNRS hosts many groups with leading roles in 5 JRA activities, we provide a full description here. CNRS is the French national research organisation, funded by the Ministry of Research. Among its many constituent laboratories, several play leading roles in Opticon. These include Marseille, Lyon, Nice, Grenoble and Paris. CNRS is also operating in collaboration with its academic partners the 2-metre class Bernard Lyot and Haute-Provence telescopes, and is a partner in the CFHT, which participate in the TNA Access programme.

CRAL (Centre de Recherche Astrophysique de Lyon) is a joint laboratory of CNRS, University of Lyon 1 (Université Claude Bernard Lyon 1) and École Normale Supérieure de Lyon. CRAL has a well-known track record in instrumentation for major observatories, particularly in the field of 3D spectroscopy. CRAL has also strong expertise in high resolution imaging techniques, adaptive optics, laser guide stars, MCAO, image deconvolution, etc. The group involved in Opticon belongs to the AiRi team (Astrophysique et Imagerie aux Résolutions de l'Interférométrie), focused on high angular resolution astronomy, from instrumental developments, control and signal processing, to the astrophysics of the observed objects. The AiRi team has always been involved into interferometric projects, working on interferometers (mono-pupil like SPID, multi-pupils like G2T, AMBER and now CHARA/VEGA), on photon-counting detectors (required at visible wavelengths) and on analysis and processing of the interferometric signal and data. Its expertise in interferometric data processing has led to major achievements in model fitting and image reconstruction.

Key staff members at CRAL include E. Thiébaud who will coordinate WP4 and M. Tallon who will actively contribute to WP1 activities.

IPAG (Institut de Planétologie et d'Astrophysique de Grenoble) is a joint research unit of CNRS and Université J. Fourier. IPAG was created in 2010 from the merging of two distinct research laboratories, LAOG (Laboratoire d'Astrophysique de Grenoble) and LPG (Laboratoire de Planétologie de Grenoble), with research themes spanning from planetary subsurfaces to the edge of the universe. IPAG has also developed over the past 15 years a strong expertise in the fields of high angular resolution and high contrast imaging, using both adaptive optics coupled with coronagraphy and stellar interferometry. IPAG has significantly contributed to several instruments for ESO. Research and development activities have been led by IPAG in parallel to instrument deployment, mainly related to integrated optics for interferometry, mini/micro deformable mirrors for adaptive optics and fast low-noise detectors for wave front sensing, the latter two being substantially supported by EC, through Opticon JRA1/JRA2, during FP6 and FP7. IPAG is currently the leading institute of the consortium in charge of the development of the SPHERE second-generation instrument for the ESO VLT, to be delivered by mid-2012, and was also the Co-PI for the phase A study of the future EPICS instrument for the E-ELT.

Key IPAG staff include: Dr. Jean-Luc Beuzit will coordinate the WP1 activities (adaptive optics concepts and technology). He has been involved in the development and deployment of several adaptive optics

systems for astronomy and is currently the Principal Investigator of the SPHERE project. Dr. Philippe Feautrier will be the manager of the WP2 (detector development). He has coordinated these efforts since the very beginning of the Opticon activities related to the development of fast and very low noise detectors for astronomy.

LAM (Laboratoire d'Astrophysique de Marseille) is one of the most important public research institutes in Europe in the area of astrophysics. It associates fundamental research in astrophysics with technological research in instrumentation. LAM has internationally recognized expertise in Active Optics, Adaptive Optics, Micro Optics, Detectors and has a significant involvement on the ESO E-ELT project, as PI of two E-ELT instruments phase A studies (EAGLE and OPTIMOS-DIORAMA).

Key members of staff for WP1, WP2, WP5 and WP6 are: E. Hugot, Researcher in optics and instrumentation for future large ground based and space borne observatories, Active Optics specialist; S. Vives, Research engineer in optical design, PM of ESA second STARTIGER initiative, ASPIICS system engineer; F. Zamkotsian, Researcher and head of the optics and instrumentation R&D group; J.L. Gach, Research engineer and detectors and controllers specialist; B. Leroux, Lecturer, responsible of the adaptive optics activities; M. Ferrari, Astronomer, LAM deputy director, in charge of the R&D department; J.G. Cuby, Astronomer, LAM Director, PI of an ESO E-ELT Instrument (EAGLE) Phase A Study.

LESIA (Laboratoire d'Etudes Spatiales et d'Instrumentation en Astrophysique) develops scientific instruments both for ground-based telescopes and for space missions. The laboratory has 146 permanent staff members including 70 engineers and technicians. LESIA has a long experience in adaptive optics (AO) system developments and on-sky tests: COME ON in 1990, ESO 3.6-m ADONIS, CFHT 4-m PUEO and VLT 8-m NAOS in 2001. LESIA has also studied large field AO concepts like the multi object AO, built the Sesame AO bench for laboratory R&D, developed AO-aided Retina imaging techniques for human eye and is more recently contributing to the development of the AO system of the SPHERE instrument for the VLT. The LESIA is also involved in the study of stellar coronagraphy for exo-planet detection since 2000.

Lagrange laboratory is a new merging (effective on 1st January 2012) between CNRS Cassiopée and Fizeau laboratories at the Observatoire de la Côte d'Azur, which have been involved in optical interferometry for more than 35 years. After pioneering developments, Fizeau developed the AMBER instrument on VLTI, and is now responsible for the MATISSE second-generation instrument for the VLTI. Fizeau has also developed the VEGA visible instrument on the CHARA Array (PI D. Mourard). Many prospective studies are developed in the field of optical interferometry and science cases, through important skills in conceptual designs, physical modelling of astrophysical sources, and through collaborations on advanced tools for interferometric image reconstruction: locally with a Signal Processing team, nationally (JMMC, collaboration through French ANR) and on the European level (collaboration Opticon). The new Lagrange laboratory will have about 124 permanent staff members, including 40 engineers and technicians.

Partner 3: Istituto Nazionale di Astrofisica, Italy

INAF is the National Institute for research in astronomy in Italy. It runs 19 research institutes in the country. It coordinates and directly finances the astronomical research for the whole non-university based community, therefore more than 90% of the researchers in the field belong to INAF; the large majority of University professors are associated to INAF. It has more than 1000 permanent staff, of which about 600 are researchers. Presently, about 300 postdoctoral, graduate students, fellows and consultants are involved in INAF research activities.

All national astronomical ground-based facilities are built, maintained and run by INAF; among these it is worth mentioning the 4-meter Galileo Telescope in the Canary Islands, which is part of the TNA Access programme, the twin 8-meter LBT Telescope in Arizona (25% share), the two 32-meter VLBI antennas in Sicily and Bologna, the 60-meter antenna being presently built in Sardinia (SRT). Several INAF institutes are activity leaders in Opticon. Among these, Brera and Padova Observatories are involved in Opticon FP7 (2009-2012). In the field of ground-based instrumentation development relevant to this proposal, Brera took part in the realisation of the 3 VLT instruments, several instruments of the TNG telescope and others for telescopes of smaller size. Expertise developed in this field covers the field of Optics, mechanics, finite element analysis, system engineering and project management. Brera has specialised in the area of new materials and processes in optics for Astronomical Instrumentation.

Among those are ion beam figuring for the final shaping of complex optical surfaces and the introduction of polymers with non-linear optical properties in the design and development of instrumentation.

Brera was the leading institute of JRA6 of Opticon FP6. The PI of this JRA is Filippo Maria Zerbi. He was PI of the REM project (2000-2005), Italian National Project Manager of the X-shooter@VLT spectrograph (2002-date) and Coordinator of the JRA6 in Opticon FP6 (2004-2008). In Opticon FP7, Brera coordinates WP6 instrumentation.

Padova Observatory has a history in the development of ground-based telescopes and instrumentation, mainly due to a leading role in the Telescopio Nazionale Galileo (TNG) project. The Galileo experience started the growth of technological skill in most of the Italian Astronomical Institutes, but leaving strong footprints in Padova in the field of System Engineering, Optics, Opto-mechanics and detector technologies. Padova Observatory headquarters are equipped with recently refurbished laboratories for Optics and Opto-electronics with clean rooms and cryo-thermal facilities. Padova is a leader in Italy for the research and development in the area of Infrared Detectors controllers. The Observatory is also very active in the area of innovative processes for optics fabrication. A key team member is Favio Bortoletto, PI of the atmospheric tip-tilt real-time corrector of the ESO-MPIA 2.2M at La Silla Observatory (1986-1988), responsible for the hardware and software development for the Observing Ground Segment (OGS) of the IR camera (ISOCAM) mounted in the ISO satellite (1988-1990), appointed director of TNG (1998-2000). Padova took part in JRA5 of the Opticon FP6 project (2004-2008) and in WP6 of Opticon FP7.

The Observatory of Rome (Osservatorio Astronomico di Roma, OAR) is one of the astronomical observatories and institutes of INAF and is characterised by a broad interest in a variety of fields of astronomical research and instrumentation. 41 research staff work at the OAR together with 29 (plus 7 temporary positions) administrative and technical staff. A total of 20 PhD students and 11 Post-Docs are currently involved in the research activity.

Dr. Isobel Hook has led the Opticon E-ELT science network in both FP6 and the current FP7 programme. In the proposed programme, she will lead the ELT science component of WP10 "E-ELT Science and Tools". She has been closely involved in the E-ELT project since 2003. She was Deputy Project Scientist and later Project Scientist for the EU FP6 "ELT Design Study" programme (2003-2008) and WP manager for the Design Reference Mission WP within the FP7 "ELT Preparatory Phase" programme 2008-2009 (both programmes led by ESO). She also currently chairs the Science Working Group for the E-ELT project.

Partner 4: Max Planck Gesellschaft, Germany

MPG participation in Opticon is managed through the MPIA. MPIA is the Max-Planck Institute for Astronomy in Heidelberg which is an astronomical research institute with more than 260 staff. MPIA runs a vast instrumentation programme for ground based observatories such as the Very Large Telescope (VLT) and the Large Binocular Telescope (LBT). Present activities include Prima, Sphere, Gravity, and Matisse for the VLT, and Luci and the Linc-Nirvana interferometer for the LBT.

MPIA is a member of consortia building the E-ELT instruments METIS and MICADO. Together with the IAA in Granada, MPIA is a partner in the operation of the Calar Alto observatory. Apart from instrumentation developed for ground based observatories, MPIA participates in international consortia that provide instruments for Herschel, JWST, and other space missions. MPIA is responsible for the operation of the 2.2m telescope on LaSilla which partakes in the Access programme. Roland Gredel from MPIA is participating in WP8 as a member of the Executive and is Chairman of the Board.

Partner 5: Science and Technology Facilities Council, UK

STFC is the UK national funding agency for astronomy, particle and nuclear physics. Its involvement in Opticon includes several telescopes in the Trans-National Access programme, and technical leadership roles in several WPs, including hosting the Opticon Project Scientist. These activities are all managed through the UKATC.

