Final Programme

STW Perspective programme

SMART OPTICS SYSTEMS

March 6th , 2008

Technology Foundation STW, Postbus 3021, 3502 GA Utrecht
www.stw.nl

Executive Summary

The Smart Optics Systems (SOS) Programme will stimulate and facilitate the development of a key enabling technology for “a clear vision in the 21st century, the century of the Photon”. In a similar way like the electronics industry was boosted in the last century through improvements in controlling and manipulating the electron, it is to be expected that the technological breakthroughs of the 21st century will greatly depend on the way we can generate, control and use harnessed light.

The SOS programme will contribute to strengthen the future competitiveness of the Dutch industry in the following three growth markets:

- Health and Life Sciences
- Industrial imaging
- Consumer optics and Astronomy.

Based on a prediction of the Phononics21 EU technology platform, these markets will triple in the coming decade. An important share in this explosive development will be due to the quest for increased resolution in imaging systems. The key enabling technology that has the potential to successfully address this quest is SOS. Illustrative is the use of deformable mirrors in astronomy with active feedback control which have dramatically improved the image resolution, since now turbulence-induced distortions can be significantly reduced at ground-based telescopes.

The SOS program aims at making this type of technology accessible and affordable to a much wider industrial community. The objective will be realized by a unique trend change in the development strategy. Instead of integrating optical components, optimized on an individual level, new design methods and technology are called for that optimize the integration of, and interaction within, the complete optical system with respect to both resolution and cost, reliability and complexity.

The integrated approach makes the SOS program multidisciplinary by nature. Each project, which anticipates the development of a new smart optics demonstrator, brings together the different key technology experts from fields such as precision mechanics, MEMS technology, control engineering, optical metrology and various application domains. To further enhance cross-fertilization the program aims at the development of demonstrators for different application domains, selected from the 3 growth markets.

The ambition of the SOS program in short is expressed as:

- Development of key technology that meets the demands for increased resolution in imaging systems.
- Methodological development in integrated optimization of optical systems containing smart components.
- Establishing a research consortium in the Netherlands that enables the dissimination and exchange of design methods, technology and prototypes of SOS.
- The initiation of a national center of excellence on SOS that will grow to one of the world leading centres.

1. Technology landscape

1.1 Introduction to Smart Optics Systems

The 21st century will be the century of the photon. When looking back history may be very instructive in predicting future technological developments. The success in mastering steam in mechanical systems was responsible for the industrial revolution in the 19st century. In a similar way the electronics industry boosted in the last century through improvements in controlling and manipulating the electron. It is to be expected that the technological breakthroughs of the 21st century will greatly depend on the way we can generate, control and use harnessed light.

The field of Smart Optic Systems (SOS) can be considered as a new emerging part of the larger area of photonic devices. Photonics has produced many innovative technologies, ranging from lasers and optical fibers to opto-electronics, resulting in extremely successful products such as CDs, DVDs, digital cameras, LCD screens and laser printers. Photonics will continue to produce important enabling technologies for various industry branches. Photonic devices are important both economically and scientifically. They are enablers for many different segments with an estimated market volume in Europe of €800 billion in products with photonic components.

A recent trend in the last 15 years was the development of optical logic such as switches and splitters. These quasi static optical components enabled applications in beamers and TVs (o.a. Digital Mirror concept of Texas Instruments), and in ICT (o.a. optical routers). This trend was characterized by electrically movable optical components, creating an electro-mechanical system. The optical system mainly benefits from the advances of semiconductor production processes, enabling massive parallel functions. This rapidly growing technology nowadays serves a €4 billion market world wide.

In particular focus areas, such as astronomy, a more challenging technology has been prototyped since the 80ties. It improves the optical image quality by using feedback control and active optical components, such as deformable mirrors and lenses. This technology is known as adaptive optics and was originally developed for astronomy and military applications. The developments were low in volume and of extreme high costs but they demonstrated that it was possible to reduce optical aberrations and to improve the image quality of observations dramatically. The SOS program foresees this technology to be matured and transferred to high-end segments such as high tech optical equipment (for instance lithography and confocal microscopy), and medical instruments (for instance retinal inspection, in vitro diagnostics and minimal invasive instruments).

