PROPOSAL SUMMARY

Research objectives and content:

Solar magnetism is one of the great challenges of astrophysics. The intricate structure of the solar magnetic field exemplifies cosmic magnetic fields; its dynamical modulation affects the human environment. The European Solar Magnetism Network exploits advanced European technology — five solar telescopes at the Canary Islands and ESA's SOHO mission in space — to gain understanding of the roots of solar magnetism.

The Network will study the structure and dynamics of solar surface fields, the topology and evolution of solar active regions, and the electrodynamical coupling between the solar interior, photosphere, and outer atmosphere by perfecting solar magnetometry, organising joint multi-telescope observing campaigns, and analysing the results through numerical inversions and simulations.

Training content:

The human product of the European Solar Magnetism Network consists of young researchers who are well qualified to tackle complex problems in (astro-)physics, space weather, image processing and numerical modelling. Their training includes hands-on training at the Canary Island telescopes and the SOHO operations centre, intensive collaboration in joint observing, data analysis and interpretation, and participation in Network-organised summer/winter schools and meetings. Offering such postdoctoral training in Europe in this expanding field counteracts a persistent brain drain to the US.

C. PROPOSAL DESCRIPTION

1a. Research Topic

Science reasons. The ESMN is devoted to understanding solar magnetism. The intricate structure of the sun's magnetic fields, the solar activity cycle and the solar influence on the heliosphere represent major quests of (astro-)physics which bear directly on the human environment. The solar magnetic fields are generated by enigmatic dynamo processes in the solar interior, are organised into the highly complex patterns of solar activity observed in the solar photosphere, dominate the structure of the outer solar atmosphere (chromosphere, transition region, corona), regulate the solar wind, affect the extended heliosphere including near-earth space weather, and underlie the solar variability which influences life on Earth through climate modulation.

The ESMN goes for the roots of space weather and coronal plasma behaviour by integrating complementary European efforts to chart and understand the structure and dynamics of solar surface magnetism, the patterns by which it betrays subsurface dynamo properties, and the electrodynamical coupling to the outer solar atmosphere. At the solar surface, the magnetic fields gain dominance over the gas pressure so that the surface field configurations control what happens further out. The ESMN therefore concentrates on joint observing and analysis programmes with optical solar telescopes (solar surface and lower atmosphere) and space telescopes (outer atmosphere), with considerable interpretative support from theory.

Technological reasons. The present ESMN[1] stands for *European Solar Magnetometry Network* and concentrates on pushing solar magnetometry with the five European Canary Island telescopes (Figure 1 on page 5) to the edge of technology. By the end of ESMN-1 three new solar telescopes will be fully operational (DOT, NSST, THEMIS) and much advanced technology (speckle imaging, adaptive optics, infrared Stokes spectropolarimetry) will be ready for use. The new telescopes and the new technology, in particular adaptive optics, herald a wholly new era in solar physics. The ESMN name change to *European Solar Magnetism Network* symbolises that ESMN-2 will exploit this technological harvest in science applications. In addition, the European-built SOHO mission (Figure 3 on page 9) remains at the forefront in space technology for years to come. ESMN postdocs receive extensive training in working with these advanced technologies.

Socio-economic reasons. European solar physics presently leads the world in groundbased observation, polarimetry and numerical modelling, and remains at the forefront in spacebased observing. The ESMN integrates these efforts and strengthens the European leadership. It fully exploits the opportunities offered by the world's premier solar telescope park (Canary Islands) and the highly successful SOHO mission by moulding these considerable European investments into a coherent programme of attack on solar magnetism.

Training a new generation of solar physicists enables Europe to exploit its investments, participate fully in the rising global interest in space weather and its causes, and counteract the persistent brain drain to the US in this expanding field. ESMN postdocs are well trained in solving complex problems involving large amounts of data, skills that are crucial in many areas of both science and industry. The ESMN extension to Associated State partners may help convince young researchers from EU–candidate countries that Western Europe provides career perspectives competitively to the US.

Timeliness. The Canary Island telescopes, image restoration, polarimetric instrumentation and advanced analysis methods together constitute a unique combination of facilities ripe for a rich yield in collaborative studies of solar magnetism. These will also prime Europe for ambitious future magnetometry from the ground (GREGOR, ATST) and from space (Solar-B, Solar Orbiter missions).

[1]The ESMN is currently funded as TMR programme during 1998–2002, designated below as ESMN-1 where distinction from the present proposal ("ESMN-2") is needed. Details on ESMN-1 including the yearly and mid-term reports are available at http://www.astro.uu.nl/∼rutten/tmr/. In a nutshell, ESMN-1 achieved the completion of the DOT and THEMIS telescopes (Figure 1), will achieve the replacement of the SVST by the NSST, installed various new Stokes polarimeters, advanced software techniques for data inversions and interpretation, ran successful multi-telescope campaigns, and progressed well in theoretical modelling techniques. The ESMN-1 emphasis was on magnetometry technology and methodology; it shifts to science applications in ESMN-2.

1b. Project Objectives

Overview. The ESMN goal is to gain basic insight in the roots of solar magnetism by establishing the structure and dynamics of magnetic fields at the solar surface, charting the patterns that constrain the solar dynamo, and identifying the magnetic coupling between the different solar regimes from the interior to the corona. The three ESMN-2 science objectives are:

(a) structure and dynamics of solar surface fields;

(b) topology and evolution of solar active regions;

(c) magnetic coupling between the solar interior, photosphere, and outer atmosphere.

They are detailed below and broken down in tasks in Section 4. The ESMN partners will combine effort and expertise in a coordinated attack with the following ESMN-2 implementation objectives:

(d) perfection of magnetometry instrumentation and methodology;

(e) solar magnetometry through multi-telescope observing campaigns;

(f) interpretation through numerical inversions and simulations,

which are detailed in Section 3 with task breakdown in Section 4 and Table 1. All tasks require specific ESMN cooperations of which the effectuation, with a key role for the ESMN postdocs, capitalises on Europe-wide know-how and intensifies Europe-wide collaborative research[2].

Objective (a): Structure and dynamics of solar surface fields. Solar surface magnetism consists of a remarkable hierarchy of discrete strong-field structures with highly dynamic patterning (as may be appreciated by playing the spectacularly vivid speckle movies available at http://dot.astro.uu.nl). The basic entity consists of the tiny *flux tubes*. They constitute an important astrophysical paradigm, pertinent also to accretion disks and other faraway objects but directly observable only on the sun thanks to the advent of speckle image restoration and adaptive optics wavefront correction. They are arranged into a *magnetic network* pattern by convective surface flows and occur at larger density in *solar plage* (faculae) which is an important modulation ingredient in the solar irradiance. Detailed examination of the dynamical network configuration at the solar surface may also resolve the ongoing debate in what measure continuous *micro- or nano-flaring* contributes steady heating to the corona.

It is highly probable that much weaker fields permeate the *internetwork* areas between flux tube clusters, but internetwork fields have not been diagnosed yet convincingly. They should constitute a weak-field dynamo which may play an important role in setting solar variability.

The larger elements in the strong-field magnetic hierarchy (*pores, umbrae*, larger spots with *penumbrae*, and fully-developed *active regions*) also pose a rich variety of astrophysics research issues and contribute solar modulation input. For example, sunspot oscillations provide important lessons in magnetohydrodynamics. In particular, concerted observation and numerical simulation of wave modes will establish how weak shocks travel up in the umbral chromosphere as *umbral flashes* and how *running penumbral waves* persist into the corona in the outer sunspot reaches.

Prominences are enigmatic cool condensations in the hot corona that are sustained and thermally isolated by highly complex magnetic fields. Advanced polarimetry including Hanle diagnostics will permit mapping the field configuration with unprecedented angular and temporal resolution and to establish the magnetohydrodynamical prominence structuring and instability mechanisms. These are also of interest to terrestrial studies of magnetic confinement in Tokamaks and related plasma fusion experiments.

Solar *eruptions* accelerate particles to relativistic speed and unleash powerful *coronal mass ejections* into space, producing significant effects in the near-earth environment. Multi-telescope observations combining

[2] ESMN constitution: the admission of new Associated States to the EC Fifth Framework Programme enables the ESMN to open up its facilities and methodologies to new Eastern European partners with interest and expertise in solar magnetism. The present proposal expands the ESMN with three well-established groups with existing ties to ESMN-1 partners (teams AsU, AISAS, ELTE), enabling them to participate in joint observing campaigns and analysis and modelling efforts. The ESMN also welcomes a new Italian partner (OAA) which replaces the ESMN-1 group at Naples whose principal interest has shifted from solar magnetism to helioseismology in the meantime. The strong OAA links to other partners and the sizable OAA contributions to ESMN tasks are detailed in Sections 4 and 5.

magnetometry at high angular and temporal resolution with space diagnostics including HESSI X-ray mapping should manage to catch flares and prominence eruptions while solar activity remains high the coming years, and chart these events in diagnostic detail at different atmospheric levels.

Objective (b): Topology and evolution of solar active regions. *Active regions* bring much large-scale magnetic flux to the solar surface, are the seat of eruptive activity, and provide key insights into the ill-understood dynamo processes that produce the solar activity cycle.

Bipolar active regions (simple sunspot pairs connected by coronal loops) are the building blocks of the larger and more complex active regions which produce eruptive activity when their topology favours formation of *current sheets* and occurrence of *magnetic reconnection.* Flares and prominence eruptions draw their energy from sudden relaxation of the magnetic field, but the trigger mechanism remains unknown. The precursor geometry may be identified through comparison of the before-and-after coronal field topology derived from high-resolution surface magnetometry, with extrapolative identification of magnetic nulls, separators, separatrices and quasi-separatrix layers where reconnection may occur, and with special emphasis on the topological role of field helicity.

Active regions result from the emergence of flux tube systems that rise from the base of the convection zone through buoyancy influenced by the Coriolis force, magnetic tension, drag, vorticity and other effects. The emergence and disappearance of active regions and their preferential grouping in *activity nests* over long time scales betray solar dynamo properties that also contribute to the erratic cyclical modulation of solar activity. The observational strategy to understand this behaviour is to combine solar surface magnetometry with sufficient resolution, field size and duration with numerical dynamo modelling. MDI on SOHO is the key long-sequence instrument while shorter-duration studies of individual active regions at higher resolution will shed light on active region emergence and decay.

Objective (c): Magnetic coupling between the solar interior, photosphere and outer atmosphere. The solar surface is not only the layer where the bulk of the solar radiation leaves our star and where the dynamo patterns generated in the interior are directly observable, but it is also the layer where gas pressure gives in to magnetic pressure. The dynamics of the photosphere with its granulation and turbulent wave excitation is hydrodynamically controlled outside active regions, but the coronal topology and dynamics are governed by magnetism. Since the coronal fields are rooted in the photosphere (no magnetic monopoles) their changing configurations are dictated by photospheric foot point motions: there is *magnetic coupling* between the regimes. It is also likely that MHD disturbances excited in the low atmosphere contribute substantially to coronal heating and the generation of the solar wind.