The UK Astronomy Technology Centre (UKATC) is the UK's National centre for the design and production of world leading astronomical telescopes, instruments and systems. It has delivered hardware to both space missions (e.g. Herschel and JWST) and the telescopes of the European Southern Observatory (Chile), the Isaac Newton Group of Telescopes (La Palma), Gemini (Chile/Hawaii)

and the UK Infrared Telescope (Hawaii), the James Clerk Maxwell Telescope (Hawaii) and the ALMA telescopes (Chile). To meet the needs of these customers the UKATC employs staff with specialist expertise including: systems engineering and project management; infrared/sub-mm optical design; cryogenics and low-temperature engineering; mechanism design and analysis; stiff structures with low vibration. Key members of staff for Opticon are:

Dr John Davies is the Opticon FP7 Project Scientist, a role which he has successfully carried out in previous FP contracts. He has considerable operational and scheduling experience of the UKIRT 4m telescope and has used most of the telescopes in the TNA programme. He has driven the formation and execution of the Opticon Common Time Allocation process which has been implemented during the existing contract. John Davies has a PhD in Astronomy and experience of the commercial aerospace sector as well as academia. **Prof C. Cunningham:** PI for WP9 Colin Cunningham (CEng, FIET) is an electronic and systems engineer with 35 years experience in the development of scientific instrumentation and interactions with industry. He has a major role with the UK E-ELT project. **Dr H. Schnetler:** Systems Engineer. Participant in WP5, Dr Schnetler has a PhD in Software Engineering, an MEng in Systems Engineering and a BEng in Electronics Engineering. She has worked for several high-tech engineering companies including aerospace and is currently the Head of Systems Engineering at the UK ATC. **Dr C. Evans:** has a PhD in Astronomy (2001) and is the instrument scientist for the EAGLE study for a near-IR, multi-object spectrograph for the E-ELT, and for new studies for multi-object spectrographs for the WHT in La Palma and for ESO's VLT. He is the PI of an ESO Large Programme with VLT-FLAMES. He will play a key role in WP9, the Innovation Network.

Partner 6: European Southern Observatory, Germany

ESO is the intergovernmental European Organisation for Astronomical Research in the Southern Hemisphere. On behalf of its fourteen member states, ESO operates a suite of the world's most advanced ground-based astronomical telescopes located at the La Silla Paranal Observatory in the Atacama desert in Chile. The ESO Headquarters are situated in Garching near Munich, Germany. ESO's 14 member states are: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Italy, the Netherlands, Portugal, Spain, Sweden, Switzerland and the United Kingdom. Brazil membership is under negotiation.

ESO is the largest observatory in Europe and is coordinating the construction of large infrastructures and instruments like the Very Large Telescope (VLT), the VLT interferometer, ALMA and is designing and planning construction of the future 42m European Extremely Large Telescope.

Representatives from the ESO Adaptive Optics and Detector Departments will actively participate in the scientific committees of JRA1 and 2 and will provide advice in technical areas directly related to the ESO existing and future facilities. ESO will also be part of the Opticon Board.

Partner 7: Consejo Superior de Investigaciones Cientificas, Spain

The Spanish National Research Council (CSIC) is the largest public institution dedicated to research in Spain and the third largest in Europe. Belonging to the Spanish Ministry of Science and Innovation through the Secretary of State for Research, its main objective is to develop and promote research that will help bring about scientific and technological progress, and it is prepared to collaborate with Spanish and foreign entities in order to achieve this aim. According to its Statute (article 4), its mission is to foster, coordinate, develop and promote scientific and technological research, of a multidisciplinary nature, in order to contribute to advancing knowledge and economic, social and cultural development, as well as to train staff and advise public and private entities on this matter. CSIC plays an important role in scientific and technological policy, since it encompasses an area that takes in everything from basic research to the transfer of knowledge to the productive sector. Its research is driven by its centres and institutes, which are spread across all the autonomous regions, and its more than 12,000 staff, of whom more than 3,000 are staff researchers and the same number again are doctors and scientists who are still training. CSIC has 6% of all the staff dedicated to Research and Development in Spain, and they generate approximately 20% of all scientific production in the country. It manages a range of important facilities the most complete and extensive network of specialist libraries, and also has joint research units.

Partner 8: Office National d'Etudes et de Recherches Aérospatiales, France

ONERA (Office National d'Etudes et Recherches Aérospatiales) is the French national aerospace research laboratory. It is a public research establishment, with eight major facilities in France and about 2,000 employees, including 1,500 scientists, engineers and technicians. ONERA is both an active participant in research and coordination. ONERA develops scientific knowledge in its own laboratories and as a project leader, it uses this knowledge, combined with that of other French and European research teams, to lead multi-disciplinary research projects that are application focused. The ONERA Optics department gather more the 120 scientists who work on new and innovative optical concepts and systems over a wide wavelength range (from UV to far IR) for aeronautic, space and defence applications. In that context, it has developed, for more than thirty years, a unique expertise in high angular resolution and more specifically in the active and adaptive optics domain. Hence, after being in charge of COME-ONE, the very first astronomical AO system ever implemented on a large telescope, ONERA has successfully design developed and integrated NAOS, the first AO system of the VLT, the 8-m class telescope of ESO, in 2001. ONERA is now in charge of the extreme AO system for SPHERE (the future VLT planet finder instrument). In the meantime ONERA is deeply involved in the study and management of three E-ELT concept studies namely ATLAS, MAORY and EAGLE. ONERA also participates in the large adaptive optic mirror (M4) phase B study, led by CILAS. All these developments have been realized in close collaborations with our privileged academic partners (Observatoire de Paris, Grenoble and Marseille) which are now gathered in the GIS-PHASE partnership. ONERA is already deeply involved in FP6 and FP7 Opticon-JRA1 activities at system (preliminary design activities) and sub-system (control, wavefront sensor and DM) levels. Key members of staffs for this new FP7-Opticon JRA are T. Fusco: project manager of SAXO, the Extreme AO system of SPHERE instrument, PI of ATLAS, the Laser tomographic AO system of the E-ELT, AO responsible of EAGLE, the 3D multi-object spectrograph of the E-ELT, J-M Conan: Co-PI of MAORY, the phase A study for the MultiConjugate AO system of the E-ELT, in charge of AO control aspects in FP6 and FP7, C. Petit: responsible of SAXO integration and tests and in charge of wide field AO experimental validations, L. Mugnier : in charge of innovative AO post processing development

Partner 9 : Stichting Astronomisch Onderzoek in Nederland, The Netherlands

ASTRON is the Netherlands Institute for Radio Astronomy, and is part of the Netherlands Organisation for Scientific Research (NWO). It provides front-line observing capabilities (e.g. WSRT and LOFAR) for Dutch and international astronomers across a broad range of frequencies and techniques. It has a strong technology development programme, encompassing both innovative instrumentation for existing telescopes and the new technologies needed for future facilities. ASTRON also conducts a vigorous programme of fundamental astronomical research. ASTRON provides overall coordination and management of RadioNet. Between 1995 and 2008, the optical instrumentation group was part of the ASTRON research and development department. From 2008 onwards, this group was taken over by NOVA (partner 21), but ASTRON provides the housing, support and infrastructure for the NOVA-ASTRON instrumentation group. This group developed in collaboration with other European partners instruments for the VLT and VLTI of ESO, the William Herschel Telescope of ING at La Palma and JWST.

Role in Opticon FP7 Phase 2: Dr. Lars B. Venema leads the Active Freeform Mirror JRA. He is senior researcher and system engineer in astronomical instrumentation. He has been involved in the definition and start up of the projects MIRI for JWST, X-Shooter for the VLT, SPHERE for VLT, and Matisse for the VLTI. He is also our system engineer for the Dutch contribution to E-ELT instruments like METIS and EPICS. Gabby Kroes is a mechanical lead engineer of the optical instrumentation group and is specialised in cryogenic precision mechanics.

Partner 10: Instituto de Astrofísica de Canarias, Spain

The Instituto de Astrofísica de Canarias (IAC) is an internationalised Spanish research centre. It is responsible for the operation of the Canary Islands' Observatories (Teide and Roque de los Muchachos Observatories), where more than 60 international research institutions from 19 countries have installed and operate their telescopes. The IAC main headquarters, located in La Laguna, is the normal workplace for the main part of its staff. A secondary HQ is located in La Palma at sea level. Scientific research in astrophysics, the operation of the Canary Island's observatories, development of advanced

instrumentation, training of young researchers/ technicians and public outreach, are the main objectives of this organisation.

This institution have been an active member of the Opticon Board from the very beginning of the coordination network, and participates in many of the Opticon activities. The IAC is also involved in the Access programme, as well as in the activities related to the study of new materials and processes for astronomical instrumentation (VPHGs).

Partner 11: Department of Innovation, Industry, Science and Research, Australia

The Australian Astronomical Observatory (AAO), a division of the Australian Government's Department of Innovation, Industry, Science and Research, operates the Anglo-Australian Telescope (AAT) and the UK Schmidt telescope (UKST) on behalf of the astronomical community of Australia. The Observatory is part of and funded by the Australian Government. Its function is to provide world-class observing facilities for Australian and international optical astronomers. The AAO has been managed by the current Director, Professor Matthew Colless, since 2004. Prof. Colless is an internationally recognised expert in observational cosmology and team leader for a number of large galaxy surveys that have made major contributions to measuring the constituents of the universe and the properties of galaxies. Other key staff are the AAO's General Manager, Mr Neville Legg, who will be responsible for the financial administration of the Opticon programme, and the AAO's Opticon liaison, Dr Gayandhi De Silva, who will manage the AAO's involvement in the Access programme for FP7 and also sits on the TDF sub-committee which validates the outcome of the Common Opticon time allocation process.

AAO staff pioneered the concept and early development of integrated photonics spectrographs, including the first prototype array waveguide spectrograph developed for astronomy, and are currently developing OH-suppression fibres for near-infrared spectroscopy. AAO partnered Durham University in two projects aimed at applying photonics to critical problems of astronomical instrumentation for current and future extremely large telescopes. AAO has extensive experience with the design, manufacture, integration, test, operation, and scientific exploitation of fibre optical instrumentation (e.g. 2dF, 6dF, OzPoz, FMOS-Echidna, AAOmega, SPIRAL, CYCLOPS, HERMES, GNOSIS, KOALA). Staff have particular experience in the investigation of the properties of infrared optical fibres and developing infrared fibre instrument concepts. Dr Jon Lawrence leads the AAO's astrophotonics research and fibre-optic instrumentation, including OH-suppression fibres and photonic spectrograph development.

Partner 12: Nordic Optical Telescope Scientific Association, Sweden

The Nordic Optical Telescope (NOT) Scientific Association (NOTSA) was founded in 1984 to construct and operate a Nordic telescope for observations at optical and infrared wavelengths. The current Associates of NOTSA are the relevant Nordic country national funding agencies:

- Forskningsrådet for Natur og Univers (Denmark)
- Suomen Akatemia (Finland)
- Háskóli Íslands (Iceland)
- Norges forskningsråd (Norway)
- Vetenskapsrådet (Sweden)

NOTSA represents these agencies in AstroNet (chairing the Board 2005-2010), ensuring the link to the overall AstroNet planning, and has participated in Opticon since FP5. The NOT telescope is a heavily oversubscribed participant in the current Opticon Access programme, and has developed an advanced set of training programmes as well.