1.2 International landscape of Smart Optics Systems

The links to the international landscape are various, since the field of photonics is vast. In Europe there is a dedicated Technology Platform called Photonics21, with more than 700 stakeholders originating from 32 countries. From Photonics21 an initiative has been started called Opera 2015. Its main objective is to compile an inventory of existing European

Optics and Photonics research industry infrastructure and to support the development of a mid to long term strategic vision. In that vision adaptive or smart optics is dominantly present [1]. Also the EPOSS (European Technology Platform on Smart Systems integration) considers converging technologies of o.a. optics, mechanics and thermo dynamics as one of the key challenges for the coming years [8]. More specifically some research centers were formed to address the promising area of smart optics. Key research centers are:

Center for Adaptive Optics (USA)

The Center for Adaptive Optics (CfAO) is one of a number of National Science Foundation funded Science and Technology Centers (STCs). Initial funding began in 2000. The goal of the STCs is the funding of basic research and education activities and to encourage technology transfer and innovative approaches to interdisciplinary programs. In total 13 universities, 10 institutes and 9 companies are involved in the CfAO.

The CfAO will concentrate on astronomical and vision science applications of adaptive optics and will reach out to other adaptive optics communities to share technologies. It will develop new instruments optimized for adaptive optics. Examples from astronomy include "integral-field" spectrographs that take spectra of thousands of tiny contiguous regions of the sky simultaneously (for studies of distant galaxies and proto-solar-systems), as well as coronagraphs to image very faint objects close to bright ones (for studies of black holes in galaxies and planets around nearby stars). Instruments to be developed for vision science include a confocal scanning laser opthalmoscope, which achieves high depth resolution as well as lateral resolution. This instrument will make possible high-resolution 3-D reconstruction of retinal blood vessels and of optic nerve fibers that carry signals to the brain.

The CfAO will conduct a strong program in science education and outreach, with significant components in the systemic improvement of education, diversification of the trained work force, and enhancement of public scientific literacy.

Micado consortium (France)

As part of its ongoing commitment to expand the applications of adaptive optics in bioimaging, Imagine Optic will spearhead the MICADO (MICroscopy improved with ADaptive Optics) consortium that will unite France’s leading experts in the fields of neuroscience and cellular imaging to develop new technology for detecting and treating neurological disorders.

MICADO is a 3-year project, founded in September 2007 and financed by the Agence National de la Recherche (ANR – France’s National Research Agency) that brings together Imagine Optic, a prominent manufacturer of Shack-Hartmann wavefront analysis and adaptive optics products, with key researchers and institutions.

1.3 Distinctive character of the Program

The SOS programme unites the well established mechatronics community, which is the basis for our world renowned high-tech industry segment with an export value of 12BEuros, with the optics/photonics community. Both have their roots in the Netherlands and a well-established scientific community, as shown in Section 1.6.

The scientific community in the Netherlands has a small number of "smart optics" experts who receive worldwide recognition for their contributions. So far these experts have focused on a specific component or single application of smart optics. One example is the worldwide recognition of the scientists of Flexible Optical for their deformable mirrors [7]. Another example is the interest caught by the astronomers worldwide to the optimal control approaches developed in the Delft Center for Systems and Control of Delft University of Technology with TNO [4]. Finally we mention the innovative type of deformable mirrors for astronomy with low cost per actuator and very low power dissipation, developed in the Control Systems Technology groups of the Eindhoven University of Technology in collaboration with TU Delft and TNO [5].

The goal of the SOS programme is to increase the size and momentum of the SOS community by bringing together the mechatronics and the photonics communities. Integration of these strong assets of the Dutch scientific community into an overall smart optics design methodology for various applications is still in its infancy but could become a major technology enabler in the next generation of photonic applications.

1.4 Economic impact of Smart Optic Systems

Since Smart Optic Systems is a rather new and emerging area, the market and economic impact is currently very difficult to quantify. However, the market potential of Smart Optic Systems covers almost all high performance optic applications. So looking at some established market segments for high performance optics gives us an indication for the Smart Optics Systems economic impact.

Recently the Photonics[21] EU Technology Platform has predicted that the Photonics related markets: (1) Information and communication, (2) Industrial Manufaturing and Quality, (3) Life Sciences and Health and (4) Lighting and Displays will triple in the coming decade.

The world market for the major high-end optical application, lithography equipment, was approximately 6B Euros in 2006 of which ASML claims to have 61%. Other high-end optical markets are: high-end binoculars, industrial metrology, spectrometers, microscopes and professional cameras.