Just above the photosphere the flux tubes merge into the *chromospheric network.* It contributes most of the solar variability in the ultraviolet but the network heating process has not yet been identified. Likely candidates are various types of magnetohydrodynamic waves and dissipation of magnetic shear and stress induced by the perpetual displacements of the photospheric tubes. Mapping time-dependent flux tube topology and analysing flux tube dynamics is a high-priority quest for high-resolution magnetometry.

Yet higher up, the magnetic network expands into *magnetic canopies* above which all gas motions are constrained by the ambient field. Canopy geometries, canopy dynamics (including wave mode conversions from acoustic and internal gravity to Alfvén waves) and canopy linkages across network cells are key research topics for concerted photosphere–chromosphere imaging the coming years.

At coronal levels, the basic building block is the *coronal loop*, delineating slender field configurations at specific temperature that become visible through density contrasts. The connection between the basic photospheric and coronal field structures is highly enigmatic—how do tubes turn into loops? Observations in Hα and EUV lines indicate a plethora of low-lying finely-scaled structures with rapid large-amplitude dynamical changes, making clear that traditional assumptions as hydrostatic equilibrium and axial symmetry ("plane-parallel layers" with a "transition region") must be replaced by much more sophisticated magnetohydrodynamical modelling and interpretation based on multi-diagnostic ground- and space-based data gathering.

Interest in the electrodynamical coupling between the low and high solar atmosphere transcends solar physics because via the solar wind, cosmic ray modulation, and coronal mass ejections it extends to the near-earth environment and the terrestrial climate.

2. Scientific Originality

Canary Island Telescopes. Figure 1 (next page) portrays and summarizes the unique solar telescope array on the Canary Islands that constitutes the ESMN's "capital" in cutting-edge telescope technology. Each telescope represents or will represent the state of the art in key techniques. Collectively, they represent a formidable and unsurpassed facility for solar research, in particular solar surface magnetometry. The five telescopes are highly complementary so that multi-telescope co-observing is a major ESMN strategy. The ESMN partner teams either control these telescopes or have frequent access and succeeded during ESMN-1 to put two of them in operation (THEMIS and DOT) with a third one (NSST) to follow soon. The Network also built and maintains multiple high-sensitivity magnetometers and develops sophisticated analysis and data inversion software to interpret magnetometry data. The newest telescopes are briefly described here.

- THEMIS: the major French-Italian facility for groundbased solar physics which came into full operation in 1999. At 90 cm aperture presently one of the largest solar telescopes in the world it has already demonstrated excellent potential in high-precision polarimetry, including intriguing high-quality observations of the so-called "second solar spectrum" (near-limb linear polarisation). The THEMIS consortium is currently designing an adaptive optics system to be integrated with the telescope by 2004 in order to optimise the performance with respect to angular resolution, while OAA team develops the Interferometric Bidimensional Spectrometer (IBIS) which will be perfectly suited for filter magnetometry exploiting the excellent THEMIS polarisation properties. With these technologies THEMIS is likely to represent the state of the art in high-precision filter- and spectropolarimetry. Website: www.themis.iac.es.
- DOT: a much smaller but revolutionary telescope. Its open structure represents the first test of the non-vacuum technology needed for future solar telescopes with apertures to exceed the size limit set by vacuum windows, a tactic now followed for GREGOR and ATST[3]. After its initial test period including highly successful trials of speckle reconstruction (an ESMN-1 effort) the DOT is presently being equipped with a sophisticated five-camera speckle acquisition system that will turn it into an ideal high-resolution (0.2 arcsec) context mapper for nearly any ESMN observing campaign. It will define the state of the art in tomographic large-field imaging. Website: dot.astro.uu.nl
- NSST: during the ESMN-1 period the KVA team successfully proposed to rebuild their SVST into a twice-larger telescope, a major and highly ambitious project that will probably deliver the first meter-class solar telescope worldwide achieving 0.1 arcsec angular resolution consistently over very long durations, a quantum jump in observational solar physics. The project originated from adaptive optics tests at the SVST which demonstrated that this technology is sufficiently mature to become a standard asset in optical solar observing (harder than in nighttime astronomy since the sun is an extended low-contrast object and actually low on photons at high resolution within the solar scene change time). The NSST design and construction proceed so fast that it will probably be available at the ESMN-2 start. It will define the state of the art in high-resolution solar imaging during the entire ESMN-2 period. Website: www.astro.su.se/groups/solar.
- GREGOR: a similar rebuilding of the GCT to larger aperture is now being undertaken as a national German project, turning it into a 1.5 m open reflector with adaptive optics that will advance the state of the art in high-resolution magnetometry to well beyond the one-meter aperture class reached (almost) by THEMIS and NSST. The axially symmetric design will allow high-precision spectropolarimetry with very low instrumental polarisation. It may become operational towards the end of the ESMN-2 period. Teams AIP and AsU participate jointly in its realisation. Website: gregor.kis.uni-freiburg.de.

Stokes magnetometry. The state of the art in Stokes vector spectropolarimetry (measuring all four Stokes parameters I, Q, U and V through complex polarisation diagnostics and calibration procedures) is currently reached most prominently by the TIP (Tenerife Infrared Polarimeter) installed by the IAC team at the German VTT telescope. The further development of Stokes spectropolarimetry will continue as large-priority activity in many teams (IAC, OP, AIP, OAA, KVA).

[3] *Advanced Technology Solar Telescope*, major project of the US solar physics community led by the National Solar Observatory aiming at a 4-meter class telescope—but well beyond the ESMN-2 duration. The Canary Islands are presently considered a potential ATST candidate site.

In additon, the IAC, OP and OAA teams together are world leader in the theory and calibration of polarised radiative transfer, with much ESMN-linked effort by IAC and OP on inversion methodology. These programmes strengthen the diagnostic value of solar magnetometry because Stokes vector spectropolarimetry requires sophisticated spectral-line modelling to derive the magnetic field vector amplitude and orientation. The huge amounts of data that the new instruments will generate may be handled efficiently by artificial neural networks as developed by the AIP team.

Space telescopes. SOHO (Solar and Heliospheric Observatory) remains the flagship of spacebased solar physics the coming years. Figure 3 on page 9 shows an example of its tomographical mapping capability. SOHO keeps operating very successfully while orbiting the first Lagrangian point of the sun-earth system. Presently the US TRACE mission adds ultraviolet imaging, often in concert with SOHO's Michelson Doppler Imager (MDI) and groundbased magnetometry. The Japanese-led Solar-B mission is slated for launch in 2005 and will put the first Stokes vector spectropolarimeter in space. Subsequently, the Solar Orbiter mission accepted by ESA will put a solar magnetograph as close as 0.2 AU to the sun at steadily increasing out-of-ecliptic latitude. These major space projects effectively confirm the importance of the ESMN research topic and represent an important career perspective for the young ESMN researchers.

Numerical modelling. Direct confrontation of observations with concerted numerical modelling has proven to be a particularly fruitful solar physics venue. Current ESMN collaborations led by UiO use actual data as simulation input in order to enable direct comparison with diverse observational diagnostics including spectral sequences from Canary Island telescopes and from SOHO. The same forward-modeling-plus-reproduction approach is taken by the ELTE team with regards to active region patterning and by AIP in simulating magneto-atmospheric waves in sunspot atmospheres.

Figure 1: Portrait gallery of European groundbased telescopes in order of ascending aperture. From left to right:
• DOT (Dutch Open Telescope), La Palma, aperture 45 cm, operational since 1999. Its fully open design minimises disturbance of the excellent atmospheric conditions at La Palma. Suited to high-resolution proxy magnetometry. A large-volume five-wavelength speckle pipeline system is being installed which will generate up to 0.5 Tbyte of wide-field tomographic imaging per observing day. Website: dot.astro.uu.nl.
• GCT (German Gregory Coudé Telescope), Tenerife, aperture 45 cm. Vacuum reflector that is especially suited to spectrographic magnetometry. It will be rebuilt into the open 1.5 m GREGOR reflector during the ESMN-2 period. Website: www.uni-sw.gwdg.de/research/exp_solar/GCT_text.html.
• VTT (German Vacuum Tower Telescope), Tenerife, aperture 70 cm. General-purpose solar telescope with extensive post-focus equipment for imaging and spectrometry. A low-order adaptive optics system saw first light recently. Website: www.kis.uni-freiburg.de/kiswwwe.html.
• THEMIS (French-Italian Télescope Héliographique pour l'Etude du Magnétisme et des Instabilités Solaires), Tenerife, aperture 90 cm, operational since 1999. Specifically designed for high-resolution magnetometry. Post-focus equipment includes an elaborate spectrometer designed for very sensitive multi-line Stokes vector magnetometry and MSDP (Multichannel Subtractive Double Pass) 2D spectrometry with magnetographic capability, and the Italian Panoramic Monochromator which will be replaced by the state-of-the-art IBIS interferometer the coming years. Website: www.themis.iac.es.
• NSST (New Swedish Solar Telescope), La Palma, aperture 96 cm. This successor to the SVST (Swedish Vacuum Solar Telescope) was proposed and started during ESMN-1. Expected to be operational from 2001 onwards. Vacuum refractor with adaptive optics that will provide breakthrough resolution (0.1 arcsec) to optical solar physics. Stokes vector magnetometry is foreseen. Website: www.astro.su.se/groups/solar.

3. Research Method

The implementation objectives (d) – (f) define tasks that together make up specific ESMN methodology in addition to the standard practices of astrophysical research. They are described here and charted in Table 1 in the next section.

Objective (d): Perfection of magnetometry instrumentation and methodology. These tasks complete ESMN-1 efforts in solar magnetometry. The various tasks are split in techniques:

– *Image restoration.* Speckle imaging at the DOT and adaptive optics at the NSST will make these telescopes the first Canary Island ones consistently reaching resolution close their respective diffraction limit, often in concert assisted by the fact that the DOT is operated from the NSST building. On a longer time scale, adaptive optics will also be developed at THEMIS (and at the German telescopes but not in ESMN context). In addition, the phase-diverse imaging methods for wavefront estimation developed by KVA will be extended to wider applications.

– *Filter magnetometry.* The DOT, NSST, and THEMIS instrumentalists will also share developments in filter magnetometry, with expertise being provided by the IAC team. For the DOT these include polarimetric tests with a tunable Ba II 455.4 nm filter provided by colleagues from Irkutsk through an INTAS grant. At THEMIS they include realisation of the Italian IBIS interferometer (OAA team), at the NSST tunable filters to be combined with fixed and variable polarisation retarders.