Partner 13: National Observatory of Athens, Greece

NOA-IAA operates two Observatories; Helmos and Kryoneri Observatories where a 2.3m and a 1.2m telescope exist, respectively. NOA-IAA staff have experience in specific site characterisation measurements (DIMM). At Helmos Observatory there is the 2.3m "Aristarchos" telescope which is being developed, preparatory to being offered under the Opticon Trans-national Access programme. NOA-IAA are part of this proposal in order to provide site characterisation measurements as well as to gain important knowledge from more experienced Observatories. Staff: Panayotis Boumis, scientist, optics,

coordinator from NOA-IAA, Emmanuel Xilouris, scientist, optics, Athanassios Katsiyannis, scientist, site testing.

Partner 14: Liverpool John Moores University, UK

LJMU is a major university which operates the Liverpool Telescope, which is part of the Access programme.

The Liverpool Telescope is a fully robotic 2 metre aperture optical and near infra-red telescope. It is the largest fully robotic telescope in the world, and offers unique rapid-response capabilities for optical studies of transient sources or follow-up of sources detected at other wavelengths. The instrumentation offered consists of two optical CCD cameras (one optimized for high time-resolution studies), an infra-red camera, an optical single-shot polarimeter and an optical, fibre-fed double-beam spectrograph. The Institute on the basis of this expertise has a leading role in WP11, Time Domain Astronomy, as the Telescope is one of the leading facilities which are involved in that science.

Partner 15: Universidade do Porto, Portugal

The University of Porto is the largest Portuguese University. The School of Engineering (UPORTO) being its main school. The school has 24 R&D/interface units ranging from chemistry to precision mechanics and biomechanics.

Dr. P.J.V.Garcia is a tenured associate professor at UPORTO where he heads the Porto SIM Pole (Laboratory for systems, instrumentation and modelling for environment and space). SIM is a joint Porto University and Lisbon University research unit focused on instrumentation, essentially for the European Southern Observatory and European Space Agency. SIM has built the CAMCAO camera for the multi-conjugate adaptive optics system MAD, it leads the Portuguese Very Large Telescope Interferometer instrumentation programme including the participation in the consortium of GRAVITY and participates in the ESPRESSO radial velocity instrument consortium. The unit leads the Portuguese participation in the GAIA mission.

Dr. Garcia has coordinated and participated in several European projects as well as nationally funded projects totalling over 1M€ of directly managed funds. He served at the ESO scientific and technical committee closely following the implementation of the second generation monolithic instrumentation, is a board member of the European Interferometry Initiative.

Partner 16: Politecnico di Milano, Italy

The Politecnico di Milano was established in 1863 with the name of "Istituto Tecnico Superiore" under the leadership of Francesco Brioschi. Deliberately planned along the lines of the polytechnics in German speaking countries by a group of academics and professors, local administrations (The City of Milan, the Province of Milan, the Chamber of Commerce and the Cassa di Risparmio delle Provincie Lombarde), cultural associations and entrepreneurs from the most prominent Milan families, the university was first located in the Collegio Elvetico in today's Via Senato. It was opened on November, 29th, 1863 and started out with 36 students.

The Politecnico di Milano is now a science and technology university producing engineers, architects and industrial designers through a variety of innovative specialist courses, with great attention being devoted to all aspects of education. The Politecnico di Milano has always been based on quality and innovation in teaching and research, resulting in a prolific relationship with the economic and manufacturing worlds through experimental research and the transfer of technology. For many years POLIMI played a major and highly successful part in new materials modeling and creation under Prof Zerbi. This work will continue under Dr Chiara Bertarelli.

Partner 17: University of Durham, UK

Durham is one of the UK's leading universities, with specific expertise in astronomical instrumentation through its Centre for Astronomical Instrumentation, housed in a large modern facility. CfAI has a long heritage in design and construction of innovative facility-class instruments: it pioneered robot multifibre systems (with AAO); developed monolithic techniques for image-slicing integral field spectroscopy; produced the first integral field spectroscopic facility on an 8/10m telescope; and is very experienced with multiple fibre systems. Recent instrument projects include GMOS (Gemini), FMOS (Subaru), KMOS (ESO-VLT) and NIRSpec-IFU (JWST). It is also a major centre for Adaptive Optics

(real-time systems, on-sky demonstration and numerical modelling and laser beacons), and has recently adapted astronomical techniques to the life sciences. It has produced extensive publications on astronomical applications in photonics, is a partner with AAO on two Astrophotonics projects, and has extensive test and metrology facilities and a precision optics micro-optics facility. The group has also hosted the laboratory integration and test of experimental and facility AO systems (ELECTRA, NAOMI, RTD, and the Durham contributions to CANARY) and will re-use the laboratory facilities and expertise in WP 1.

Staff Profile: Jeremy Allington-Smith, PhD, FRAS, mIAU : Associate Director of CfAI and university Reader (leader of many integral field and multi-object spectroscopy projects). Coordinator of AstroPhotonica Europa. WP3 co-leader. Senior engineer and project manager. Graham Murray: Experienced fibre system scientist, constructor of first 8/10m-class IFU. Richard Myers: Associate Director of CfAI and university Reader, PI for the CANARY project.

Partner 18: National University of Ireland, Galway, Ireland

The National University of Ireland, Galway was established in 1845 and currently has over 15,000 students undertaking a range of taught programmes and research throughout its seven faculties and many Research Centres. The university currently manages over 70 EU projects and since 2000 NUI, Galway has won over €70m in research funding. The main task that is attributed to NUI, Galway is the principal investigator of the HTRA component of the ELT Science Network, Dr. Andrew Shearer.

Partner 19: Astrophysical Institute Potsdam, Germany

The Leibniz Institute for Astrophysics Potsdam (AIP) is registered under German Law as a non-profit governmental research organisation in Brandenburg, Germany. The key research topics are cosmic magnetic fields and extragalactic astrophysics, with a considerable part of the institute's efforts aim at the development of research technology in the fields of Astrophotonics, spectroscopy, robotic telescopes, and e-science.

The AIP is the successor of the Berlin Observatory founded in 1700 and of the Astrophysical Observatory of Potsdam founded in 1874. The latter was the world's first observatory to emphasize explicitly the research area of astrophysics. In this proposal AIP's main efforts are:

(i) Leading the Astrophotonics work package (WP3); (ii) Photonic Spectroscopic System design; (iii) Leading the development of Photonic OH-Suppression filters; (iv) Integrated Photonic Spectrograph development; (v) Leading the system prototype development; (vi) Engagement in outreach, innovation and dissemination activities. Expertise: AIP staff have extensive experience with Astrophotonics, Photonic OH-Suppression Filters development, Integrated Photonic Spectrograph development; System design, manufacture, integration, test, operation, and scientific use of fibre optical instrumentation (PMAS-LARR, PMAS-PPak, VIRUS-P, VIRUS-P2); Data reduction and analysis software for fibre-optical IFUs (PMAS, SPIRAL, INTEGRAL, VIMOS, FLAMES, VIRUS, IMACS); Coordination of EC-funded Euro3D Research Training Network (FP5) on the subject of integral field spectroscopy (IFS), involving fibre-coupled lens array IFUs Relevant Staff: Roger Haynes (Head of Astrophotonics at innoFSPEC Potsdam); Martin M. Roth (Founder of innoFSPEC Potsdam); Bernhard Roth (InnoFSPEC Centre manager and laser scientist); Jose Chavez-Boggio (photonic scientist in non-linear photonics); Harendra Fernando (photonic scientist in integrated photonics); Jean-Christophe Olaya (optical engineer and optical fibre transitions expertise); Emil Popow (manufacture, integration and test of astronomical instrumentation); Additional photonic scientist with background in fibre Bragg grating, design and manufacture.

Partner 20: Uniwersytet Warszawski

Warsaw University Astronomical Observatory (OAUW) is part of the largest university in Poland – University of Warsaw. The Observatory was founded in 1825 and it continuously carries out the scientific research and educational work. OAUW is a relatively small institute, with 12 astronomers with the positions corresponding to Associate Professor and higher, plus typically 2-3 astronomers with research position. The institute conducts the undergraduate and graduate studies in astronomy, with usually about 10 PhD students.

OAUW hosts headquarters to the two major Polish astronomical projects: Optical Gravitational Lensing Experiment (OGLE) and All Sky Automated Survey (ASAS). OGLE has been operating continuously since 1992 and is now in its fourth phase collecting time-domain photometric data for nearly a billion stars in the densest regions of the sky using a dedicated telescope in the Las Campanas Observatory, Chile. The scientific outcomes of the OGLE include detections of the first microlensing events and discoveries of planets with microlensing and transit methods. OGLE is supported by the European Research Council grant under the European Community's FP7 programme. ASAS is another long-term photometric monitoring survey, conducting all sky observations from two stations in Chile and Hawaii since 1997. The staff of the Warsaw Observatory is also involved in many other observational leading world projects, including Araucaria Project, the Planck and Gaia satellite missions, HESS and VIRGO collaborations.

The expertise in the time-domain astronomy gained over many years by the Warsaw astronomers makes the OAUW an ideal place to conduct the Opticon- tasks within the time-domain activities.

Key staff members: Łukasz Wyrzykowski (Gaia alerting system, studies of transient events), Andrzej Udalski (PI of the OGLE), Igor Soszyński (variable stars), Grzegorz Pojmański (PI of the ASAS), Szymon Kozłowski (data reductions, time-domain quasar studies).

Partner 21 : Universiteit Utrecht on behalf of Nederlandse Onderzoekschool Voor Astronomie (NOVA), Netherlands

NOVA is a federation of the astronomical institutes at the universities of Amsterdam, Groningen, Leiden, Nijmegen and Utrecht, currently legally represented by the Leiden University. NOVA is one of the six national top research schools. NOVA's status and funding are secured by the Dutch Minister of Education, Culture and Science through at least 2018. NOVA astronomers have experience in the chain from scientific idea, instrument concept, design and construction to successful science data collection and analysis for instruments at international facilities on the ground and in space. For The Netherlands, NOVA was the prime contract partner for ESO for scientific instrumentation projects for the VLT, the VLT Interferometer, ALMA, and for the E-ELT and for ESA on JWST-MIRI and Gaia-DPAC. The NOVA Optical Infrared Instrumentation Group hosted at ASTRON is the national expertise centre for optical-infrared astronomical instruments. Its expertise also includes working experience on systems aspects of astronomical instruments, opto-mechanical design, cryogenics and construction and testing of complex instruments. The group designed and constructed many scientific instruments such as VISIR, MIDI, X-Shooter, Matisse and MIRI, in cooperation with ASTRON, SRON, industry and international partners. UL-NOVA's task within WP5 comprises the development of active freeform mirrors to enable reduction of complexity of future instrumentation with applications in various disciplines. UL-NOVA's involvement in this project is led by Dr. Lars Venema. He is senior researcher and system engineer in astronomical instrumentation. He has been involved in the definition and start up of the projects MIRI for JWST, X-Shooter for the VLT, SPHERE for VLT and Matisse for the VLTI. He is also our system engineer for the Dutch contribution to E-ELT instrumentation like METIS and EPICS.