The world market for telescopes is (apart from some dedicated large scale projects) $100 million world wide, and includes universities, research institutes and avid amateur astronomers.

The global market for microscopes and accessories for medical devices was worth about $2.1 billion in 2006. Sales are projected to exceed $2.3 billion in 2007 and approach $3.6

billion in 2012, a compound annual growth rate (CAGR) of 9.1% between 2007 and 2012. Optical microscopes are projected to have a growth rate of 5.6%. While microscopes are a billion-dollar industry, their true importance lies in the activities they make possible, such as life sciences research, microelectronics, and advanced materials science. Microscopy is particularly important to the expanding field of micro and nano technology.

1.5 Relevance for the Netherlands

The recent photonics event on April 3rd 2007 in The Hague Conference Center, The Netherlands, showed the tremendous Dutch interest in the topic. Both industry and academia were present with more than 400 attendees. It is of major relevance that The Netherlands maintains its leading position in photonics by initiating the new promising field of Smart Optics Systems.

Based on the preceding information related to SOS in a Dutch perspective, the following SWOT analysis is made.

<u>Strength</u>
- Builds on proven Dutch expertise (mechatronics, control, optics)
- Application areas are built on Dutch strength (medical, high tech, space)
- Large system integrators in the Netherlands (ASML, Philips…)

<u>Weakness</u>
- No large industrial players in optics in the NL
- Scattered field

<u>Opportunity</u>
- Realizing a number one position in smart optics world wide
- Realizing a new high potential industry segment in the Netherlands
- Bringing together a unique multi-disciplinary group of experts

<u>Threat</u>
- Limited industrial momentum
  This is dealt with by involving many SMEs with a high innovative potential
- Losing focus
  This is dealt with by both a focussed technical scope and a well set selected of applications.

1.6 Other national and international initiatives

The SOS program will be complementary to the following National initiatives

<u>IOP Photonics</u>
The IOP Photonics aims to rank Dutch research and companies among the world's seven leading countries in two specific areas of expertise:
- Advanced light sources and detection systems
- Application of photonic devices in health and medicine.

The first area is fully complementary to the SOS program due to the nature of the topic, whereas the second area requires some synchronization to prevent overlap.

PfHTS

The Program for High Tech Systems (PfHTS) aims at strengthening the high tech precision sector in the Netherlands. This public private initiative incorporates opto-mechanics for high-tech imaging equipment. PfHTS will be focused on the production, calibration and metrology of high-tech equipment, whereas SOS will be aimed at the adaptive nature and control aspects of high-tech opto-mechatronics. Overlap between PfHTS and SOS is prevented and synergy is maximized by mutual participating experts as coordinators.

Memphis

The scope of the MEMPHIS project is the research and development of an integrated electronic-photonic technology platform (Silicon logic, HF, nano-electronics and photonics) to provide a broad range of multi-function miniaturized electronic-photonic devices. This technology platform leads to:

1) a fundamental cost effective and excellent electronic-photonic technology
2) enabling the development of novel electronic-photonic devices
3) leading to the optimal integral production processes including
4) design tools, simulation and fast-nano-photonic prototyping for a
5) broad range of applications in areas like telecommunication, medical diagnostics, imaging and light generation.

Looking at the list above we can conclude that the Memphis consortium and the SOS program have a different scientific scope and will therefore have no significant overlap. In the case when smart optics will enter the consumer market in the future, the SOS program will build on the results of the Memphis consortium.

CTMM

The Center for Translational Molecular Medicine (CTMM) aims at visualizing and manipulating processes on the molecular level inside (in vivo) and outside (in vitro) the human body. Due to the small scale of these processes imaging techniques outside the visual spectrum are applied (such as MRI, CT, PET, X-ray etc…). No overlap is foreseen between CTMM and the SOS program. The hope is expressed that eventually high-tech analysis equipment on the cellular level is developed within SOS program that will be complementary to the CTMM research on the molecular level.

2. Ambition and goals

2.1 The envisaged trend change in SOS development strategy

To explain the innovative character of the goal to make the smart optics technology industrially accepted, use is made of the actual and predicted growth trend in the scope of application of SOS as depicted in Figure 1. In this figure we recognize the proof of concept phase of Adaptive Optics between the 1980 and mid-nineties. This period is characterized by low volume and extreme high cost developments mainly restricted to the market of ground-based telescopes for Astronomy. Halfway the nineties a first major trend change in the technology development took place under the introduction of micro-machined deformable mirrors.