– *Spectropolarimetry.* Perfection of the new IAC and AIP spectropolarimeters at the German telescopes, of THEMIS spectropolarimetry, and installation of new versions of the IAC-built LPSP spectropolarimeter at the VTT and NSST are important collaborative ESMN tasks, as is spectropolarimetric calibration (especially for the heliostat-fed VTT and NSST).

Objective (e): Solar magnetometry through multi-telescope observing campaigns. The ESMN will continue the regular organisation of multi-telescope observing campaigns and spend effort on related tasks such as data dissemination. Tasks:

– *Campaign coordination.* The multi-telescope joint programme procedures will again follow the mechanisms evolved by the ESA team for SOHO, with JOP (joint observing programme) setup through email and daily targetting through WWW linkage.

– *Joint multi-telescope campaigns.* A principal ESMN activity. Most campaigns will take place during May–October when the probability of excellent seeing at the Canary Islands is highest. The durations are typically 1–3 weeks.

– *Data dissemination.* The ESMN will join current efforts towards realisation of the "Virtual Solar Observatory", which will open solar physics data bases worldwide to qualified researchers via the web through sophisticated search engines. In addition, the ESMN will continue its efforts in establishing, maintaining, and streamlining national and transnational data archives.

Objective (f): Interpretation through numerical inversions and simulations. Numerical data analysis, data inversions and simulations of actual data provide the theoretical framework in which the ESMN interpretes its observations. Specific tasks:

– *Data analysis.* An area of intense worldwide collaboration through the SolarSoft IDL library and other joint software packages to which the ESMN contributes. The dynamical character of solar structures put heavy emphasis on time-dependent data analysis including advanced Fourier analysis. The joint development of appropriate analysis software is a key reason for intense ESMN young-researcher collaboration.

– *Data inversions.* The IAC team is world leader in polarimetric data inversions, a technique getting much attention now also at OP, AIP, and OAA. It is quite clear that all future spectropolarimetry will have to rely on elaborate inversion modelling for interpretation, especially with respect to chromospheric structures and prominences.

– *Data simulations.* The technique of numerically simulating actual data was pioneered by UiO in the context of acoustic oscillations. It must be expanded to MHD wave modes (with emphasis on canopy structure) and to different field regimes including sunspots (objective (a)). The same tactic will be developed for active region topology and evolution (objective (b)) and to model the magnetic coupling between photosphere and outer atmosphere (objective (c)).

4. Work Plan

Specifications. Table 1 specifies the work division, Table 2 specifies the manpower investments. A scheduling chart is given in Figure 2 on page 9. The collaborative Network tasks are split between science tasks itemized in Table 1 that together make up the objectives (a) – (c) of Section 2, the implementation tasks (d) – (f) described in Section 3, and the training elements defined in Section 10 with the partner task distribution shown in Table 4 on page 25.

Timing aspects. ESMN-1 ends April 30, 2002. If accepted, the ESMN prefers to continue without break but another starting date set by EC constraints will pose no serious problem. The multi-telescope campaigns will mostly take place during the May–October good-seeing season. Within these periods, they will be set by telescope scheduling, in particular for the larger national facilities and for SOHO. Therefore, the timing schedule in Fig. 2 may slide within the four-year frame and be time-warped somewhat.

Network get-togethers will take place as specific ESMN meetings and as special sessions during the yearly solar physics Euroconferences and other international meetings.

The ESMN summer schools may actually take place in autumn or winter (as is traditionally the case for the IAC's regular winter school programme).

Milestones, mid-term review, final report. Major milestones for assessment, in particular at the mid-term review but also in the yearly reporting, are:

– postdoctoral researchers hired as proposed;
– gender aspects positive;
– results and joint publications on science objectives (a) – (c);
– demonstrated progress in implementation objectives (d) – (f);
– effective multi-telescope campaign coordination;
– multi-telescope campaigns completed and successful;
– summer/winter schools completed and successful;
– technological, observing and analysis training given;
– industrial training realised;
– effective networking between partners, including postdoc exchanges and including the Associated State teams;
– presentation training successful;
– public outreach effectuated.

At the completion, the Final Report will enable assessment on the overall results:

– successful completion of the full training programme;
– effective integration of the Associate State teams;
– successful implementations (tasks (d) – (f));
– breakthrough results on solar magnetism (tasks (a) – (c));
– high-visibility public outreach.

Subcontracting. None.

Science Objective	Task	Teams
(a) Surface Fields	(a1) flux tubes	KVA+UU+OAA+AISAS
	(a2) weak fields	IAC+OAA+OP
	(a3) sunspots	all teams
	(a4) prominences	OP+AsU+OAA+UiO+AISAS
	(a5) eruptions	OP+AsU+OAA
(b) Active Regions	(b1) topology	ELTE+AsU+OP+ESA+AISAS+KVA
	(b2) evolution	ELTE+AsU+OP+ESA+AISAS+KVA
(c) Magnetic Coupling	(c1) interior–surface	ELTE+AsU+IAC
	(c2) photosphere–chromosphere	UU+KVA+UiO+ESA+IAC+AIP
	(c3) chromosphere–corona	ESA+UU+UiO+AsU+AISAS+AIP
Implementation Objective	Task	Teams
(d) Magnetometry Perfection	(d1) image restoration	UU+KVA+OP
	(d2) filter magnetometry	UU+OAA+IAC+KVA
	(d3) spectropolarimetry	IAC+OP+OAA+AIP+KVA
(e) Multi-Telescope Observing	(e1) campaign coordination	ESA+OP+others
	(e2) joint campaigns	all teams
	(e3) data dissemination	all teams except ELTE
(f) Interpretation	(f1) data analysis	all teams except ELTE
	(f2) data inversions	IAC+OP+OAA+AIP
	(f3) data simulations	UiO+ELTE+AIP

Table 1: Network tasks and team collaborations. The upper part of this table splits the science objectives (a) – (c) into tasks in the form of specific topics. The teams listed in the third column are the primary ones involved in the corresponding collaborative research. The lower part splits the implementation objectives (d) – (f) into the tasks described in Section 3. The team abbreviations specify the primary specialists.

Participant	Professional research effort on the Network project (person-months)		Number of researchers likely to contribute to the Network project (number of individuals)
	by young researchers to be financed by the contract (a)	by researchers to be financed from other sources (b)	(c)
1. UU	30	154	6
2. IAC	30	158	8
3. OAA	30	152	7
4. UiO	30	130	7
5. KVA	30	115	6
6. AIP	30	146	6
7. OP	30	141	8
8. ESA	30	63	6
9. AsU	0	130	6
10. AISAS	0	146	6
11. ELTE	0	96	3
Totals	240	1431	69

Table 2: Promised professional research effort. The number of individual researchers in the last column includes ESMN postdocs and is the maximum expected with high confidence to be present during the project duration. The actual number may be higher depending on the presence of graduate students working on ESMN topics.

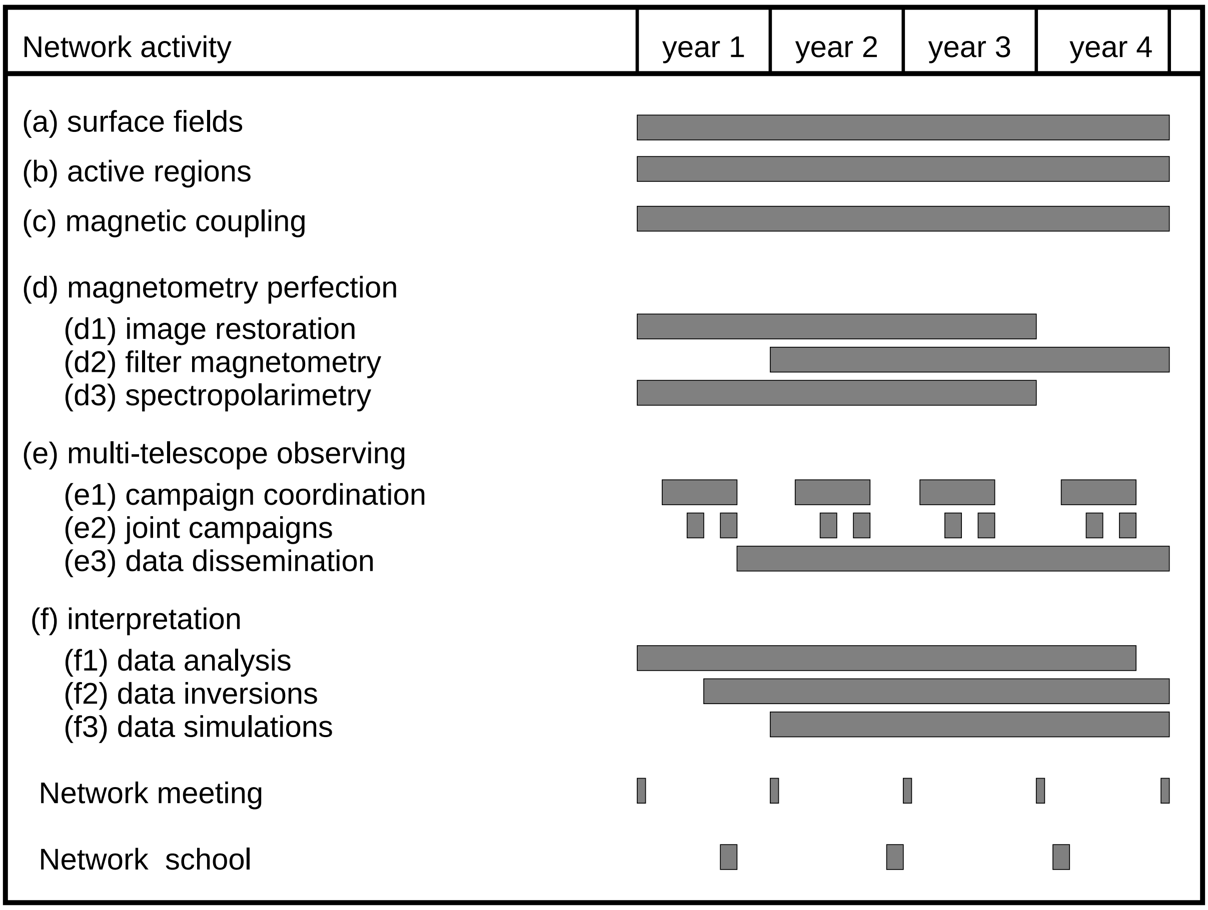

Figure 2: Planning schedule for joint activities and implementation tasks.