Partner 22: e2v, United Kingdom

e2v is a specialist high-tech company with over 1600 employees and FY2011 sales of approximately 250 million euro. At the Chelmsford, UK headquarters the company supplies high performance imaging solutions using CCD and CMOS technologies that are used by most observatories and space agencies worldwide. It specialises in custom sensors for applications such as wavefront sensing, astronomical imaging and has delivered sets of devices for prestigious programmes such as the Hubble Space Telescope, ESA's GAIA mission, the ESO VLT, and many others. **Paul Jorden** (technical specialist and ex astronomical instrument builder) will play a co-ordinating role together with experienced e2v project managers, design engineers and other technical staff.

Partner 23: Heriot Watt University, United Kingdom

Heriot Watt University (HWU) is a world leader in many areas of photonic science, including Ultrafast laser inscription (ULI) - one of the key technologies required for astrophotonics. Dr Robert Thomson is based in the Physics department at HWU and is an expert in the technology and applications of ULI – a revolutionary 3D photonic device fabrication technology. In 2009 he proposed (together with Jeremy Allington-Smith at the Centre for Advanced Instrumentation at the University of Durham) that the unique

capabilities of ULI would make it an enabling technology for astrophotonics. In June 2010, Thomson started a 5-year STFC Advanced fellowship aimed at investigating the astrophotonic applications of ULI. Recent highlights of the fellowship include a post-deadline paper at the 2010 Frontiers in Optics Conference in Rochester-NY, the first conference to feature a dedicated session to astrophotonics, and the first demonstration of an integrated photonic lantern [R. R. Thomson et al, "Ultrafast laser inscription of an integrated photonic lantern," *Opt. Express* 19, 5698 (2011)]. Thomson currently operates a dedicate ULI laboratory, and has access to a suite of photonic device characterisation equipment. These will be use extensively during the Astrophotonics project.

Partner 24: University of Bath, United Kingdom

The University of Bath is one of the UK's leading universities, with an international reputation for research and teaching at the highest academic standards. It has a distinctive approach that emphasises the education of professional practitioners and the promotion of original inquiry and innovation in partnership with business, the professions, public services and the voluntary sector. The University has 2707 staff, of whom 1542 are academic or academic-related. 60% of the work submitted for the 2008 Research Assessment Exercise was judged to be "world leading" or "internationally excellent". The value of our research portfolio is over €120 million and annual research income is in the region of €37 million. The University has strong international links and has been involved in many European Commission funded projects through the various Framework Programmes and the Marie Curie schemes.

The PI at the Centre for Photonics and Photonic Materials (CPPM) is Prof Tim Birks. He has 25 years' experience in optical fibre technology, including a pioneering role in the development of the photonic crystal fibre, and invented the "photonic lantern" upon which the proposed PSS is based. The CPPM has world-class facilities for the design, fabrication and characterisation of novel optical fibres.

Partner 25: Alpao, France

ALPAO is a spin-off company of the Universit Joseph Fourier (Grenoble) and Floralis. It is a fast growing company proposing adaptive optics solutions for astronomy, vision science, microscopy and low power LASER. Alpao commercializes off-the-shelf and custom deformable mirrors for those fields of application. Furthermore, ALPAO proposes an original open toolbox called Alpao Core Engine for reducing the time-to-market of adaptive solutions.

Thanks to a unique portfolio of patents and licenses, ALPAO keeps innovating and introducing new breakthrough technologies.

In 2006 and 2008 ALPAO was recognised by the French Ministry of Research for its innovative technology. Other partners include the Institut de Planétologie et d'Astronomie de Grenoble, OSEO (French agency for the innovation), ANR, Region Rhone-Alpes, Grenoble Alpes Incubation, the Reseau Entreprendre and UBIFrance.

2.3 Consortium as a whole

The Opticon consortium involves all the major national research infrastructure funding organisations which support optical-infrared astronomy infrastructures with telescopes larger than 2m aperture. It involves the national and multinational agencies which own and operate the infrastructures (observatories) which deliver the access, and allow the science. It involves the major technology research groups, in Institutes and Universities across Europe, which have proven capability to deliver successful R&D in advanced astronomical technology across Europe. It involves research groups in Universities and Institutes which provide specialist technical expertise, specifically relevant to new technologies not yet mainstream in astronomical applications. It involves industrial partners, in several countries, which can provide the specialist industrial-scale production facilities not available in research groups. Seven of the 25 partners are newly introduced to the partnership specifically for activities in this proposal, viz CSIC, AIP, UNIWARSAW, HWU, UBAH, e2v, and Alpao.

A key aspect of the Opticon consortium is inclusivity. It is this which makes Opticon a large community. This structure has been adopted after extensive review, with a goal to ensure that a coherent approach to the range of challenges facing next-generation astronomy technology can be delivered. Retaining involvement of apparently diverse communities is important, to allow synergies. An example is inclusion inside Opticon of the European Interferometry Initiative community (WP4, WP14). It may seem to a non-expert that interferometry is complementary to single-mirror telescope astronomy, but in practise both subjects are photon-starved, and need (and use) the same detector technology. Both subjects demand precision phase-stable opto-mechanical systems, in fringe-tracking and in adaptive optics. Thus it is maximally beneficial to integrate the communities for mutual advantage.

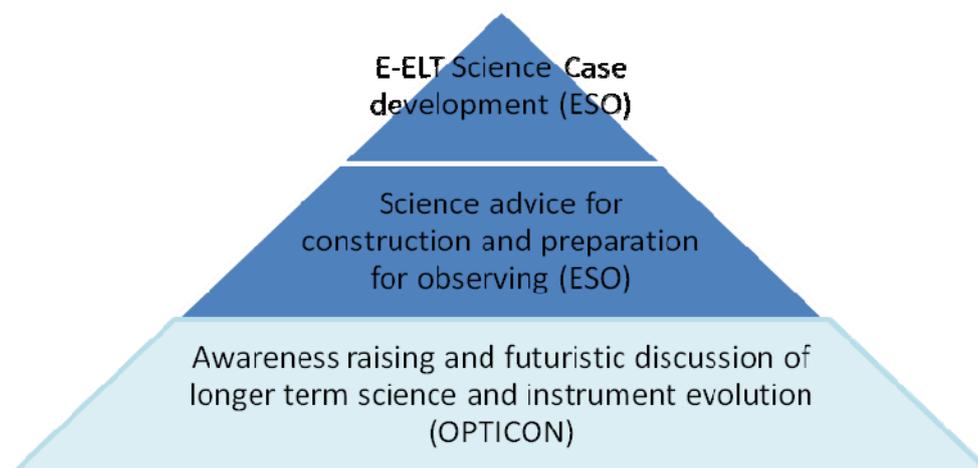
This situation evolves, and is monitored, to ensure the partnership is best-balanced at every time. For this proposal round, high spatial resolution ground based solar astrophysics has been judged to have reached critical mass, and to be clearly focussed on its own new major infrastructure, a new large solar telescope. Thus those activities, currently part of the present Opticon, and contributing to and benefitting from Opticon developments in high-resolution adaptive optics, are proposing to have their own I3 funding. The three agencies which lead the European Solar astronomy community are not part of the Opticon partnership for this proposal. Several networking activities, especially in software standards, have been completed, so the relevant groups (Milan, ESO) are no longer continuing. More significantly, ESO are now preparing to approve and implement construction of the European Extremely Large Telescope (E-ELT), the flagship future ambition for European astronomy. This is such a huge commitment ESO Council has been forced to limit all external commitments on its staff, to prevent possible timetable disruption. Thus ESO staff no longer lead Opticon work packages. Nonetheless, all relevant work continues in close collaboration with ESO, ESO staff continue to provide strategic direction, technical support, and to be available for technical reviews. ESO senior management continue to be represented on the Opticon Executive. Thus excellent communications, collaboration and consistency in developments is maintained.

In the construction phase of the E-ELT, ESO will be required to establish its own arrangements for obtaining scientific advice and guidance directly from the scientific communities of its Member States on all aspects related to the implementation of the project, including updates to the science case and assessment of evolving issues (such as assessing trade-offs between performance and technical or financial feasibility); and the direct issues regarding preparations for observing. This cannot be handled outside ESO. However, there will also be a need for activity relating to the development of a broader awareness of the scientific opportunities of the E-ELT and a more futuristic debate about the longer term development of the science and the instrumentation. During construction, ESO will not have the resources to pursue these debates, and Opticon activity in this area would be very beneficial.

The exact details of the ESO science advisory arrangements cannot be finalised until the ESO Council has approved the final construction proposal. ESO will work closely with the Opticon WP manager as

these arrangements develop to ensure that maximum benefit is delivered to the science community by ensuring complementarity and avoiding duplication and unnecessary overlap.

The interface between ESO and Opticon is summarised in the figure below, developed by ESO.



ESO-Opticon Science Interface during E-ELT Construction

A new agency partner for this proposal is the Spanish national funding agency CSIC. Their involvement follows the evolving ownership of Europe's observatories, under the plan – described elsewhere – to coordinate and optimise operation of Europe's 2-4m telescopes. Many of these telescopes are located in Spain, and are making the transition from non-Spanish national facilities to jointly owned and operated facilities in new partnerships. Thus CSIC has a growing role in their future and is naturally involved as a full partner in Opticon. In addition, in the spirit of helping integration into the international astronomical community of new national developments, we provide observer status (at their expense) in relevant telescope operation/ access/ science exploitation discussions to representatives of the Iranian National Observatory, which is building a 3.4m telescope and which is collaborating in operation of the UK/NL/Spain facilities on the Canary Islands.

Specialist technology partners, complementary to the experienced astronomy research organisations, provide uniquely valuable expertise when potential applications of new technologies are being considered. This is especially true of photonics, where the technology is mature, yet new to astronomy. Here three new partners (AIP, HWU, UBAH) have been identified which contribute expertise not otherwise available in the consortium. We anticipate very considerable mutual benefits from these new working partnerships. Industrial partnerships can have very special advantages in cutting edge R&D. In particular, there are, especially in detector manufacture and opto-electronics, industrial scale processes which are critical for technical developments, but which are simply unavailable on non-industrial scales. Here the continuing partnership of the high-tech industry ONERA is invaluable. A highlight is the new industrial partner, e2v, Europe's leading manufacturer of optical detectors. The involvement of e2v as a full partner follows a sub-contractor role in Opticon FP6. This developing involvement is a positive comment on the mutual advantages to both astronomy and industry arising from the Opticon R&D activity. The specialist SME Alpao is a very major participant in WP1, integrating this cutting edge R&D with its commercial innovation and application. A further mutual advantage, involving industrial spin-off, is described in Section 3.2.