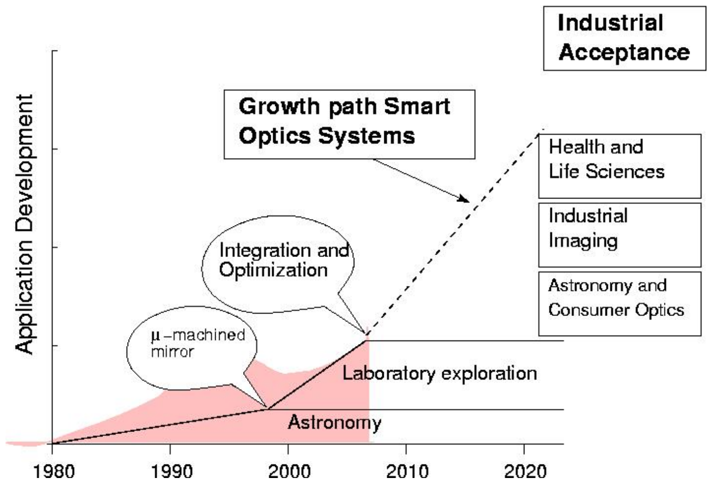

Figure 1: Growth trend in the application development of SOS

This important trend change opened the avenue for further exploration of the adaptive optics technology in non-astronomy related application domains. These explorations were up till now conducted mostly in government sponsored research laboratories and investigated the use of adaptive optics in health monitoring, such as retinal imaging.

The presence of wavefront aberrations due to distortions in the optical path or manufacturing inaccuracies in the components is a limitation that occurs frequently in scientific imaging. Solving this problem leads to better diagnostic tools and to scientific breakthroughs. For example in bio-medical imaging, Prof. Tien Wong of the University of Melbourne has demonstrated that using smart optics is the key enabler of discovering the onset of diseases like diabetes or stroke by making an accurate image of the retina of a patient.

The main line of research in this laboratory exploration phase, was the use of more or less standardized smart optics components. The development strategy during this laboratory phase was targeted towards the modification of these individual components to achieve an improved optical resolution (performance) This optimization of individual components is still the defacto standard in ongoing and recently approved Smart Optics research projects, such as the 2,5 Million Euro "Aktive Mikrooptic" DFG Schwerpunkt project of Prof. Dr. Hans Zappe of the University of Freiburg [2]. On a smaller scale a similar trend can be observed within the Netherlands, see e.g. [3].

Today, we are facing the challenge to make the smart optics technology accepted to a wider range of industries i.e. to enable the transition from the laboratory to industrially designed products on the wide scale of the 3 Photonics growth markets:

- Health and Life Sciences
- Industrial imaging
- Consumer Optics and Astronomy.

To achieve such a wide scale transition the SOS programme aims at establishing a second major trend change in the development strategy. Namely to optimize the integration of the all the key smart optics (active and passive) components instead of integrating optimized individual components. Such overall optimization should not only take performance into consideration but also cost, complexity and product reliability. In the system-oriented optimization the dynamic feedback correction of wavefront aberrations is an integral part in the design. This surpasses the classical approach where feedback was regarded as a final compensation to already designed/optimized optical components.

Applying a mechatronic design concept and integrating dynamic feedback from the beginning of the design of SOS is revolutionary in this field and motivates the term “Smart Optics Systems”, rather than active optics or adaptive optics. It allows for shaping the closed-loop response already during the system design. A recent study on high-speed atomic force microscopy [6] has demonstrated the potential of such integrated approach to improve the imaging speed by more than two orders of magnitude. Other more classical examples from the electronics field of breakthroughs established through such integrated approach was the development of operational amplifiers, where feedback was the key design enabler to produce high quality amplifiers built from low cost, non-ideal active components.

2.2 Methodological and Technological Challenges

The innovation focuses on the integrated, system-oriented design approach, that accounts for performance and constraints on costs, complexity and reliability. The innovative integrated approach requires the development of multi-criteria, constraint optimization methods. Such methods need to enable the combined optimization of structural mechanics, optical design parameters, actuator and sensor arrays, image processing and closed-loop control in order to meet system requirements. The simultaneous optimization of both structural (passive) design parameters in combination with the (active) controller parameters results in non-convex, nondeterministic polynomial state-time hard (NP-hard) optimization problems. The challenge within the program is to strive to provide new mathematical solutions to these optimization problems or to simplifications of these which allow for a reliable and more efficient virtual design and analysis.