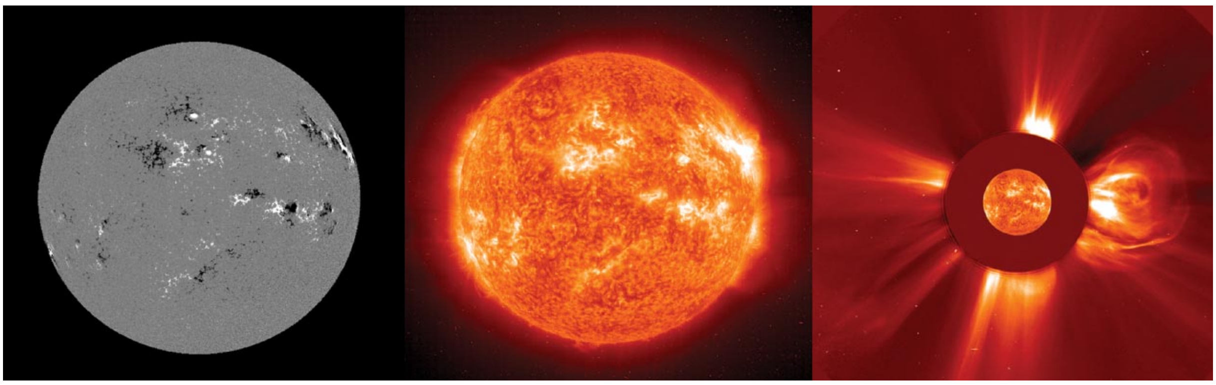

Figure 3: Magnetic coupling between the solar photosphere and the outer solar atmosphere portrayed by SOHO, in order of ascending height. From left to right:
• MDI magnetogram taken on April 2, 2001. Black and white represent strong magnetic fields with opposite polarities. Active region AR9393 (the largest sunspot group of the present cycle) was close to the western limb.
• EIT He II 304 Å image showing the distribution of hot plasma in the lower corona at the same time.
• LASCO C2 coronagraph image showing the outer corona at the time.
On this day, AR9393 produced the largest X-ray flare ever observed, and a large coronal mass ejection seen at right in the LASCO image. The sample images shown here illustrate the dramatic tomographic capability that SOHO brings to studies of solar magnetism and space weather — reliably, continuously, and for years to come. SOHO (Solar and Heliospheric Observatory) is the First Cornerstone Mission of ESA's Horizon 2000 Programme and was launched on December 2, 1995 in collaboration with NASA. Website: http://soho.estec.esa.nl.

5.1 Collective Expertise: participant UU (number 1)

Expertise. The Utrecht Sterrekundig Instituut is renown in solar physics, stellar physics, plasma astrophysics, and for its regular production of young astrophysicists. The UU efforts in solar physics now concentrate on solar instrumentation, solar surface magnetism, and chromospheric dynamics. Network-specific expertise is in spectral line formation and solar instrumentation. The team excels in advanced teaching.

Instrumentation. The UU team operates the DOT (Dutch Open Telescope) on La Palma, a novel solar telescope of highly innovative design (Fig. 1 on page 5). The telescope and support tower are transparent to the strong winds that bring the best seeing to La Palma and so minimise locally-induced disturbance. The DOT is operated from the nearby NSST building (KVA) and is presently being equipped with a sophisticated multi-camera multi-wavelength speckle data-acquisition system. Connections to industry concern mechanical telescope drives (both DOT and NSST) and high-quality optics manufacture. Details: http://dot.astro.uu.nl.

Network role. The UU team will, in addition to ESMN coordination, concentrate on objectives (a), (c), (d) and (f). Specific Network tasks are to operate the DOT for ESMN campaigns (often in tandem with KVA operation of the NSST) in which the DOT will supply large-field proxy magnetometry at high angular resolution, to embark with IAC on high-resolution Stokes magnetometry using a Russian (INTAS-supported) narrowband Ba II filter at the DOT, and to develop Hα diagnostics with AsU. UU undergraduate and graduate students will extensively be involved in Network activities, and the UU team will spend extra effort on ESMN training including summer school organisation. It will also maintain the principal ESMN website.

Research linkages. The UU team has had intensive collaborations with the UiO, KVA and IAC teams and presently collaborates with the KVA, AIP and AsU teams. The wide-field high-resolution proxy magnetometry that the new DOT data-acquisition system delivers constitutes unique context information for most ESMN programmes. The DOT installation on La Palma enjoys hospitality of the KVA and IAC.

Key scientific staff & involvement in ESMN research (ESMN scientist in charge underlined):

Scientist	Specialism	Experience	Involvement	
<u>Dr. R.J. Rutten</u>	line formation	32 years	60%	coordination, analysis
Dr. R.H. Hammerschlag	instrumentation	31 years	80%	instrumentation
Ir. F.M. Bettonvil	instrumentation	10 years	80%	instrumentation & observing

Current temporary staff working on ESMN topics: postdoc P. Sütterlin (ESMN) and graduate student J.M. Krijger, plus undergraduate students. It is expected that two more graduate students will participate in ESMN research the coming four years.

Recent publications:

Rutten, R.J., Hammerschlag, R.H., Sütterlin, P., Bettonvil, F.C.M., van der Zalm, E.B.J., 2001, "Solar magnetometry with the Dutch Open Telescope", in "The Solar Cycle and Terrestrial Climate", *ESA Special Publications* SP-463, 611–616. Also available at http://dot.astro.uu.nl.

Sütterlin, P., Hammerschlag, R.H., Bettonvil, F.C.M., Rutten, R.J., Skomorovsky, V.I., Domyshev, G.N., 2001, "A Multi-Channel Speckle Imaging System for the DOT", in M. Sigwarth (Ed.), Advanced Solar Polarimetry – Theory, Observation, and Instrumentation", *Astronomical Society Pacific Conference Series*, in press. Preprint available at http://dot.astro.uu.nl.

5.2 Collective Expertise: participant IAC (number 2)

Expertise. The Instituto de Astrofísica de Canarias (Tenerife, Spain) has internationally recognized experience in astrophysics and contains one of the largest and youngest solar physics groups in Europe. In particular, the IAC team has wide Network-relevant expertise in high-precision spectropolarimetry, instrumentation for solar polarimetry, magnetometry methods based on the Zeeman and Hanle effects, radiative transfer theory and modelling, and numerical inversion techniques of polarization data. The IAC team also has much experience in organising conferences and advanced schools, and it puts much effort in disseminating science results to the general public.

Instrumentation. Through international agreements the IAC controls 20% of the observing time at each Canary Island telescope with additional 5% access through international collaborations. During ESMN-1 the IAC team successfully developed two novel polarimeters for the near-infrared and visible domains. The Tenerife Infrared Polarimeter (TIP) is presently operational at the German VTT while the La Palma Stokes Polarimeter (LPSP) will be adapted to both the VTT and the NSST in order to achieve Stokes spectropolarimetry with unprecedented polarimetric accuracy and spatial resolution.

Network role. The IAC team functions as ESMN pivot, facilitating use of all Canary Islands solar telescopes and contributing to ESMN training. Its main science tasks will be high-precision spectropolarimety, interpretation in terms of the Zeeman and Hanle effects, and applications to solar photospheric and chromospheric magnetism. Some graduate students will also be involved in ESMN activities.

Research linkages. The IAC team has excellent contacts with all other network teams, at present having close collaborations with the OAA and AsU partners. Collaborations with the KVA, UU, AIP and OP teams are likely to be enhanced in ESMN context.

Key scientific staff & involvement in ESMN research (ESMN scientist in charge underlined):

Scientist	Specialism	Experience	Involvement	
Dr. J. Trujillo Bueno	spectropolarimetry	15 years	60%	theory and observation
Dr. J. A. Bonet	observation	25 years	30%	telescope coordination
Dr. M. Collados	instrumentation	15 years	60%	THEMIS+VTT+TIP
Dr. V. Martínez Pillet	instrumentation	13 years	60%	NSST+VTT+LPSP
Dr. I. Rodriguez Hidalgo	solar physics	14 years	30%	public outreach
Dr. V. B. Ruiz Cobo	inversion techniques	14 years	30%	Stokes diagnostics
Dr. J. Sánchez Almeida	spectropolarimetry	14 years	60%	theory and observation

Current temporary staff working on ESMN topics: postdoc O. Dittmann (ESMN) and graduate student A. Asensio. One or two other graduate students are also expected to work on ESMN topics the coming four years.

Recent publications:

Socas Navarro, H., Trujillo Bueno, J., Ruiz Cobo, B., 2000, "Anomalous Polarization Profiles in Sunspots: Possible Origin of Umbral Flashes", *Science* 288, 1396–1398.

Sánchez Almeida, J., Lites, B.W., 2000, "Physical Properties of the Solar Magnetic Photosphere under the MISMA Hypothesis. II. Network and Internetwork Fields at the Disk Center", *Astrophysical Journal* 532, 1215–1229.

5.3 Collective Expertise: participant OAA (number 3)

Expertise. The Osservatorio Astrofisico di Arcetri in Florence has a century-old tradition of solar physics studies, reflected by a large number of researchers involved in related solar and plasma physics. ESMN expertise includes solar surface magnetism, studies of explosive phenomena, solar instrumentation, and the theory of the generation and transfer of polarised radiation in stellar atmospheres. The OAA polarimetry expertise is widely recognised and represents a fundamental asset to the Network, providing basic tools for the interpretation of solar magnetometry data. Much experience is now also gained in acquisition and analysis of large multiwavelength data sets for active region studies.

Instrumentation. The OAA team shares access to the French-Italian THEMIS telescope with 15% observing time guaranteed to Italian researchers. The OAA operates and maintains the Italian Panoramic Monochromator (IPM) on THEMIS and currently develops a next-generation tunable filter (IBIS = Interferometric BIdimensional Spectrometer) to be installed at THEMIS in 2003. IBIS will observe a large two-dimensional field of view with fast spectral scanning over an extended wavelength range. In combination with the excellent polarisation analysis capabilities of THEMIS, IBIS will operate as a high-performance precision magnetometer.

Network role. The OAA team will concentrate on objectives (a), (d), (e) and (f). Specific Network tasks are the completion of IBIS and its implementation at THEMIS and the development of theoretical tools for the interpretation of novel polarimetric observations. The team will actively participate in the organisation and management of ESMN observing campaigns and subsequent multi-wavelength data analysis. Undergraduate and graduate students will be actively involved in Network activities. The team will provide ESMN training, including teaching at ESMN schools.

Research linkages. The OAA team presently collaborates with the IAC and OP teams. The ESMN activities will enhance its contact with other teams. The team also houses the secretariat of the European Joint Organisation for Solar Observations (JOSO) which is actively involved in the organisation of solar physics Euroconferences.