Overall, and the real reason for the large number of partners in Opticon, is that RTD developments are pointless unless there is an optimised viable set of telescopes to benefit from the technologies. The programmes to push those facilities to their limits, and the number of facilities required, are determined by proposals to funding agencies which are based on the community's research ambitions. The community's research ideas are made robust and most wide-ranging by enabling and empowering the

whole community. It is delivery of that joined-up vision which defines the Opticon consortium, and which is enabled by that consortium.

2.3.i) Subcontracts

The Opticon consortium has been structured to make available all key capabilities through partners. Nonetheless, some highly specialised equipment must be provided through external subcontracting. The work foresees only two external subcontracts. One, to be managed by ONERA, is for development of specialist algorithms in real-time control, with value 16Keuro. Prospective suppliers with suitable capability have been identified. The second, to be managed by ALPAO, with value 100Keuro, for the study of an optimised control method to limit the effects of mechanical resonances in large deformable membranes. Discussions with potential suppliers are underway, to ascertain possible suppliers and their competence level.

2.3.ii) Other Countries

There is no funding requested for countries outside the list of those approved for participation in EU funded activities.

2.3.iii) Additional Partners

The Opticon partnership has been developed to include all necessary capabilities to complete the project, and to gain full value from its activities. No additional partners are anticipated.

2.4 Resources to be committed

The Opticon partners are major institutions, industries, and funding agencies. All partners with leading responsibilities have a proven record of delivery of networks, organisations and technological R&D over many years. The newer partners have been elected to deliver specific expertise, and to widen the industrial involvement. All partners have been involved in the detailed development of their respective work package descriptions, staff effort allocations and resource allocations. Each partner has confirmed that they are fully aware of the detailed work plans and that they indeed have available all relevant resources, commitments and internal authority as appropriate. All partners are sufficiently large organisations, and are sufficiently committed to the Opticon work plan, that each will ensure appropriate resources are available. The project resources will not be centralised – rather effort and responsibility is invested at sub-WP level, so that local responsibility and resource management is optimal. The project coherence is delivered coherently, while resources are managed locally. There are no major equipment costs other than as described in the WP descriptions.

Calculation of the Unit Cost for Transnational Access

Participant number	2	Organisation short name		CNRS	
Short name of Infrastructure	CFHT	Installation number	1	Short name of Installation	CFHT
Name of Installation	Canada-France-Hawaii telescope			Unit of access	Night

A. Estimated direct eligible costs of providing access within the project life-time excluding personnel costs	Describe the direct eligible costs for providing access to the installation over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible .			Eligible Costs (€)
	Summit building operation and maintenance			246,154
	Summit workshops and labs operation			80,000
	Telescope operation and maintenance			230,769
	Instruments – operation and maintenance			307,692
	Summit utilities (electricity – communications - ...) + mid-level access (Hale-Pohaku)			2000000
	Base (vehicles, transportation, shipments, processing, data storage for observers)			1846153.846
	Total A			4,710,769
<i>of which subcontracting (A')</i>				
B. Estimated personnel direct eligible costs needed to provide access within the project life-time	Category of staff (scientific and technical only)	Nr. of hours (1)	Hourly rate (2)	(3) = (1) x (2)
	Engineers (tech)	116,480	57.3846154	6,684,160
	Technicians (tech)	91520	37.8461538	3463680
	Resident Astronomers (sci)	49920	48.9230769	2442240
	Remote Observers (sci)	33280	40.4615385	1346560
				0
				0
				0
				0
				0
Total B			13,936,640	
C. Indirect eligible costs = 7% x ((A-A')+B)				1,305,319
D. Total estimated access eligible costs = A+B+C				19,952,728
E. Total estimated quantity of access provided to all normal users of the infrastructure (i.e. both internal and external) within the project life-time				1,280
F. Fraction of the Unit cost to be charged to the proposal ^[1]				100%
G. Estimated Unit cost charged to the proposal = F x (D/E)				15588.07
H. Quantity of access offered under the proposal (over the whole duration of the project)				12
I. Access Cost ^[2] = G x H				187,057

Calculation of the Unit Cost for Transational Access

Participant number	2	Organisation short name	CNRS	
Short name of Infrastructure	OHP	Installation number	1	Short name of Installation OHP193
Name of Installation	Observatoire de Haute Provence 193cm telescope		Unit of access	Night

A. Estimated direct eligible costs of providing access within the project life-time excluding personnel costs	Describe the direct eligible costs for providing access to the installation over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible .			Eligible Costs (€)
	Utilities (phone, energy, cleaning...)			120,000
	Consumables (nitrogen, DVDs, ...)			120,000
	Computer maintenance			120,000
	Telescope maintenance			16,000
	Instrument maintenance			120000
			Total A	496,000
	<i>of which subcontracting (A')</i>			0
B. Estimated personnel direct eligible costs needed to provide access within the project life-time	Category of staff (scientific and technical only)	Nr. of hours (1)	Hourly rate (2)	(3) = (1) x (2)
	Astronomers in charge (planning and support)	3,400	57.14	194,276
	Technical manager, maintenance	640	61.89	39609.6
	Maintenance officer	1930	39.84	76891.2
	Operationnal support (day)	6400	35.15	224960
	Night assistants	14400	58.12	836928
	Computer engineers (maintenance)	3800	52.83	200754
	Mechanical staff (maintenance)	3800	35.15	133570
	Electrical engineers (maitenance)	3800	45.21	171798
	Administrative support (planning, missions...)	3800	36.33	138054
		Total B	2,016,841	
C. Indirect eligible costs = 7% x ([A-A'] + B)				175,899
D. Total estimated access eligible costs = A+B+C				2,688,740
E. Total estimated quantity of access provided to all normal users of the infrastructure (i.e. both internal and external) within the project life-time				1,420
F. Fraction of the Unit cost to be charged to the proposal ^[1]				100%
G. Estimated Unit cost charged to the proposal = F x (D/E)				1893.48
H. Quantity of access offered under the proposal (over the whole duration of the project)				60
I. Access Cost ^[2] = G x H				113,609

Calculation of the Unit Cost for Transational Access

Participant number	2	Organisation short name		CNRS	
Short name of Infrastructure	TBL	Installation number	1	Short name of Installation	TBL
Name of Installation	Telescope Bernard Lyot			Unit of access	Night

A. Estimated direct eligible costs of providing access within the project life-time excluding personnel costs	Describe the direct eligible costs for providing access to the installation over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible .			Eligible Costs (€)
	Maintenance contract (t° asserv, dôme, lift, gas ,safety, cleaning, quality control, ,,,)			61,000
	Maintenance consumables (oil, glycol, small hardware , electronic components ,,,)			33,000
	Maintenance operations (dome, equipment and repairs)			45,000
	Computer consumables			18,000
	Communications (phone, fax)			10000
	Staff accomodation (at Pic du Midi) and gasoline and vehicule maintenance			139000
	electric bill			126000
		Total A		432,000
<i>of which subcontracting (A')</i>				
B. Estimated personnel direct eligible costs needed to provide access within the project life-time	Category of staff (scientific and technical only)	Nr. of hours (1)	Hourly rate (2)	(3) = (1) x (2)
	Night Assistant (6) 50%	19,200	29.6	568,320
	Technical operations (6) (50%*2/3)	12800	29.5	377600
	Maintenance Staff (instrument, electronics, ,,,)	21600	33.49	723384
	Software Engineer (50%narval +20%upgrade)	3200	33.49	107168
	Software Assistant Engineer (50%narval +10%upgrade)	3200	29.6	94720
	Administration (50%)	3200	29.6	94720
				0
				0
				0
	Total B		1,965,912	
C. Indirect eligible costs = 7% x ([A-A'] + B)				167,854
D. Total estimated access eligible costs = A+B+C				2,565,766
E. Total estimated quantity of access provided to all normal users of the infrastructure (i.e. both internal and external) within the project life-time				960
F. Fraction of the Unit cost to be charged to the project ^[1]				100.0%
G. Estimated Unit cost charged to the project = F x (D/E)				2672.67
H. Quantity of access offered under the project (over the whole duration of the project)				32
I. Access Cost charged to the project ^{[2][3]} = G x H				85,525

Calculation of the Unit Cost for Transational Access

Participant number	3	Organisation short name	INAF	
Short name of Infrastructure	TNG	Installation number	1	Short name of Installation
Name of Installation	Telescopio Nazionale Galileo		Unit of access	Night

A. Estimated direct eligible costs of providing access within the project life-time excluding personnel costs	Describe the direct eligible costs for providing access to the installation over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible .			Eligible Costs (€)
	Equipments			519,732
	Consumables			188,176
	Maintenance			583,240
	Operational costs			629,852
	Information Technology			77,872
			Total A	1,998,872
<i>of which subcontracting (A')</i>				
B. Estimated personnel direct eligible costs needed to provide access within the project life-time	Category of staff (scientific and technical only)	Nr. of hours (1)	Hourly rate (2)	(3) = (1) x (2)
	Astronomers, 10.4 FTE	62,899	51.0570777	3,211,449
	Telescope Operators, 4 FTE	26400	30.5281818	805,944
	Technical staff, 11 FTE	66528	30.4556097	2,026,151
				0
				0
				0
				0
				0
			Total B	6,043,544
C. Indirect eligible costs = 7% x ([A-A'] + B)			562,969	
D. Total estimated access eligible costs = A+B+C			8,605,385	
E. Total estimated quantity of access provided to all normal users of the infrastructure (i.e. both internal and external) within the project life-time			1,200	
F. Fraction of the Unit cost to be charged to the project ^[1]			100.0%	
G. Estimated Unit cost charged to the project = F x (D/E)			7171.15	
H. Quantity of access offered under the project (over the whole duration of the project)			16	
I. Access Cost charged to the project ^{[2][3]} = G x H			114,738	

Calculation of the Unit Cost for Transational Access

Participant number	4	Organisation short name	MaxPlanck	
Short name of Infrastructure	CAHA	Installation number	1	Short name of Installation CAHA 3.5m
Name of Installation	CAHA 3.5m		Unit of access	Night

A. Estimated direct eligible costs of providing access within the project life-time excluding personnel costs	Describe the direct eligible costs for providing access to the installation over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible .			Eligible Costs (€)	
	Maintenance			1,496,792	
	Utilities			1,525,058	
	Consumable			1,117,776	
			Total A	4,139,626	
B. Estimated personnel direct eligible costs needed to provide access within the project life-time		Category of staff (scientific and technical only)	Nr. of hours (1)	Hourly rate (2)	(3) = (1) x (2)
		Scientific	24,577	100	2,457,734
		Technical	59395.248	100	5939524.8
					0
					0
					0
					0
					0
					0
			Total B		8,397,259
C. Indirect eligible costs = 7% x ([A-A'] + B)				877,582	
D. Total estimated access eligible costs = A+B+C				13,414,467	
E. Total estimated quantity of access provided to all normal users of the infrastructure (i.e. both internal and external) within the project life-time				1,360	
F. Fraction of the Unit cost to be charged to the proposal ⁽¹⁾				100%	
G. Estimated Unit cost charged to the proposal = F x (D/E)				9863.58	
H. Quantity of access offered under the proposal (over the whole duration of the project)				30	
I. Access Cost ⁽²⁾ = G x H				295,907	