The program calls for the development of new smart optics technology. Examples of the current Scientific challenges are:

- The realization of lithography machines that follow Gordon Moore’s law of increasing transistor density in IC’s.

- Optical Coherence Tomography (OCT) to perform non-invasive retinal imaging at various depths, to diagnose diseases like stroke, hypertension and diabetes and optimize their treatment.
- Intraocular lenses to restore vision after lens extraction due to cataract and to correct age-related presbyopia.
- High-resolution very long-range observation through turbulence.
- Image improvement of tissue through intervening body fluids.
- The next generation of Laser TV’s requiring pulse width control to align the parallel rays emitted by the array of diodelasers.
- The development of instrumentation for Extremely Large Telescopes for probing fainter stars and earth-like planets.

Some of the corresponding technological challenges for the smart optics program are:

- Deformable mirrors with very high actuator density.
- Distributed control to handle 1000’s of actuators and sensor channels.
- Very low noise wavefront sensing.
- Low power dissipation electronics.
- Mid-infrared deformable mirrors.
- Image restoration algorithms
- Surface metrology in the 10-100 picometer range.
- Laser beam profile control.

Furthermore, for many smart optics devices a development step has to be made with respect to low cost, miniaturization, reliability, user-friendliness and (medical) certification.

2.3 Interdisciplinary work and synergy

For the various application areas there is a clear overlap in smart optics challenges. This will enable the cross-fertilization between different projects within the program. This cross-fertilization would not exist with individual projects. Furthermore, the program’s focus on a system’s approach will bring together the specialists, like e.g. the optical designer, mechanical engineer, control engineer, bio-medical specialist, MEMS experts, astronomer and so on. This will result in the necessary breakthroughs for the next generation of smart optics systems that was not possible with individual projects, only focusing on the optimization of a subpart. The presence of multi-disciplinarily researchers within one project will be mandatory for success. To further enhance cross fertilization the program aims at the development of demonstrators for different application domains, selected from the 3 Photonics growth markets listed earlier.

Also stimulation measures between the projects are taken, such as an active coordination action of the program committee during the selection process and regularly during the course of the program. Furthermore, a yearly congress will be organized that brings together the projects and researchers of SOS and the international field. These measures to stimulate knowledge exchange between different projects, the research partners and the industrial participants will create a research momentum and knowledge mass that exceeds by far that what could be brought together in an individual project.

2.4 First workshop SOS

On January 30th 2008 the SOS program initiators organized a workshop at TNO. In total 50 experts in the field were approached and 21 external people participated the workshop. Considering the narrow time frame for the invitations, this was a good result. Both academia (Universiteit Utrecht, Universiteit Twente, Universiteit Leiden), medical centra (AMC Amsterdam, Erasmus MC), knowledge institutes (TNO, Astron) and industry (ASML, JPE, Nedinsco, Okotech, Philips, Vision Dynamics) contributed to the success of that day. We have received many requests of companies who could not meet the short deadline, but wished to stay involved.

The workshop introduced the SOS framework and goals. In three parallel sessions which were chosen to be the three application areas the key research priorities were set. The outcome of the workshops was as follows:

For high-tech systems the key priority is set to reach a high system performance using smart system integration. This is required to overcome expensive individual system component optimization processes and calibration procedures. A holistic system approach by means of a full system optimization was considered to be crucial.

In the medical application transparency is key (rather than ultra high precision). This requires both spatial and spectral shaping elements. The medical area could benefit significantly by filling in the market gap between static spectral light devices and high end ultra high frequent devices (e.g. electro-microscopy).

The astronomy would benefit from wide field correction, continuing progress in deformable mirrors (small pitch, low cost and low dissipation) and advances in wavefront sensing and control.

3. Application fields

The SOS programme will focus on the following three promising application domains.

Extreme performance imaging systems
The application area of extreme performance imaging systems is dominated by the IC Lithography industry where diffraction limited optics with a minimal wavelength of 13.5 nm and in the future even around 8 nm will be used requiring an imaging fidelity far below one nanometer while contrast and light loss determine requirements on surface quality and shape reliability in the order of around 50 pm maximum deviation. Other industrial developments requiring improved imaging systems are e.g. extended depths of field lenses for bar-code reading of boxes/suitcases/luggage of different height on a transport belt.