Key scientific staff & involvement in ESMN research (ESMN scientist in charge underlined):

Scientist	Specialism	Experience	Involvement	
<u>Dr. G. Cauzzi</u>	solar magnetism, JOSO	12 years	70%	observations, IBIS
Prof. E. Landi degl'Innocenti*	polarisation theory	30 years	70%	theory and modelling
Dr. F. Cavallini	instrumentation	25 years	70%	IBIS instrumentation
Dr. M. Landolfi	polarisation theory	24 years	50%	theory and modelling
Dr. A. Falchi	stellar atmosphers, flares	30 years	40%	observations, IBIS

* Formally employed by the University of Firenze but part of the OAA team.

Current temporary staff working on ESMN topics: postdoc R. Manso-Sainz (UoF), one undergraduate student.

Recent publications:

Cauzzi, G., Falchi, A., Falciani, R., 2001, "Search for Microflaring Activity in the Magnetic Network", *Solar Physics* 199, 47–60.

Landi degl'Innocenti, E., 1998, "Evidence against Turbulent and Canopy-like Magnetic Fields in the Solar Chromosphere" *Nature* 392, 256–258.

5.4 Collective Expertise: participant UiO (number 4)

Expertise. The Institute of Theoretical Astrophysics of the University of Oslo has a strong position in solar physics. The UiO efforts in solar physics now concentrate on solar surface magnetism, chromospheric dynamics, chromospheric line formation, transition region and coronal physics, and the solar wind. The team has an excellent track record in these areas. Network-specific expertise is in spectral line formation, radiation hydrodynamics and observing. The Oslo team is word leading in realistic radiation hydrodynamics simulations of chromospheric dynamics.

Instrumentation. The UiO team is co-investigator in both SOHO/CDS and SUMER which provide excellent space based observations. UiO has also a 10% share in the NSST. The team's numerical simulations are very demanding in computer power. Access to powerful computing platforms is secured at the institute level through a tightly coupled 12-CPU cluster with Gigabit connections, 12 Gbyte memory and an 850 Gbyte disk system. Powerful graphical workstations permit real-time 3D volume rendering. The team also has access to a 44-CPU computer at the faculty level and other supercomputers at the national level, linked to the institute through networks with bandwidth of 100 Mbit/s or more.

Network role. The key task for the UiO team consists of the interpretation of Network observations by performing pertinent radiation hydrodynamics simulations (objectives (b) and (f)). The UiO team will spend extra effort on ESMN training including summer school organisation.

Research linkages. The UiO team collaborated intensively with the UU, KVA and OP teams in the past and looks foward to continuing these as well as enhance its contacts with other partner teams.

Key scientific staff & involvement in ESMN research (ESMN scientist in charge underlined):

Scientist	Specialism	Experience	Involvement	
Prof. M. Carlsson	radiation hydrodynamics	21 years	70%	modeling
Prof. O. Engvold	solar physics	36 years	10%	observations
Prof. V. Hansteen	radiation hydrodynamics	16 years	50%	modeling

Current temporary staff working on ESMN topics: postdocs C. Rosenthal (ESMN) and A. McMurry, graduate students E. Sollum and S. Bard, plus undergraduate students. It is expected that one more graduate student will obtain a PhD on ESMN research the coming four years.

Recent publications:

Rosenthal, C.S., Bogdan, T.J., Carlsson, M., Hansteen, V., McIntosh, S., Nordlund, Å., Stein, R.F., 2000, "Wave Propagation in the Magnetised Solar Atmosphere", in "Recent Insights into the Physics of the Sun and Heliosphere: Highlights from SOHO and other Space Missions", *Proceedings IAU Symposium No. 203*, E18.

Carlsson, M., Stein, R.F., 1997, "Formation of Calcium H and K Bright Grains", *Astrophysical Journal* 481, 500–514.

5.5 Collective Expertise: participant KVA (number 5)

Expertise. The KVA team belongs to the Royal Swedish Academy of Sciences but is also (starting June 18, 2001) part of the Stockholm Center for Physics, Astronomy and Biotechnology. Over the past 20 years, the team has developed world-leading competence in radiative transfer methods, solar atmosphere modeling and diagnostics, solar physics instrumentation, and image restoration techniques (phase diversity methods).

Instrumentation. The 48 cm Swedish Vacuum Solar Telescope (SVST) on La Palma, widely recognized for its high optical quality, is now being replaced by the 96 cm NSST (see Figure 1 on page 5). With its integrated adaptive optics system, the NSST will be the largest high-resolution solar telescope in the world and provide unique potential for high-resolution imaging, spectroscopy and polarimetry. The instrumentation developed for NSST also includes a new fast tip-tilt mirror. A new spectrograph for simultaneous observation in multiple wavelength regions is planned for 2002. Sophisticated image acquisition systems will allow several large-array CCD cameras to operate simultaneously and employ phase-diversity wavefront sensors for image restoration. Tunable narrow-band filters will also be available. More information at http://www.astro.su.se/groups/solar/.

Network role. The KVA team will contribute to all objectives (a) – (g). It will run the NSST in Network observing campaigns, continue to accommodate the DOT operation in its observatory building, and it will not only continue its pioneering efforts to significantly improve the spatial resolution of solar imaging magnetometry but also assist the other telescope-owning teams in adopting these new techniques. The KVA team will continue its efforts in interpreting observational data by use of numerical simulation and inversion.

Research linkages. The KVA team expects close collaborations in particular with the UU, UiO (which has a 10% share in NSST), and IAC teams as well as the Lockheed-Martin Solar and Astrophysics Laboratory. In addition, the KVA team will continue to collaborate with Compaq Equipment on the development of adaptive optics and correlation tracker systems, and aims to continue its practice of making its designs and software available to other ESMN groups.

Key scientific staff & involvement in ESMN research (ESMN scientist in charge underlined):

Scientist	Specialism	Experience	Involvement	
<u>Prof. G.B. Scharmer</u>	instrumentation, rad. transf.	21 years	80%	instrumentation, analysis
Dr. D. Kiselman	atmospheric modeling	11 years	40%	observation, interpretation
Dr. M.G. Löfdahl	wavefront sensing	9 years	30%	image restoration, AO

Current temporary staff working on ESMN topics: postdoc S.B.F. Dorch (ESMN), graduate students L. Rouppe van der Voort (KVA) and B. Gudiksen (ESMN). It is expected that on average 1.5 graduate student will work on ESMN topics the coming four years.

Recent publications.

Dorch, S.B.F., Archontis, V., Nordlund, Å., 1999, "3D simulations of twisted flux ropes", *Astronomy & Astrophysics* 352, L79–82.

Scharmer, G.B., Shand, M., Löfdahl, M.G., Dettori, P.M., Wei, W., 2000, "A workstation-based solar/stellar adaptive optics system", in "Adaptive Optical Systems Technologies", *Proceedings SPIE* 4007, 239–250.

5.6 Collective Expertise: participant AIP (number 6)

Expertise. The Astrophysikalisches Institut Potsdam has a long tradition in investigations of activity phenomena induced by magnetic fields, concerning solar active regions and global solar phenomena as well as other astrophysical applications. The topology of solar magnetic structures has been investigated for more than a century; six decades ago the famous 'Einsteinturm' at Potsdam was the first European location where solar magnetic fields were measured through spectropolarimetric methods. A strong point of the team is its cooperation with other astrophysics groups such as the solar radio astronomers and the MHD turbulence and dynamo theorists at Potsdam. Training activities include lecturing at the Potsdam University and at the Berlin universities as well as hands-on training in observation techniques at the Einsteinturm.

Instrumentation. The AIP team shares access to the German telescopes on Tenerife (Vacuum Tower Telescope VTT and Gregory Coudé Telescope GCT, see Figure 1 on page 5). Together with other German solar research groups, ESMN partner AsU, colleagues at Graz (Austria) and with advice from partner UU, the team is rebuilding the GCT turning it into the 1.5 m GREGOR open telescope with adaptive optics, lightweight mirrors and an advanced polarimetry system. First light is expected in 2004 or 2005. In addition, the Einsteinturm provides an old but large (60 cm aperture) and directly accessible instrument at home which enables the team to test new instrumentation and to train young solar physicists. Details: http://aipsoe.aip.de/soe-e.html.

Network role. The AIP team will contribute its expertise in Stokes vector spectropolarimetry [objectives (d) – (f)] and in investigating the structure and dynamics of magnetic fields [objectives (a), (c)] applying both measurements and modelling. The team will increase its participation in SOHO plus ground-based telescope observing campaigns [objective (e)], and take an active part in the Network training programme.

Research linkages. The AIP team has well established collaborations with the UU, IAC, OP, ESA and AsU teams and is involved in SOHO. It looks forward to closer collaboration with the other ESMN teams. Together with other German solar physics groups, the AIP has links with industry for developing lightweight mirrors and adaptive optics, fast synchronised CCD cameras, and liquid crystal modulators for 2D spectropolarimetry. The AIP team is also involved in the EU RTN 'PLATON' network of which the research topics are complementary to the ESMN ones.

Key scientific staff & involvement in ESMN research (ESMN scientist in charge underlined):

Scientist	Specialism	Experience	Involvement	
<u>Prof. J. Staude</u>	solar magnetism	34 years	70%	modelling, interpretation
Dr. A. Hofmann	solar physics	24 years	80%	observation, analysis
Dr. H. Balthasar	solar physics	19 years	80%	observation, analysis

Current temporary staff working on ESMN topics: postdoc K. Muglach (ESMN), graduate students T. Carroll (DLR = German Space Research Center), V. Landgraf, A. Pregla, A. Settele and J. Rendtel (DFG = German Science Foundation), I. Nickelt (AIP). Another postdoc and graduate student will be funded through PLATON.

Recent publications:

Zhugzhda, Y.D., Balthasar, H., Staude, J., 2000, "Multi-mode oscillations of sunspots", *Astronomy & Astrophysics* 355, 347–354. Also available at http://aipsoe.aip.de/∼staude/.

Balthasar, H., Collados, M., Muglach, K., 2000, "Oscillations in a pore", *Astronomische Nachrichten* 121, 321–327. Preprint available at http://www.aip.de/∼preprint/Preprints.html (No. 2000-19).

5.7 Collective Expertise: participant OP (number 7)

Expertise. The Solar Astronomy Department of the Observatoire de Paris at Meudon has internationally recognized experience in solar physics and constitutes one of the largest solar physics groups in Europe. In particular, the ESMN team listed below has expertise in high-precision spectropolarimetry, instrumentation for solar telescopes, spectroscopy and polarimetry, as well as diagnostic methods (based on both the Zeeman and Hanle effects). The team also develops numerical inversion techniques of observed lines and extrapolation methods of the surface magnetic field topology to the corona. It is involved in various aspects of theoretical solar magnetohydrodynamics.