Calculation of the Unit Cost for Transational Access

Participant number	4	Organisation short name		MaxPlanck	
Short name of Infrastructure	CAHA	Installation number	2	Short name of Installation	CAHA 2.2m
Name of Installation	CAHA 2.2m			Unit of access	Night

A. Estimated direct eligible costs of providing access within the project life-time excluding personnel costs	Describe the direct eligible costs for providing access to the installation over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible .			Eligible Costs (€)
	Maintenance			553,608
	Utilities			564,062
	Consumable			413,424
			Total A	1,531,094
B. Estimated personnel direct eligible costs needed to provide access within the project life-time	Category of staff (scientific and technical only)	Nr. of hours (1)	Hourly rate (2)	(3) = (1) x (2)
	Scientific	9,831	100	983,094
	Technical	21998.24	100	2199824
				0
				0
				0
				0
				0
				0
			Total B	3,182,918
C. Indirect eligible costs = 7% x ([A-A'] + B)			329,981	
D. Total estimated access eligible costs = A+B+C			5,043,993	
E. Total estimated quantity of access provided to all normal users of the infrastructure (i.e. both internal and external) within the project life-time			1,360	
F. Fraction of the Unit cost to be charged to the proposal ^[1]			100%	
G. Estimated Unit cost charged to the proposal = F x (D/E)			3708.82	
H. Quantity of access offered under the proposal (over the whole duration of the project)			24	
I. Access Cost ^[2] = G x H			89,012	

Calculation of the Unit Cost for Transational Access

Participant number	4	Organisation short name	MaxPlanck		
Short name of Infrastructure	MPG2.2m	Installation number	1	Short name of Installation	MPG/2.2m
Name of Installation	Max Planck 2.2m Telescope			Unit of access	Night

A. Estimated direct eligible costs of providing access within the project life-time excluding personnel costs	Describe the direct eligible costs for providing access to the installation over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible .			Eligible Costs (€)
	direct cost 405 kEuro/yr			1,620,000
	Telescope support T. Anquita/R.Lachaume 80 kEuro/yr including travel to LaSilla			320,000
	Total A			1,940,000
	<i>of which subcontracting (A')</i>			
B. Estimated personnel direct eligible costs needed to provide access within the project life-time	Category of staff (scientific and technical only)	Nr. of hours (1)	Hourly rate (2)	(3) = (1) x (2)
	MPIA support 0.1 FTE at 80kEuro/yr	800	40	32,000
				0
				0
				0
				0
				0
				0
				0
	Total B			32,000
C. Indirect eligible costs = 7% x ([A-A'] + B)			138,040	
D. Total estimated access eligible costs = A+B+C			2,110,040	
E. Total estimated quantity of access provided to all normal users of the infrastructure (i.e. both internal and external) within the project life-time			1,000	
F. Fraction of the Unit cost to be charged to the project ^[1]			100.0%	
G. Estimated Unit cost charged to the project = F x (D/E)			2110.04	
H. Quantity of access offered under the project (over the whole duration of the project)			12	
I. Access Cost charged to the project ^{[2][3]} = G x H			25,320	

Calculation of the Unit Cost for Transational Access

Participant number	5	Organisation short name		STFC	
Short name of Infrastructure	ING	Installation number	1	Short name of Installation	WHT
Name of Installation	William Herschel Telescope			Unit of access	Night

A. Estimated direct eligible costs of providing access within the project life-time excluding personnel costs	Describe the direct eligible costs for providing access to the installation over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible .			Eligible Costs (€)
	Utilities and consumables (water,electricity,nitrogen,gasoline,storage media,rent etc)			2,692,000
	Maintenance (spares, repairs, aluminizing, computing, licenses etc)			1,384,000
	Subsistence at the observatory			344,000
	Total A			4,420,000
	<i>of which subcontracting (A')</i>			
B. Estimated personnel direct eligible costs needed to provide access within the project life-time	Category of staff (scientific and technical only)	Nr. of hours (1)	Hourly rate (2)	(3) = (1) x (2)
	Scientific staff	30,368	43.69	1,326,778
	Observing Support Assistants	26992	35.86	967933.12
	Technical operations staff	53984	33.91	1830597.44
	Engineering staff	66132	37.82	2501112.24
				0
				0
				0
				0
				0
Total B			6,626,421	
C. Indirect eligible costs = 7% x ([A-A'] + B)				773,249
D. Total estimated access eligible costs = A+B+C				11,819,670
E. Total estimated quantity of access provided to all normal users of the infrastructure (i.e. both internal and external) within the project life-time				1,300
F. Fraction of the Unit cost to be charged to the proposal ^[1]				100%
G. Estimated Unit cost charged to the proposal = F x (D/E)				9092.05
H. Quantity of access offered under the proposal (over the whole duration of the project)				10
I. Access Cost ^[2] = G x H				90,921

Calculation of the Unit Cost for Transational Access

Participant number	5	Organisation short name		STFC	
Short name of Infrastructure	ING	Installation number	2	Short name of Installation	INT
Name of Installation	Isaac Newton Telescope			Unit of access	Night

A. Estimated direct eligible costs of providing access within the project life-time excluding personnel costs	Describe the direct eligible costs for providing access to the installation over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible .			Eligible Costs (€)
	Utilities and consumables (water,electricity,nitrogen,gasoline,storage media,rent etc)			300,000
	Maintenance (spares, repairs, aluminizing, computing, licenses etc)			152,000
	Subsistence at the observatory			40,000
	Total A			492,000
	<i>of which subcontracting (A')</i>			
B. Estimated personnel direct eligible costs needed to provide access within the project life-time	Category of staff (scientific and technical only)	Nr. of hours (1)	Hourly rate (2)	(3) = (1) x (2)
	Scientific staff	6,748	43.69	294,820
	Technical operations staff	13496	33.91	457649.36
	Engineering staff	28340	37.82	1071818.8
				0
				0
				0
				0
				0
	Total B			1,824,288
C. Indirect eligible costs = 7% x ([A-A'] + B)				162,140
D. Total estimated access eligible costs = A+B+C				2,478,428
E. Total estimated quantity of access provided to all normal users of the infrastructure (i.e. both internal and external) within the project life-time				1,300
F. Fraction of the Unit cost to be charged to the proposal ^[1]				100%
G. Estimated Unit cost charged to the proposal = F x (D/E)				1906.48
H. Quantity of access offered under the proposal (over the whole duration of the project)				8
I. Access Cost ^[2] = G x H				15,252

Calculation of the Unit Cost for Transnational Access

Participant number	10	Organisation short name		IAC	
Short name of Infrastructure	TCS	Installation number	1	Short name of Installation	TCS
Name of Installation	TELESCOPIO CARLOS SÁNCHEZ			Unit of access	Night

A. Estimated direct eligible costs of providing access within the project life-time excluding personnel costs	Describe the direct eligible costs for providing access to the installation over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible .			Eligible Costs (€)
	Utilities (electricity, water, telephone/fax, cleaning, nitrogen, etc.)			121,770
	Consumables (gasoline, etc.)			11,643
	Replacement informatics' equipment			17,557
	Mountain high equipment for personnel			8,071
	Residencia			58,908
	Subsistence			37,291
	Data storage			9,020
	Summit workshops and labs operation			16,912
	Telescope operation and maintenance			139,810
	Instruments – operation and maintenance			16,912
	Common services of the observatory			108,240
	Time Allocation Committee			3,383
	Base (vehicles)			23,780
Total A			573,297	
<i>of which subcontracting (A')</i>				
B. Estimated personnel direct eligible costs needed to provide access within the project life-time	Category of staff		Person-Months	Personnel Costs (€)
	Head of Telescope Operation		35.5	77,615
	Support Astronomers		31.2	294,727
	Telescope Operators		24.2	108,790
	Technicals in Telescopic Operations		16.1	115,798
	Head of Technical/Maintenance Staff		39.6	71,438
	Workshop Masters IM		22	79,376
	Workshop Assistants IM		17.3	62,418
	Head of the Observatory Technical Service		60.4	14,178
	MOT Technicians		60.4	42,470
	MOT Technicians b		60.4	42,470
	Optical engineer		31.2	7,995
	Workshop Technicians		16.1	4,126
	Total B			921,401.00
C. Indirect eligible costs $\leq 7\% \times ([A-A'] + B)$ ^[1]			max	104628.86
D. Total estimated access eligible costs = A+B+C				1,599,327.00
E. Total estimated quantity of access provided to all normal users of the infrastructure (i.e. both internal and external) within the project life-time				1,104
F. Fraction of the Unit cost to be charged to the project ^[2]				100.0%
G. Estimated Unit cost charged to the project = F x (D/E)				1448.67
H. Quantity of access offered under the project (over the whole duration of the project)				16
I. Access Cost charged to the project ^{[3][4]} = G x H				23,178.72

Calculation of the Unit Cost for Transational Access

Participant number	11	Organisation short name		AAO	
Short name of Infrastructure	AAT	Installation number	1	Short name of Installation	AAT
Name of Installation	Anglo Australian Telescope			Unit of access	Night

A. Estimated direct eligible costs of providing access within the project life-time excluding personnel costs	Describe the direct eligible costs for providing access to the installation over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible .			Eligible Costs (€)
	Support staff travel to and accomodation at telescope			614,738
	Telescope Repairs and Maintenance			335,581
	Occupancy costs			1,603,664
	Consumables			381,613
	Communication costs			61,993
	Vehicle leasing and running costs			210,852
	Fees for services			62,365
	Total A			3,270,806
	<i>of which subcontracting (A')</i>			
B. Estimated personnel direct eligible costs needed to provide access within the project life-time	Category of staff (scientific and technical only)	Nr. of hours (1)	Hourly rate (2)	(3) = (1) x (2)
	Scientific/Technical	148,800	49	7,223,699
				0
				0
				0
				0
				0
				0
				0
	Total B			
C. Indirect eligible costs = 7% x ([A-A'] + B)				734,615
D. Total estimated access eligible costs = A+B+C				11,229,121
E. Total estimated quantity of access provided to all normal users of the infrastructure (i.e. both internal and external) within the project life-time				1,184
F. Fraction of the Unit cost to be charged to the proposal ^[1]				100%
G. Estimated Unit cost charged to the proposal = F x (D/E)				9484.05
H. Quantity of access offered under the proposal (over the whole duration of the project)				56
I. Access Cost ^[2] = G x H				531,107

Calculation of the Unit Cost for Transnational Access

Participant number	12	Organisation short name		NOTSA	
Short name of Infrastructure	NOT	Installation number	1	Short name of Installation	NOT
Name of Installation	Nordic Optical Telescope			Unit of access	Nights