While the properties of the imaging systems are from a generic point of view quite similar to Astronomy the short wavelength, very high Numerical Aperture (NA) with a relatively wide field and lesser need of high frequency motion control are clear differences.

A separate field of interest is the shaping of laser beams for illumination of Lithography equipment (low k_1, CD= $k_1\lambda/NA$). To achieve this, active diffractive optical elements can play an important role and a multidisciplinary system integration approach is necessary to achieve the optimal performance.

Because of the unique and extreme nature of these extreme high performance imaging systems the cost of singular solutions are often extremely high. Because of this, project proposals with applicability in more than one application area are possible, where short wavelength (UXV,VUV,UV) are used to pattern materials with high precision.

Health and life sciences
Smart optics has a high potential to serve as an enabling technology in the Life Sciences with its growing demand for non- or minimal invasive tools for imaging, diagnosis, and treatment of healthy and diseased tissue at a high spatial, temporal, and spectral resolution. a growing number of researchers have created retinal imaging systems that use adaptive optics to eliminate the optical distortions caused by the structures of the eye itself. It is claimed that a resolution of 2-3 μm for these AO-based systems versus 15-20 μm for the conventional scanning laser ophthalmoscopes currently in use. The improved resolution targets early diagnoses of sight-robbing diseases such as macular degeneration, diabetic retinopathy and glaucoma.

In another emergent application, researchers at RPI’s Center for Automation Technologies and Systems have come up with a new kind of AO-enabled microscope. This Adaptive Scanning Optical Microscope (ASOM) uses a scanning mirror and camera to provide both a large field of view and high resolution, two attributes that don’t usually go hand-in-hand. An AO element in the microscope quickly cleans up any blurriness that results when the scanning mirror is not looking straight down into the sample.

Another promising application for AO involves biometrics. AOptix, which specializes in adaptive optics systems for laser telecommunications and biometrics, will soon begin beta testing an automated iris-recognition system. It employs a wave-front sensor, closed-loop control software and deformable mirrors to make real-time corrections to the tracking and focus errors that arise as the person being scanned moves. Rather than requiring that person to position themselves with limitations of the optics in mind.

Consumer Optics and Astronomy

Adaptive Optics systems for astronomical telescopes already have a successful track record in reducing the wavefront distortions induced by atmospherical turbulence. Common systems in large telescopes typically work with a single deformable mirror containing up to a few hundreds of actuators, a shack-hartmann sensor and an elementary type of real-time control. In the application field of long-range cameras turbulence compensation has recently been introduced. Here the emphasis however lies on image restoration (post-processing) algorithms.

The trends in turbulence compensation in imaging systems are higher bandwidths of correction and larger fields of view. The research programme would therefore especially welcome project proposals that address one or more of the following topics:

1. Wide Field Adaptive Optics
- the integration of deformable mirror correction with image restoration algorithms
- demonstration on breadboard level
- application to night-time and solar astronomy, long-range cameras, retina imaging, ...

2. New type of wavefront correctors
- about 1 mm pitch
- 1000+ actuators
- low cost
- integrated efficient control and low dissipation electronics

3. Improvements in wavefront sensing and control
- Wavefront sensing with a single photodetector
- Low noise wavefront sensing
- Demonstrator implemented in real-time

Furthermore, the Smart Optics should strive for open source and common platform developments to stimulate co-operation, cross-fertilization and exchangeability of technology.

4. Organization of the Smart Optics Systems program

Who can apply

Scientists employed by Dutch universities or scientific institutes recognized by NWO are eligible to submit a (pre-)proposal (see OTP-guidelines for eligibility criteria).

Each project within the SOS framework has to reflect the multidisciplinary system-oriented character of the program. Therefore each project proposal needs to involve reseachers /PhD students from each relevant discipline. Ideally, the PhD students share the same working place (project room) and are assisted by an experienced researcher (post-doc or industry related), who secures the coherence between the individual research activities. In the project description it should be made clear how the multidisciplinary and system oriented approach is organized within the project.