Instrumentation. The OP team has successfully developed the THEMIS telescope (Figure 1 on page 5) on Tenerife which is financed for 80% by the French solar physics community and 20% by Italian colleagues. THEMIS offers several observing modes: multi-line spectropolarimetry, spectro-imaging with polarimetry (MSDP), and monochromatic imaging with the Italian IPM (to be replaced by IBIS, see OAA description). The OP team exploits these capabilities in its THEMIS observing programmes and aims to share in further THEMIS development by the THEMIS staff at Tenerife (adaptive optics, fast CCD detectors). The OP team has also built a MSDP image formatter for the spectrograph of the German VTT on Tenerife.

Network role. The principal ESMN tasks of the OP team concern spectropolarimetry with THEMIS in coordinated campaigns and the subsequent data reduction and analysis in connection with ESMN objectives (a) and (b). In addition, the team will spend effort on polarimetric inversion techniques and the underlying theory of the Zeeman and Hanle effects. Promising graduate students and postdocs will also be involved in ESMN activities.

Research linkages. The OP team has close ties to the OAA, ELTE, AsU, IAC and ESA partners.

Key scientific staff & involvement in ESMN research (ESMN scientist in charge underlined):

Scientist	Specialism	Experience	Involvement	
<u>Dr. B. Schmieder</u>	solar physics	30 years	50%	multi-wavelength studies
Dr. J. M. Malherbe	solar magnetic fields	20 years	50%	observation + analysis
Dr. P. Mein*	spectro imagery	35 years	25%	THEMIS+VTT observations
Dr. M. Semel	spectropolarimetry	35 years	50%	THEMIS observations
Dr. V. Bommier	atomic physics	20 years	30%	THEMIS + atomic theory
Dr. G. Aulanier	extrapolation techniques	5 years	30%	3D magnetic fields
Dr. P. Demoulin	MHD	15 years	30%	theory + modelling
Dr. L. van Driel –Gesztelyi	solar physics	25 years	30%	THEMIS + space observation

*Officially retired — but not in actual practice.

Current temporary staff working on ESMN topics: postdoc K. Tziotziou (ESMN). It is expected that one or two young researchers will join on ESMN topics the coming years on other funding.

Recent publications:

van Driel-Gesztelyi L., Malherbe J.M., Demoulin P., 2000, "Emergence of a U-loop: sub-photospheric link between solar active regions", *Astronomy & Astrophysics* 364, 845.

Tziotziou K., Heinzel P., Mein P., Mein N., 2001, "Non-LTE Inversion of Chromospheric CaII Cloud-like Features", *Astronomy & Astrophysics* 366, 686.

6.8 Collective Expertise: participant ESA (number 8)

Expertise. The ESA Solar System Division at ESTEC (Noordwijk, The Netherlands) supports solar space missions for the whole European solar physics community. It encompasses a solar physics research unit which conducts the acquisition and analysis of groundbased and spacebased solar data as well as the development of new solar instrumentation. The unit includes the SOHO Project Scientist (B. Fleck) and the SOHO Science Operations Coordinator (S. Haugan). Other staff members are also involved in the daily SOHO operations. The ESA team has experience in a broad range of solar research fields including flux tube and solar atmospheric dynamics (chromospheric oscillations etc.), MHD simulations, topology and evolution of solar active regions, ultraviolet spectroscopy and imaging, and helioseismology. In addition, there is much expertise in solar-related stellar physics (solar/stellar connection, stellar magnetic activity, flare stars, etc.).

Instrumentation. At present the ESA team is mainly involved in the SOHO mission (Figure 3 on page 9), for which it has also provided hardware. Various team members routinely take part in the daily SOHO operations.

Network role. The ESA team will continue its role with respect to the SOHO mission. The ESA team contributes greatly to the ESMN through the unique opportunities offered by the various instruments onboard SOHO to enhance the ESMN multi-telescope observing campaigns (objective (e)). The ESMN research objectives of the ESA team are (a)–(c). The ESA team coordinates and runs Joint Observing Programmes (JOPs) combining ground based observatories (THEMIS, VTT, SVST, DOT) and space based observatories SOHO (MDI, CDS and EIT) and TRACE. The team also takes part in data analysis, interpretation and the organisation of local workshops. It provides younbg researcher training not only at Estec but also at the SOHO operations facility at Goddard Space Flight center, USA.

Research linkages. The ESA team has collaborations with the AIP, IAC, UiO, and UU teams.

Key scientific staff & involvement in ESMN research (ESMN scientist in charge underlined):

Scientist	Speciality	Experience	Involvement	
Dr. B. Fleck	chromospheric dynamics	12 years	20%	SOHO Project Scientist
Dr. P. Brekke	transition region dynamics	12 years	20%	SOHO Deputy Project Scientist
Mr. S. Haughan	data analysis	5 years	30%	SOHO SOC
Dr. B.H. Foing	UV imaging/spectroscopy	19 years	5%	data analysis/instrumentation

At present postdocs E. O'Shea (ESMN) and S.W. McIntosh (ESA) are part of the team. It is expected that typically one postdoc funded by ESA will work on ESMN topics the coming years.

Recent publications:

Fleck, B., Brekke, P., Haugan, S., Sanchez Duarte, L., Domingo, V., Gurman, J.B., Poland, A.I., 2000, "Four Years of SOHO Discoveries — Some Highlights", *ESA Bulletin* 102, 68–86.
Also available as http://zeus.nascom.nasa.gov/~bfleck/Preprints/ESA_Bull102.pdf.

O'Shea, E., Banerjee, D., Doyle, J.G., Fleck, B., Murtagh, F., 2001, "Active Region Oscillations", *Astronomy & Astrophysics* 368, 1095–1107.

5.9 Collective Expertise: participant AsU (number 9)

Expertise. The Astronomical Institute of the Academy of Sciences of the Czech Republic at Ondřejov has an extensive track record in solar physics, particularly in the investigation of active phenomena in the solar atmosphere: flares, sunspots, prominences, evolution of active regions, small- and large-scale activity structures. To understand the physics of the complex plasma mechanisms at work in flares and prominences, optical and UV spectral diagnostics are used together with numerical simulations of plasma processes and radiation transport to derive the basic structural, magnetic and dynamical plasma parameters. Quiet and active regions are studied at all atmospheric levels to understand the interactions between plasma motions and magnetic field. Emphasis is put on observations with medium and very high spatial resolution obtained with local instruments and Canary Island telescopes, respectively. Global and large-scale dynamic properties of the Sun are investigated analysing horizontal motions of the magnetised plasma. Training activities include lecturing at Charles University in Prague and at Masaryk University in Brno. Details: http://www.asu.cas.cz/english/depart/solar/.

Instrumentation. The Ondřejov Observatory of the AsU has a wide range of local instruments used for solar spectroscopy, magnetometry, and activity patrol. Two 50 cm horizontal telescopes are presently undergoing major revision. The first one feeds a photoelectric scanning magnetograph with enhanced Doppler sensitivity which has yielded a long record of the longitudinal components of photospheric magnetic and velocity fields. The second will serve as a multichannel spectrograph for observations of fast-changing processes. In addition there is the famous Multichannel Flare Spectrograph which allows to record flare spectra simultaneously in the most important optical lines, and there are two 20-cm refractors used for active region patrol in white light and Hα. The AsU welcomes increased ESMN access to the large solar telescopes at the Canary Islands and to data from SOHO. The team will also participate in the ambitious German GREGOR project.

Network role. The AsU team will concentrate on objectives (a), (b), (d) and (f). It will contribute its expertise in spectral diagnostics of flares and prominences and in plasma modelling (objective (f)), its knowledge of magnetic and velocity patterns in quiet and active regions (objective (b)), and its experience in mapping interactions between convection and strong magnetic fields in and around sunspots and pores (objective (a)). The team has also much experience in solar observations and instrumentation (objective (d)).

Research linkages. The AsU team has already well-established contacts with other participants in the network: AIP, IAC, OP, and KVA. Collaboration with the UU team began recently with AsU analysis of observations from the DOT.

Key scientific staff & involvement in ESMN research (ESMN scientist in charge underlined):

Scientist	Specialism	Experience	Involvement	
<u>Dr. M. Sobotka</u>	small-scale structures	16 years	50%	observation, analysis
Dr. P. Ambrož	large-scale structures	29 years	50%	modelling
Dr. P. Heinzel	radiative transfer	19 years	40%	NLTE diagnostics
Dr. M. Karlický	solar plasma	20 years	30%	modelling, interpretation
Dr. M. Klvaňa	solar magnetism	23 years	50%	observation, instrumentation
Dr. P. Kotrč	solar physics	21 years	50%	observation, analysis

Current temporary staff working on ESMN topics: emeritus Dr. V. Bumba, PhD students J. Kašparová and M. Stupka.

Recent publications:

Heinzel, P., Schmieder, B., Vial, J.-C., Kotrč, P., 2001, "SOHO/SUMER Observations and Analysis of the Hydrogen Lyman Spectrum in Solar Prominences", *Astronomy & Astrophysics* 370, 281–297.

Sobotka, M., Vaźquez, M., Bonet, J.A., Hanslmeier, A., Hirzberger, J., 1999, "Temporal Evolution of Fine Structures in and around Solar Pores", *Astrophysical Journal* 511, 436–450.

5.10 Collective Expertise: participant AISAS (number 10)

Expertise. The solar physics group at the Astronomical Institute of the Slovak Academy of Sciences at Tatranska Lomnica in Slovakia is devoted to investigating solar magnetic phenomena, in particular active regions, the solar corona, prominences, and the global solar cycle. The AISAS team puts much emphasis on analysing the fine structures of the solar photosphere in quiet and active regions and presently extends its interest to solar chromosphere diagnostics on the basis of VTT and SUMER (SOHO) data. The team is also experienced in photospheric velocity measurements using LTE line profile analysis. Very recently modelling of the solar photosphere through numerical inversion has been started.

Instrumentation. The AISAS team presently operates a double coronagraph, a horizontal solar telescope with a large spectrograph, and a double patrol telescope at Tatranska Lomnica. These facilities enable the team to train young solar physicists in solar instrumentation and to develop new techniques such as two-dimensional spectrometry using multi-beam fiber-optic feeds.

Network role. The AISAS team will contribute to objectives (a) – (b) through implementation of objective (e) with emphasis on comparison between observed and simulated spectra from quiet and active solar structures. The team will actively participate in Network observing campaigns building on its experience with VTT and SUMER time-sequence acquisition. The team's undergraduate and graduate students are expected to participate actively in the ESMN observing campaigns and the ESMN schools. As to the latter, the AISAS team offers to host one ESMN Summer School to promote East-West linkage between the ESMN partners.