A. Estimated direct eligible costs of providing access within the project life-time excluding personnel costs	Describe the direct eligible costs for providing access to the installation over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible .		Eligible Costs (€)
	Observatory operations		385,200.00
	Observatory infrastructure and utilities		642,000.00
	Telescope operations and maintenance		107,000.00
	Instrument maintenance and data management		171,200.00
	Directorate operations		192,600.00
		Total A	1,498,000.00
		<i>of which subcontracting (A')</i>	
B. Estimated personnel direct eligible costs needed to provide access within the project life-time	Category of staff	Person-Months	Personnel Costs (€)
	Scientific	187.8	1,754,800.00
	Operations, maintenance and engineering	172.8	1,134,200.00
	Software	81	642,000.00
		Total B	3,531,000.00
C. Indirect eligible costs $\leq 7\% \times ([A-A'] + B)^{[1]}$		max 352030	352,030.00
D. Total estimated access eligible costs = A+B+C			5,381,030.00
E. Total estimated quantity of access provided to all normal users of the infrastructure (i.e. both internal and external) within the project life-time			1,256
F. Fraction of the Unit cost to be charged to the project ^[2]			100.0%
G. Estimated Unit cost charged to the project = F x (D/E)			4284.26
H. Quantity of access offered under the project (over the whole duration of the project)			80
I. Access Cost charged to the project ^{[3][4]} = G x H			342,740.80

Calculation of the Unit Cost for Transational Access

Participant number	14	Organisation short name		LJMU	
Short name of Infrastructure	LT	Installation number	1	Short name of Installation	LT
Name of Installation	Liverpool Telescope			Unit of access	Hours

A. Estimated direct eligible costs of providing access within the project life-time excluding personnel costs	Describe the direct eligible costs for providing access to the installation over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible .			Eligible Costs (€)
	Service Charges made by IAC and Common Services contribution			163,692
	Electricity and Telephones / other Communication charges			58,032
	Consumables (oil, fuel, refrigerant gas, computer consumables, cleaning materials, paint)			23,052
	Spare parts for Telescope			20,000
	Equipment hire : Crane / Skip / Lifting Equipment hire (including aluminising mirror)			48,378
	Vehicle costs : Car insurance / Maintenance / any other costs associated with Vehicle			26,400
	Maintenance Contracts and Specialist Engineering Consultants			288,380
	Staff Training			4,000
	Travel and subsistence for technical staff, and shipping of equipment			96,360
	Total A			728,294
of which subcontracting (A')			288,380	
B. Estimated personnel direct eligible costs needed to provide access within the project life-time	Category of staff (scientific and technical only)	Nr. of hours (1)	Hourly rate (2)	(3) = (1) x (2)
	Scientific & Management Staff			
	Professor Mike Bode	599	127.02	76,085
	Professor Iain Steele	2,996	71.89	215,382
	Research Staff			
	J Marchant	5,992	40.77	244,294
	R Smith	5,992	48.15	288,515
	Technical Staff			
	S Bates	5,992	39.77	238,302
	S Fraser	5,992	41.17	246,691
	N Clay	5,992	39.33	235,665
	C Mottram	5,992	42.32	253,581
	Total B			1,798,515
	C. Indirect eligible costs = 7% x ((A-A')+B)			156,690
D. Total estimated access eligible costs = A+B+C			2,683,499	
E. Total estimated quantity of access provided to all normal users of the infrastructure (i.e. both internal and external) within the project life-time			9,600	
F. Fraction of the Unit cost to be charged to the proposal ^[1]			100%	
G. Estimated Unit cost charged to the proposal = F x (D/E)			279.53	
H. Quantity of access offered under the proposal (over the whole duration of the project)			320	
I. Access Cost ^[2] = G x H			89,450	

3 Impact

3.1 Expected impacts listed in the work programme

In order to demonstrate the expected impacts of this activity we will address each element of the Call impacts in turn.

“Provide and facilitate access to the key research infrastructures; integrate these facilities and resources with a long term perspective.”

This is the heart of the Opticon TNA programme. Over recent years Opticon has worked in partnership with the ASTRONET strategic planning group and individual national and international agencies which own and operate infrastructures to carry out a full review of the scientific potential of Europe's medium-sized telescopes. These facilities were threatened with closure, while at the same time being the only facilities which were both capable of cutting-edge science and which were open to non-national use. That review (the European Telescope Strategic Review Committee or “Drew-Bergeron report”) made clear that their full scientific potential could be realised only if fundamentally new modes of operations could be identified and implemented to deliver long-term viability at much reduced cost. The urgent need to identify and implement proof of principle trials of these new modes of operation is the challenge being successfully met under the current Opticon contract. The process, described above, involves a series of Opticon initiatives, all new to optical-infrared astronomy. Opticon established the Telescope Directors' Forum, which brings together observatory directors to share best practice and explore common challenges for the first time. Opticon developed software essential to allow a common interface for applications to any available telescope and did so at minimum cost by enhancing software developed by RADIONET. That software is implemented in the first ever multi-facility, multi-agency, multi-country integrated proposal review and application processing system implemented in optical-infrared astronomy. A crucial aspect of the Opticon observing system is that unsuccessful proposers receive more than just a rejection, constructive feedback from the committee is always provided to the individual. On a wider scale the requirements identified to improve community proposal standards are harnessed to inform special training schools, especially focussed on relatively small and new communities, so these communities can take their full place in the future research area (WP13). It is this system which delivers the long-term perspective. Much more importantly is financial viability. Here Opticon has been able to work, with ASTRONET, towards the essential reorienting of the roles of national telescopes. Traditionally, every telescope must deliver access to every popular type of instrument required by its national community. Vastly expensive duplication and inefficiency resulted. Obviously, a system whereby each telescope specialised in the one or two things it does best and access to speciality instruments is provided through telescope access rather than instrument changes, is much more efficient and cheaper. By working with agencies, and equally importantly with the national user communities, through the Telescope Directors' Forum, the first agreements to reduce duplication, are now in place. Proving that system can and will work, and can and will deliver cost and efficiency savings, and can and will deliver better science, is the ambition of this current proposal. If Opticon succeeds in delivering that evidence, the community will be well on the way to longer-term viability. We note, for comparison, that the US observatory system, which has failed to implement radical change along the lines being implemented through this proposal in Europe, is currently under serious risk of complete closure (the US “Portfolio Review”, and system roadmap, is being developed as an urgent response after threat of funding cuts, rather than proactively planned, as in Europe). These activities are delivered through WP7, WP12, in aspects of WP9, WP11, and WP13. The coordination with ASTRONET is funded through WP8.

“stimulate new scientific activities aimed at taking full advantage of new experimental possibilities which will be offered by the future European Extremely Large Telescope.

This is the objective of the whole of the rest of the Opticon I3 programme, as introduced in Section 1. As

with every I3, Opticon includes networking and technical R&D activities. The balance of and complementarity between those activities is summarised in the Organogram diagram, in Section 1.3.iv.

The networking activities deliver impact at many levels, including explicit efforts to maintain the integration of the wider community in the continuing development of the scientific potential of the E-ELT (WP10). This WP includes not only general developments, but specific efforts to prepare for and to realise unique new experimental possibilities which are not possible with existing facilities, but will be with an E-ELT, including ultra-high time resolution astronomy, probing the unexplored quantum optics regime. In addition to ultra-high time resolution science, E-ELTs will be the first opportunity to study transients at faint magnitudes. Learning about transient science is a whole exciting and fast developing subject, currently being pioneered using specially-modified medium-sized telescopes (see above) including some of those in the Opticon telescope network. The big future opportunity is the European Space Agency mission Gaia, scheduled for launch in mid-2013, which will raise the subject to a new level and new challenges. Preparing the community, both the scientific community and the infrastructure community, to take full advantage of this new opportunity in parameter space is a completely new challenge, for which Opticon proposes establishing the completely new WP11, Time Domain Astronomy. This science will certainly develop over the next decade, so this work, while of intrinsic interest, will certainly start to prepare the community for E-ELT-scale challenges. Of course, extremely large telescopes deliver extremely high spatial resolution imaging – and so does interferometry. A critical learning curve for the community in readiness for an order of magnitude improvement in spatial resolution is developing knowledge of what might be visible, and how complex the Universe might seem. This is delivered through WP14 and the technical developments in WP4, which support the European Interferometry community, and scientific algorithmic developments which are of enormous immediate value, and will be vital for exploit of the innovative E-ELT science. An I3 also delivers technology R&D, where the impact will come from enhancing the performance of the infrastructures, by improving the instrumentation on all telescopes, from the medium-sized telescopes in the Opticon suite to the giant instruments which the community is preparing to build for the E-ELT. A major factor in assuring high impact from technology R&D is of course to understand how the specific activities proposed have been identified, from the very many possible. The Opticon technology developments have been identified after extensive analysis, with all of the basic technology communities, the experienced instrument builder groups, the national funding agencies, and the potential beneficiary infrastructures being involved. The process starts inside Opticon, where current activity supports a Technology Roadmapping programme. This network, involving experts from the wide astronomy and space communities and associated industrial experts, identifies future technology developments which have the potential for significant future impacts. We emphasise this process already involves industry at this early pre-proposal stage, to ensure maximal innovation, cross fertilisation and socio-economic potential.

Concepts identified through this roadmap are the basis of all activity in the current Opticon proposal. We consider these in turn. WP1 develops adaptive optics systems, in particular moving beyond the basic operational systems now starting to come on line (themselves significantly advanced by previous Opticon efforts). The challenge here is to develop ambitious adaptive optics systems which meet the wide range of scientific requirements to which the community aspires. These enhanced adaptive optics systems will become workhorses on all medium to large telescopes as they become available, but are critically required for the instruments the community is designing to deliver the ambition of the E-ELT. The involvement of the industrial partners, ONERA and especially Alpao, ensures that the future provision of these advanced systems, which are required globally not just in Europe, will involve new work in European industry. Adaptive optics systems, high-time resolution astronomy, faint-object astronomy, high-dispersion astronomy, all demand noise free efficient and fast photon detectors. WP2 works with a new industrial partner, Europe's leading manufacturer of large-format detectors (e2v, partner 22) to deliver working cameras with performances an order of magnitude better than those developed in the present contract. There is considerable industrial spinoff, as noted below. WP3, astrophotonics, aims to deliver to astrophysics the benefit of vast global investments in photonics by the telecom, biomedical and sensing applications communities. This WP allows the astronomy community to collaborate as full partners with very large industrial research activities, so delivers impact disproportionately. If photonic systems prototyped in the existing contract can be enhanced and brought

to maturity based on work in this proposal then adapted to astronomy the potential impacts are paradigm changing. Similarly, the potential industrial applications are very large indeed, hence the large industrial interest.