Furthermore, it should be stressed that each project proposal should aim at a “hardware” result, in the form of a demonstrator, a functional model or a breadboard. Also close collaboration between universities and users or industry should be ensured. For this purpose a traineeship of the PhD students at the laboratories of one of the users may be planned.

Proposals and selection

The selection of proposals will be done in two steps: a call for pre-proposals and an invitation to the applicants of pre-proposals to submit full proposals. The pre-proposals will be evaluated by the Program Committee. The STW board will decide on the funding of the full proposals.

Pre-proposals

Pre-proposals (3 A4) should contain a short description (2 A4 max.) of the proposed research, utilization paragraph and estimated budget (see Annex 1). The proposal should make clear which potential users will contribute to the project. Support letters are optional for the pre-proposals but can be included (letters of intent are accepted).

The pre-proposals will be ranked by the program committee on the basis of how well they fit within the scope of the program. The members of the program committee will first assess the pre-proposals individually before being discussed plenary in the committee. The program committee will advise the applicants 1) to submit a full proposal or 2) to adjust the proposal so that it would fit better into the program or 3) not to enter the subsequent selection procedure.

Note: If the full proposal budget is changed significantly with respect to the budget of the pre-proposal, STW has to be informed immediately.

Full proposals

Full proposals must consist of a detailed description of the expected results, planning of the research and a utilization paragraph. The utilization paragraph should include the important industrial challenges that will be solved, the time frame to implementation and the expected bottle-necks during the implementation. Companies and institutes, which will potentially contribute, should be involved bottom-up during the preparation of the proposal.

A full proposal will be evaluated only if it is preceded by a pre-proposal. The scientific quality and the utilization perspective of the full proposals will be evaluated individually by peer review. An independent jury of about eight (inter) national experts of universities and industry (applicants will be excluded) will rank the full proposals. Each jury member will give 3 marks for each proposal: one for scientific quality, one for utilization potential and one for the strategic fit within the program. The marks will be averaged with equal weight to one final score for the proposal which determines the ranking. In addition to the ranking by the jury the program committee will formulate an advice on the cohesion between the project proposals and their relevance for the program. The decision of the STW board will be based on the ranking by the jury and the advice of the program committee.

The guidelines for full proposals are based on the "Open Technology Program (OTP)" with as the main difference that the potential technology users (companies/institutes) should contribute for at least 25% of the total project costs. The proposals should therefore be accompanied by a 'letter of participation' in which the contribution has been made explicit and in which details are given on what, when and how these contributions will be made available. For more details see "richtlijnen voor het open technologieprogramma" (www.stw.nl).

Evaluation criteria of full proposals

Full proposals will be evaluated on scientific quality, utilization perspective and fitting within the framework of the SOS program.

Scientific quality

- Originality and innovative character of the proposal
- Expected impact on the scientific community
- Research method
- Time schedule
- Budget
- Infrastructure

Utilization

- Potential economic impact
- Past performance in utilization by the applicants
- Contribution to the development of applied knowledge
- Impact on utilization if the project is carried out successfully
- Different steps needed (time path) to utilize the results
- Chance on patents and/or know how agreements
- Participation of users

The jury will be asked to assess the proposals on these aspects and also on the strategic fit within the program.

The program committee will evaluate the fit of the pre-proposals within the framework of the program and will use the following considerations:

- How well do the goals of the project fit within the ambition of the program. Do the expected results meet the industrial needs in the long term (2012-2016)?
- To what extent does the proposal fit within the research themes of the program?
- Does the program strengthen the Smart Optics Systems expertise in the Netherlands in general and of the participants in the project in particular?
- To which extent is the project proposal multidisciplinary? What are the positive effects from the interdisciplinary cooperation? How is interaction in between researchers and between university and industry organized?
- Do the proposals overlap each other and if so, what are the consequences for the funding?