Research linkages. The AISAS team collaborates presently with the AsU, ESA and IAC teams. Its ESMN partnership will enhance contact with the remaining partners. The recently started collaboration with IAC colleagues in radiative transfer and active region development will be intensified in ESMN context. The team co-chairs the Joint Organization for Solar Observations (JOSO) for the 'Eastern' part of the organization (Vice-president and editor of the JOSO Annual Report).

Key scientific staff & involvement in ESMN research (ESMN scientist in charge underlined):

Scientist	Specialism	Experience	Involvement	
<u>Dr. A. Kučera</u>	solar physics	21 years	70%	observation, interpretation
Dr. J. Rybák	solar physics	17 years	80%	observation, data analysis
Dr. A. Antalová*	solar physics	35 years	30%	coronal physics
Dr. J. Sýkora*	solar physics	37 years	30%	coronal polarimetry

*Drs. A. Antalová and J. Sýkora are officially retired but remain active.

Current temporary staff working on ESMN topics: PhD students J. Koza and K. Brčeková. It is expected that two graduate students will work on ESMN topics the coming four years.

Recent publications.

Kučera, A., Balthasar, H., Rybák J., Wöhl H., 1998, "Heights of Formation of Fe I Photospheric Lines", *Astronomy & Astrophysics* 332, 1069–1074.

Kučera, A., Brčeková, K., Hanslmeier, A., Rybák J., Wä ohl H., 2000, "Fe I and Ca II K Lines in Quiet and Active Regions", in "The Solar Cycle and Terrestrial Climate", *ESA Special Publications* SP-463, 357–362.

5.11 Collective Expertise: participant ELTE (number 11)

Expertise. The solar magnetohydrodynamics group at the Department of Astronomy of the Eötvös University in Budapest was formed in the 1960's. The efforts of this small theoretical research group concentrate on modelling MHD phenomena related to solar activity, with special regard to the solar dynamo problem, the origin and evolution of active regions, and to coronal heating. Despite the small size of the group, its activity is widely known among workers in the field. Owing to the shortage of jobs in astronomy in Hungary, many former members of the group now work at foreign institutions.

Facilities. The ELTE team concentrates on theoretical work, for which satisfactory computing resources are available (including a number of Unix workstations as well as easy access to the faculty-owned PMS-1 cluster supercomputer). The team is occasionally involved in observational projects in cooperation with other ESMN teams, using SOHO and Canary Island telescopes.

Network role. The ELTE team will concentrate on research objectives (a) – (c) through implementation of objective (f) with emphasis on theoretical modelling of solar surface field patterns. In particular, the team aims to study the redistribution of magnetic flux over the solar surface by nonlinear diffusive processes and advection. This will include in-depth studies of phenomena related to sunspot decay and flux transport around sunpots, and will rely on high-resolution observational data collected by ESMN partners. The interaction of large-scale photospheric flows (torsional oscillations, meridional circulation) with magnetic fields is another focus of interest within science tasks (a) and (b). Undergraduate and graduate students are expected to be intensely involved in ESMN activities.

Research linkages. The ELTE team has long-standing collaborations with the IAC and OP teams which have resulted in multiple joint publications. These contacts will be intensified in ESMN context, especially with respect to young team members, and new collaborations with other ESMN teams will be started in which the ELTE team will contribute theoretical background and insights.

Key scientific staff & involvement in ESMN research:

Scientist	Specialism	Experience	Involvement	
Dr. K. Petrovay	MHD	14 years	50%	theoretical modelling

Current temporary staff working on ESMN topics: graduate students Ms. E. Forgács-Dajka, Mr. D. Marik plus undergraduate students. It is expected that two more graduate students will work on ESMN topics the coming four years.

Recent publications:

Petrovay K., 2000, "What Makes the Sun Tick? The Origin of the Solar Cycle", in "The Solar Cycle and Terrestrial Climate", *ESA Special Publications* SP-463, 3–14.

Petrovay K., 2001, "Turbulence in the Solar Photosphere", *Space Science Reviews* 95, 9–24.

6. Collaboration

Meetings and secondments. The ESMN aims to continue the successful collaborative practices implemented during ESMN-1: frequent meetings (often combined with broader conferences), multiple multi-telescope campaigns every year, small to-the-point workshops devoted to specific data analysis and interpretation, and high-level ESMN schools.

One policy planned for ESMN-1 which proved hard to realise was to have mid-term postdoc appointment switches, too often inhibited by the EC nationality rules. The ESMN now pursues frequent secondment to partner institutes as alternative.

Joint tasks. The various team collaborations are defined in the rightmost column of Table 1 on page 8. Most tasks are highly collaborative; some are dominated by one partner being expert but in most cases the task distribution over the listed partners is fairly equal.

Multi-telescope campaigns. The observing campaigns are both the most intensive and the most extensive collaborations of the Network, involving all partners in the ESMN landmark activity and with substantial networking obviously a conditio sine qua non. ESMN postdocs perform a special role by participating frequently at other telescopes than the one contributed by or used by their own team. This not only enhances their training but it also spreads detailed knowledge of each facility's characteristics across the Network.

Integration of fresh teams. Teams OAA, AsU, AISAS and ELTE are newcomers in the ESMN. The switch from Naples to Florence bringing OAA into the ESMN is primarily due to a change of interest from solar magnetism to helioseismology at the first institute. OAA is a fresh team to the ESMN but not so in solar magnetism, being a major partner in THEMIS and world leader in the theory of polarised radiative transfer.

Obviously, the addition of the AsU, AISAS and ELTE teams has been enabled by the acceptance of EU-candidate countries as Associated States to the Fifth Framework Programme. These new teams have been invited to join the ESMN as minor partners. Given the budgetary constraints they are budgeted for networking travel only (Table 5 on page 26). The goal is to let AsU and AISAS participate extensively in the observing campaigns at the Canary Island telescopes, to train their students in high-volume data analysis, to enable ELTE partners to collaborate with similarly oriented scientists at OP, IAC and AsU, to let the Associated State graduate and undergraduate students participate in the ESMN training mobility and the ESMN schools, and to stimulate ESMN recruitment of young researchers from the Associate State partners. The overall strategy is to prepare the upcoming generation of solar physicists from future EC-member countries to be familiar with the high-tech facilities and methodology, organisations, and individuals in the EC solar family.

7. Organisation and Management

The ESMN aims to continue the successful management practices developed during ESMN-1. In brief, these rely on combining heavy use of the web with frequent personal contacts.

Web-based administration. The ESMN administration is fully web-accessible to all partners, the pertinent disk directories being web-linked all the time, with confidential information (such as applications) protected by username/password combinations. Monitoring of this site shows that the partners frequently consult these files whereas no outsider break-in has been noted. This is a highly efficient mechanism that largely does away with question-and-answer email traffic.

All ESMN applications and candidate selections are handled electronically without any paper documentation whatsoever. The ESMN website (at www.astro.uu.nl/∼rutten/tmr/) and all position advertisements stipulate that applications should preferably arrive as email or web transfer, and that advice was followed by all ESMN-1 applicants.

Personal meetings. The ESMN has adopted the strategy of handling its business when members meet at broader international conferences, including the regular solar physics Euroconferences (organised in an OP–OAA–UiO–ESA–AISAS collaborative effort with OP as lead initiator). Thus, in addition to regular

ESMN meetings there are frequent personal get-togethers to discuss and decide ESMN policies.

Coordinator management experience. The proposed coordinator (R.J. Rutten, UU) is also the present ESMN-1 coordinator, has organised multiple scientific meetings (*e.g.,* director and principal editorship of two NATO Advanced Research Workshops, coordinator of the Dutch Astronomers Conference during five years, numerous scientific organising committees), founded the EPS European Solar Physics Newsletter, coordinated NATO Collaborative Research and NWO CIS (former USSR) grants, currently manages NATO and INTAS grants for East-West collaborations, has been member of ESA advisory committees and project teams, has managed computer services, and is the DOT project scientist. Website: www.astro.uu.nl/∼rutten.

Result dissemination. The primary vehicle for ESMN result dissemination consists of publications in the mainstream astrophysical literature and in solar physics conference proceedings.

In addition, the ESMN makes a special effort to report on its activities to the general public in the form of web outreach (at www.astro.su.se/∼dorch/esmn), popular-science articles, and public popular-science lectures. The combination of Canary Island telescopes, the SOHO mission and beautiful solar imagery make this a desirable and worthwhile activity. For example, SOHO's fifth anniversary on April 27, 2001 was celebrated in over fifty public lectures across Europe, initiated and orchestrated by the ESA team. At each public event SOHO CD-roms and posters were handed out in large number. The ESMN aims to continue this practice.

8. Training Need

Space weather. Solar physics is part of astrophysics and is in principle a pure science — but since solar magnetism affects the geosphere it also has direct consequences to the human environment. Explosive events in the solar atmosphere affect the Earth's magnetosphere and endanger telecommunication satellites, manned space missions, and power distribution grids; in addition, it is now clear that the jet stream patterns that influence the major weather systems are modulated by the solar activity cycle and even that part of the present global heating may come from solar activity. The increasing global importance of this "space weather" increases the need to understand solar magnetism and the need for young researchers that are trained in gathering, analysing and interpreting solar magnetism data. This need is already evident in the US where NASA's *Living with a Star* programme presently causes a solar physicist shortage.

Utilisation of European facilities. A straightforward economic reason at the Community level to invest in young-researcher training in ESMN research consists of the telescope array in Fig. 1 (page 5) plus the SOHO mission. These are large investments that have brought Europe to the forefront in the field. This position must be exploited and strengthened.

Such utilisation is also important in view of the more distant future, with the Solar-B and Solar Orbiter space missions and the GREGOR and ATST ground telescopes definitely on the horizon. Solar magnetism and space weather will constitute a field of intense world-wide endeavour also after the ESMN-2 period. Possessing the best current facilities worldwide, it behoves Europe to train and fund manpower in this important growth area.

Job perspectives. The ESMN trains its young researchers in techniques that are highly valuable also outside solar physics or space weather applications. They become very computer-literate, having much experience in high-speed data acquisition, large-volume data handling, sophisticated analysis techniques, and more generally in complex problem solving including numerical simulations at the forefront of computational physics. Such researchers are an asset to Europe's high-technology economy. Indeed, the ESMN has just lost the first of its ESMN-1 postdocs to industry (Zeiss, with the postdoc's ESMN expertise an important recruiting consideration).

9. Justification of the Appointment of Young Researchers

The quantification of the deliverable person-month effort of the young researchers for which funding is requested is given in Table 3. The overall total amounts to 240 personmonths and is the minimum young-researcher effort that the ESMN promises to deliver if this proposal is selected.