Our interferometry activities, (WP4 is described above), have moved on from investigating infrastructure issues and into the key area of delivering user friendly high-resolution imaging reconstruction. Again we note potential industrial applications, especially in image processing for process quality control and security and medical diagnostics. WP5, another spinoff from the Key Technologies Roadmap exercise, is working to test the viability of controllable complex optical surfaces in cryogenic spectrographs. If these can be built cheaply and reliably they would allow much simpler, smaller, cheaper instruments to be built to meet a variety of needs, especially in relation to off-axis optics. WP6 investigates new materials. This field – holograms, programmable crystals, polymer fibres, laser-etched gratings – encapsulates the new materials dominating discussion of future applications, from flat screens to intelligent screens. It is a consumer technology of the future, as well as a scientific material of the near future. The dramatic impact of this WP in the current Opticon in saving European industrial VPH grating production capability is mentioned below.

3.2 Dissemination and/or exploitation of project results, and management of intellectual property

The management of Intellectual Property Rights (IPR) is specified in the Opticon Consortium agreement, which is closely based on the EC standard model and approved by the industrial and agency partners who have considerable expertise in this area. In essence, those who develop new processes, concepts and patents own the IPR. During the contract activity, the benefits of the IPR are preferentially made available to all contractors.

In practise, the overwhelming majority of new knowledge resulting from the EC activities is made publicly available. The major vehicle of dissemination of intellectual property is via scientific publications in peer reviewed journals or communication to relevant congresses and conferences. The authorship of these publications is agreed inside the relevant WP and supervised by the WP management. Opticon and EC funding will always be acknowledged in the standard form when the publication/communication is totally or partially a result from this programme.

The aspects of new knowledge of widest interest fall in two groups – scientific publications resulting from the telescope access programme, disseminated through the standard scientific literature, and technical advances presented at the relevant (usually international, SPIE) conferences and published in conference proceedings. All these publications are reported in the Opticon reports to the EC and are of course generally disseminated as widely as is feasible by the authors. In special cases, major scientific journal articles present significant technical results

A recent example of special note is the pair of articles describing the Opticon fast camera, OCAM. This work led to two major publications, one technical in SPIE (“Characterization of OCAM and CCD220: the fastest and most sensitive camera to date for AO wavefront sensing”, Feautrier, Philippe; Gach, Jean-Luc; Balard, Philippe; Guillaume, Christian; Downing, Mark; Hubin, Norbert; Stadler, Eric; Magnard, Yves; Skegg, Michael; Robbins, Mark; and 15 coauthors, [2010SPIE.7736E..32F](#)), and one for the astronomical community, in PASP (“OCAM with CCD220, the Fastest and Most Sensitive Camera to Date for AO Wavefront Sensing”, Feautrier, Philippe; Gach, Jean-Luc; Balard, Philippe; Guillaume, Christian; Downing, Mark; Hubin, Norbert; Stadler, Eric; Magnard, Yves; Skegg, Michael; Robbins, Mark; and 15 coauthors. [2011PASP..123..263F](#)).

The OCAM development is an especially positive, but not unique, example of the effort made inside Opticon to maximise dissemination of information, and the considerable success that such dissemination can have. First, we emphasise that OCAM is a technical success, delivering wide direct impact. Copies have been bought by ESO, for VLT use, and by GranteCan, the Spanish 12m telescope, for their adaptive optics use. Demand is so high that a spinoff company has been created, “Firstlight Imaging”, with 15 FTE staff, to develop and market such imaging systems in order to give access to this high level

technology to every European astronomical infrastructures, especially when they do not have in house a strong enough detector group with the required skills. Moreover, this spin off will investigate fast imaging markets outside astronomy. The target in the medium term is to recruit 10 to 20 staff in the spin off.

Part of this success follows effort at dissemination. OCAM was presented to the press, following its successful testing, through a set of Press Releases. One was presented on French TV3 national news, was noticed by a senior Civil Aviation person, and led to a current project, DROP. This uses OCAM plus a small commercial telescope plus some robotics, plus smart special purpose image analysis software to monitor active airport runways for debris which might present a risk to departing aircraft, as so tragically demonstrated by the July 2000 Concorde crash. Such safety systems are mandatory, but are currently supplied only by North American firms. This establishes a European presence in a large and important market and shows the potential for societal impact of our research outside astronomy.

This is an impressive but not unique example. A second follows from the work of WP6, focussing on Volume Phase Holographic Gratings (VPHG). These are polymer gratings, essential for the largest high-efficiency astronomical spectrographs, and also with many industrial process control applications. In May 2010 the only European-based VPHG producer (ATHOL) became bankrupt – through loss of key personnel, headhunted to US competition. The Opticon Executive, with the WP6 leadership, judged the retention in Europe of the critical IPR as of the highest priority. The key people identified the remaining production capability for VPHGs which would allow access as being a research group working with Japanese industry (Nippon Paint) based in Tokyo Women's University. An extensive training visit to Japan followed, leading to a documented VPHG production training course, available in Europe, with Opticon IPR. The polymers themselves are provided by a Brazilian company (Polygrama). All other processes are controlled inside the relevant Opticon WP6 activity. Again, a key technology has been delivered to Europe.

There are other examples. Astrophotonics activity has already revolutionised interferometric instrumentation in astronomy with fully integrated coherent fringe-tracking beam combiners and the SWIFTS-Lipmann interferometer providing simple, compact and robust performance enhancing technologies. These illustrations show the seriousness with which the Opticon partners have, and continue, to take IPR and dissemination issues. The national agencies which are members of Opticon all manage significant IPR exploitation efforts inside their organisations, with which communications are established (below). The industrial partners of course work closely with the technical developments primarily to enhance their own knowledge, for other applications.

We are hopeful for similar advances from the current proposal and are confident the relevant dissemination and IPR will be managed well.

We clarify here a common query regarding Opticon's target audience for outreach. Much of astronomy appeals to, and is marketed to, the general public, schools, educational groups, public media, and so on. HST and VLT images are everywhere. All Opticon participants are actively involved in this work through their organisations, who commit considerable resources to this task. It would not be cost effective to duplicate this effort, although we feed ideas and information into it where possible. Where it is appropriate, and uniquely interesting systems are available, we do make the direct effort, and invest resources, in outreach. One specific example here is WP1.5. Opticon activities themselves however do not produce science results directly – access users may produce science of PR interest, but it is their science. Enabling that science, delivering management systems for infrastructures, and such like, has (very) limited public appeal, though we noted above the highly effective OCAM PR releases and their impact. Rather the target audience for Opticon activity and to publicise success, are the funding agencies, their funding sources, which are governments, and industry. Communication at that level, which can be very effective in delivering results, is where Opticon focuses its efforts. This is productive, as the continuing survival of the Medium sized telescopes attests. It is effective, as the new industrial partners, e2v and Alpao, attest. It is worthwhile, as the continuing support for Opticon R&D by the national funding agencies, which in turn can convince their governments that this type of R&D delivers

societal value, illustrates.

INNOVATION

In line with the political context set out by Innovation Union a specific work package on innovation is requested in all Integrating Activities projects to increase the potential for innovation, including social innovation, of the related infrastructures. This work package would cover activities to reinforce the partnership with industry, e.g. transfer of knowledge and other dissemination activities, activities to foster the use of research infrastructures by industrial researchers, involvement of industrial associations in consortia or in advisory bodies.

Opticon has already earned a reputation for innovation, for productive partnerships with industry, including as consortium members, for knowledge dissemination, and for effective exploitation of appropriate IPR.

Even before this new requirement Opticon had an activity meeting exactly this ambition. The Key Technology Network (under FP7, now WP9, Innovation Network) was established for this. The specification for that activity included Roadmapping workshops, with attendance from a wide range of backgrounds, maintenance of the Roadmap, including coordination with ESA, Two-way Technology Transfer, to and from Industry, and an activity to develop industrial awareness of the astronomical community's needs. The Roadmap from this work was presented at an invited plenary talk at the largest international meeting of relevance, SPIE at San Diego (US), 2010. The relevant WP lead has become a member of the Scientific Committee of ESF-ESA TECHBREAK: Technological Breakthroughs for Scientific Progress, along with ESA, ESF, and industrial (Thales Alenia Space; ASD-EUROSPACE) members.

The objective of this continuing network is to coordinate efforts in Europe to benefit Optical and Infrared Astronomy by stimulating the timely development of key technology, and to maximise knowledge transfer with industry in this field. As such it is expected that both scientific and economic impact will be high, as has been demonstrated in previous Opticon programmes. The operation of the network is described under WP9. As in the case of public outreach, we will leverage this effort by working with the innovation and industry groups of our partner organisations.

4 Ethical Issues

The Coordinator, on behalf of all participants, confirms that none of the ethical issues listed in the “Ethical Issues” table applies to this contract.

Research on Human Embryo/ Foetus		YES	Page
	Does the proposed research involve human Embryos?		
	Does the proposed research involve human Foetal Tissues/ Cells?		
	Does the proposed research involve human Embryonic Stem Cells (hESCs)?		
	Does the proposed research on human Embryonic Stem Cells involve cells in culture?		
	Does the proposed research on human Embryonic Stem Cells involve the derivation of cells from Embryos?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	YES	

Research on Humans		YES	Page
	Does the proposed research involve children?		
	Does the proposed research involve patients?		
	Does the proposed research involve persons not able to give consent?		
	Does the proposed research involve adult healthy volunteers?		
	Does the proposed research involve Human genetic material?		
	Does the proposed research involve Human biological samples?		
	Does the proposed research involve Human data collection?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	YES	

Privacy		YES	Page
	Does the proposed research involve processing of genetic information or personal data (e.g. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?		
	Does the proposed research involve tracking the location or observation of people?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	YES	

Research on Animals		YES	Page
	Does the proposed research involve research on animals?		
	Are those animals transgenic small laboratory animals?		
	Are those animals transgenic farm animals?		
	Are those animals non-human primates?		
	Are those animals cloned farm animals?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	YES	

Research Involving non-EU Countries (ICPC Countries)		YES	Page
	Is any material used in the research (e.g. personal data, animal and/or human tissue samples, genetic material, live animals, etc.):		

	a) Collected and processed in any of the ICPC countries?		
	b) Exported to any other country (including ICPC and EU Member States)?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	YES	

Dual Use		YES	Page
	Research having direct military use		
	Research having the potential for terrorist abuse		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	YES	

5 Consideration of gender aspects

Gender balance is a well-known challenge in physical sciences, and especially in the engineering-interface opto-mechanical systems of the types involved in Opticon JRA activities. We of course do what we can, and take considerable trouble to avoid bias. Nonetheless, our ability to affect the workplace balance is very limited. Opticon funds support only a very few new positions – mostly they support people already in post in related activity, or deliver funds to organisations which manage them using their own policy. However, where we can, we try. Opticon supports two staff in E-ELT science related positions, both women, where special efforts are made to manage and cater for maternity leave. We have a senior female engineer managing our risk. Gender and life-balance issues are flagged in Opticon-supported workshops and training schools. In fact, media reports tell us astronomy has the most-equal gender balance at PhD level of any physical science. We do our best to keep that balance in continuing positions, given our very limited opportunity. Specific gender sensitivity training has been organised by the relevant agencies for some of our management team. Similar activities will continue to be organised as feasible.