The ESMN aims to hire postdocs exclusively but will keep in mind that shorter-term openings (for example when postdocs leave prematurely for permanent jobs) may be filled with graduate students, most likely coming from University and Academy (Associated States) partners.

Postdoc costing considerations. All postdoc salaries are budgetted according to the "Reference rates for Marie Curie Fellows" specified in the Guide for Proposers. These salaries are higher than the present ESMN postdoc salaries in many cases, but ensuring competitiveness in the face of current European industrial and American space-weather demand is an important motivation to aim high rather than low. In addition, mobility compensations are not budgeted explicitly because these are constrained by strongly varying local regulations.

The resulting salary estimates combined with the 1.5 million funding limit and the desire for ESMN schools and networking defines 30 person-months as optimum appointment duration, a six-month reduction from the 36 person-months appointments of most ESMN-1 postdocs. The reduction is not fatal to accomplishing outstanding research and receiving in-depth training, but the ESMN sees 2.5 years as a minimum desirable hiring period.

It should be noted that during ESMN-1 a large number of applications was received and that stringent candidate selection was feasible by all partners except the team at Naples, Italy. The present partner switch from Naples to Florence is likely to remedy the latter problem for a variety of reasons. The ESMN is confident, also on the basis of recent hiring experience through national funding programmes and in view of the fact that the number of undergraduate and graduate students in European astronomy has not declined in recent years, that the ESMN track record of hiring outstanding young researchers will be maintained.

Job posting. The Network vacancies will be advertised in the electronic Solar Physics Newsletter, posted on various WWW sites including the EC Network vacancy board, and through announcements to all solar physics institutions in the Member States, Associated States, and likely institutes elsewhere.

Participant	Young researchers to be financed by the contract (person-months)			Scientific specialities in which training will be provided
	Pre-doctoral researchers (a)	Post-doctoral researchers (b)	Total (a + b)	
1. UU	–	30	30	P-08 (astrophysics), P-04 (optics)
2. IAC	–	30	30	P-08 (astrophysics), P-04 (optics)
3. OAA	–	30	30	P-08 (astrophysics)
4. UiO	–	30	30	P-08 (astrophysics)
5. KVA	–	30	30	P-08 (astrophysics), P-04 (optics)
6. AIP	–	30	30	P-08 (astrophysics), P-04 (optics)
7. OP	–	30	30	P-08 (astrophysics), P-04 (optics)
8. ESA	–	30	30	P-08 (astrophysics)
9. AsU	–	–	–	P-08 (astrophysics)
10. AISAS	–	–	–	P-08 (astrophysics), P-04 (optics)
11. ELTE	–	–	–	P-08 (astrophysics)
TOTAL	–	240	**Overall total** 240	

Table 3: Young researcher quantification. The training specialties of the three Associated State partners are added because they will provide training to visiting ESMN postdocs.

10. Training Programme

The ESMN aims to maintain its track record in young-researcher training the coming years. In brief, excellent candidates were found for all slots during ESMN-1, successful collaborations resulted, and the

ESMN schools were rated very highly. The training objectives and elements remain essentially the same.

Training objectives. The ESMN aims to give each ESMN postdoc:

– solid expertise in science objectives (a) – (c);

– extensive collaborative experience by participating in implementation objectives (e) – (f);

– large added value in career competitiveness.

From the ESMN point of view the last objective aims at scientific careers, but it inevitably enhances a candidate's perspective re industry as well.

Gender aspects. The ESMN wholeheartedly supports female/male balance equality in any human endeavour, including science and solar physics. The proportion of young female solar physicists is presently increasing so that the ESMN hopes to welcome appropriate applications to obtain better balancing. The fact that two new local coordinators (OP and OAA) are female (and that the OP scientist-in-charge may be regarded as the leading female solar physicist in Europe) may help through setting an example.

Training elements. The ESMN training programme includes the following elements in addition to the inherent postdoc training quantified in Table 3, with the task distribution over the partners specified in Table 4:

– *Optical observing technology.* Over half of the postdocs will be appointed at partners with considerable interest in optical observing technology: optical solar telescopes, secondary optics including adaptive optics, polarimetry technology, fast-readout CCD technology, and large-volume data acquisition. Training in these technologies is an inherent part of the research programs at these partners.

– *Observing strategies.* By sharing in the joint observing campaigns, ESMN postdocs receive extensive hands-on telescope training. They will also take part in the pre- and post-campaign planning and evaluation meetings and some of them may join the daily planning and operations at the SOHO Experiment Operations Facility to receive training in space mission control. This training element contributes project management skills.

– *Data reduction and analysis techniques.* These collaborative tasks imply extensive training in sophisticated computer methods to handle large amounts of data. Much of this effort is executed via electronic communication, enhancing postdoc expertise in handling complex problem solving at-a-distance and communicative effectiviness.

– *ESMN schools.* Three ESMN postdoctoral schools are again planned in continuation of the very successful ESMN-1 ones (the first at UiO on radiation hydrodynamics, the second a "Canary Island Winter School" on spectropolarimetry, the third on solar magnetism to be held in The Netherlands the coming winter). Teams UiO, IAC and UU are again the candidate organisers but it is likely that the third ESMN school will actually take place at AISAS in order to enhance Associated State partnership visibility.

– *Advanced seminars.* Postdocs located at the university partners will take part in the advanced seminars run at these institutions.

– *Postdoc exchanges.* The Network will establish frequent postdoc exchange between partners, and also between partner telescopes, in order to efficiently diffuse magnetometry techniques as well as data reduction and analysis software expertise.

– *Training at industry.* See Section 12.

– *International meetings.* All postdocs will of course take part in the yearly Network meetings, and in other meetings of interest such as solar physics Euroconferences.

– *Presentation training.* All ESMN postdocs are required to represent the ESMN and present their own work frequently at international meetings, and to describe their work in ESMN context including formal EC reporting and reviewing.

Training Objective	Task	Teams
Magnetometry Techniques	optical observing technology	UU, IAC, KVA, AIP, OP, AISAS, OAA
	observing strategies	all teams except ELTE
	SOHO	ESA
	data reduction & analysis	all teams except ELTE
Post-Doctoral Schooling	ESMN schools	UiO, IAC, UU + AISAS
	advanced seminars	all university teams
Exchange	young-researcher exchange	all teams
	training at industry	KVA, possibly others
	ESMN meetings	UU + all teams
	presentation training	all teams

Table 4: Network training task distribution. The team specifications denote principal responsibility.

11. Multidisciplinarity in the Training Programme

The topic codes in the rightmost column of Table 3 show that much of the ESMN training is multidisciplinary in combining solar astrophysics with optical observing technology.

In addition, the enormous data rates that characterise solar physics data acquisition (intrinsically required by the fast variability of any solar scene) make solar physics researchers exceptionally well-versed in advanced computing and computer system management. For example, the new DOT speckle system will generate up to 0.5 Tb of data per observing session, with a top-capacity data pipeline and 500 Gbyte storage system of which the architectural design was accomplished by the present ESMN postdoc in the UU team. Comparable advanced computing will be an important activity for many ESMN postdocs.

12. Connections with Industry in the Training Programme

Many partners are involved in industrial technology development in connection with the Canary Island telescopes, often actively pushing firms to deliver cutting-edge techology or to reach unusually high product quality. There are two particular industrial connections of importance with regards to the ESMN training programme.

Connection to Compaq Equipment. The KVA team collaborates intensively with the Compaq Systems Research Center, in particular Dr. M. Shand. It is anticipated that this collaboration will focus the coming years on the development of state-of-the-art adaptive optics and tip-tilt correlation tracking systems for meter-class solar telescopes, and that the resulting know-how and technology will be spread jointly to other ESMN teams (in particular re THEMIS). Through M. Shand, Compaq Equipment is prepared to participate actively not only in the design and development of these systems but also in ESMN training related to them.

Connection to Lockheed-Martin. The KVA and UU teams are actively involved in joint R&D with the Solar and Astrophysics Laboratory of the Lockheed–Martin company which was a frequent collaborator at the SVST and is likely to be a frequent collaborator at the NSST and DOT during the coming years. Both teams have regularly sent researchers to the Lockheed-Martin premises for training, in particular in high-level data reduction and analysis techniques. Both teams aim to continue this training activity.

13. Financial Information

Table 5 specifies the proposed budget and its distribution over the ESMN participants. The entries all adhere to the financial guidelines. The mean total per partner amounts to 130,912 Euro.

Column A: personnel and mobility costs. The Reference Rates for Marie-Curie Fellows as specified in the Guide for Proposers are strictly followed. As mentioned above, these tend to be higher on average than the current salaries paid to ESMN-1 postdocs, but some markup is desirable since recruiting competitiviness may be an issue and mobility costs are not explicitly budgeted (because the local rules which they must obey vary too strongly).

All entries are based on 30 person-month recruitment, seen as a compromise between the view that a shorter duration is non-optimal with regards to research and training content, the importance of not reducing the Network extent, the need for sufficient networking and school support, and the desire to include Associated State teams in ESMN observing campaigns and data analysis.

Column B: costs linked to networking. The basic networking alllotment per partner is 15,000 Euro irrespective of partner team size because the major part should go to the ESMN postdoc while experience teaches that larger teams also have better alternative funding possibilities for travel and outplacement.

The three new Associated State members are budgeted at the same networking cost. In their case it will enable staff and students to travel to the Canary Islands and the other partners to share in joint observing campaigns, analysis, and interpretation, and to let pre- and postdoctoral students participate in ESMN training including the ESMN schools.

The three ESMN schools to be organised by partners UU, IAC and UiO are budgeted at 20,000 Euro each.

Column C: overhead. Set at 20% of the allowable costs.

Financial information on the Network project				
Participant	Personnel and mobility costs related to the appointment of young researchers (Euro) (A)	Costs linked to networking (Euro) (B)	Overheads (Euro) (C)	Totals (Euro)
1. UU	126,750	35,000	32,350	194,100
2. IAC	100,260	35,000	27,052	162,312
3. OAA	114,390	15,000	25,878	155,268
4. UiO	129,060	35,000	32,812	196,872
5. KVA	138,630	15,000	30,726	184,356
6. AIP	131,190	15,000	29,238	175,428
7. OP	108,000	15,000	24,600	147,600
8. ESA	126,750	15,000	28,350	170,100
9. AsU	–	15,000	3,000	18,000
10. AISAS	–	15,000	3,000	18,000
11. ELTE	–	15,000	3,000	18,000
Totals	975,030	225,000	240,006	**Grand Total** 1,440,036

Table 5: Proposed financial distribution. The entries in column (A) correspond to the Reference Rates for Marie-Curie Fellows.