Program Committee

The program committee consist of the following experts:

Dr.ir. Niek Doelman, TNO
Dr. Gleb Vdovin, Flexible Optical/Delft University of Technology
Prof. ir. Rob Munnig Schmidt, ASML/Delft University of Technology
Prof. dr.ir. Michel Verhaegen, Delft University of Technology, DCSC (Chairman)
Prof. dr. Klaus Boller, University of Twente
Prof. dr. Christoph Keller, University of Utrecht

Time schedule SOS proposals

Call for pre-proposals (2 A4)	March 7th 2008
Deadline pre-proposals	April 21st 2008
Notification to applicants about pre-proposal: positive / negative advice to submit full proposal	May 5th 2008
Deadline full proposals	June 23rd 2008
Start review by experts	June 30th 2008
Deadline protocol	September 15th 2008
Ranking by Jury ready	October 13th 2008
Advice Program Committee to STW board ready	October 24th 2008
Proposal for funding send to STW-board	October 31st2008
Decision by STW board on funding plus notification to applicants	November 7th 2008

5. Budget

For this call a budget of M€ 4.3 is available which must be matched by the contributions of potential technology users (companies/institutes) to a total of at least M€ 5.7. The maximum of project costs that can be requested from STW is € 750.000 per project. A contribution of potential "users" of the project results of at least 25% of the total project budget is compulsory and adds up to the requested amount.

The users do not have to co-finance up-front in the program but may contribute in-kind (materials, equipment, facilities etc.) and/or financially in the project wherein they will participate.

To realize the ambitions of the Programme a budget for conferences, workshops and events will be reserved on programme level. This will be 5% of the funding available which is K€ 215,-

6. References

[1] Towards a Bright Future for Europe, Strategic Research Agenda in Photonics, Photonics21 EU Technology Platform (www.Photonics21.org).

[2] H. Zappe, ’Aktive Mikrooptik, neues Schwerpunktprogramm der DFG fur die Universitat Freiburg’, (2,5 millionen Euro), May 2007

[3] E. Bente ‘IR swept source for high resolution function imaging in medicin," IOP-Photonic Devices IPD-067774, TU/e, June 2007

[4] K. Hinnen, M. Verhaegen and N. Doelman, Exploiting the spatiotemporal correlation in adaptive optics using data driven H2-optimal control Journal of Optical Society America A, Vol. 24, No. 6, June 2007

[5] R.F.M.M. Hamelinck, P.C.J.N. Rosielle, M. Steinbuch, R.M.L. Ellenbroek, M. Verhaegen, N. Doelman, Actuator tests for a large deformable membrane mirror, in Advances in Adaptive Optics II; Editors: B. L. Ellerbroek, D. Bonaccini Calia, Orlando, Florida, United States, 9, (2006)

[6] P. Hansma, G. Schitter, G. Fantner and C. Prater, ‘High-Speed Atomic Forces Microscopy’, Science, Vol. 314, October 2006.

[7] http://www.okotech.com/

[8] SRA of the European Technology Platform on Smart Systems Integration (EPoSS), 2006 (http://www.imt.ro/technological_platforms/sra_EPoSS.pdf)

ANNEX 1. Pre-proposals

The project outline - which must not exceed 3 pages – should be written in English. The structure must be as follows:

1. Title
2. Names and addresses of the applicants
3. Expertises of the applicants and the objectives to increase these expertises
4. Fit within the themes of the program
5. Spearheads of the project
6. Concise description of the planned research. At least a description should be given of the expected results and the implementation thereof in industry
7. Names and addresses of the industrial partners of the project, if possible the names of the contacts within the companies
8. Support and involvement of the industrial project partners to this research project (qualitatively and quantitatively)
9. Preliminary budget
10. References.

Upon receiving a pre-proposal STW will decide on its admission (eligibility criteria). The program committee will assess the strategic fit within the research program and its themes. Each individual program committee member will give a mark for the strategic fit for each proposal. Then, in a plenary session the program committee will discuss all pre-proposals and formulate an advice to the applicants. This advice can be: 1) to submit a full proposal or 2) to adjust the proposal so that it would better fit into the program or 3) not to enter the subsequent selection procedure.

ANNEX 2. Format of the full proposal

STW receives your proposal by e-mail (info@stw.nl) in doc or pdf format.

- *Mention on the front page ‘Smart Optics Systems’ in the upper left corner*
- *The maximum length is approximately 12 (twelve) pages of A4*
- *The proposal and support letters must be written in English.*

Administrative data
On maximally half a page you should provide:

- Title. The title of the project has a maximum of 225 characters. For publicity purposes, a short, non-technical title or acronym is required as well.
- Name, address, phone number, fax number and e-mail address of the applicants and possible co-applicants and the telephone number of the secretary.
- STW sends the official correspondence to the main applicant. This is the first applicant mentioned. STW assumes the main applicant will have the supervision on the project. He or she becomes the project leader and bears the final responsibility for the execution of the research and the utilization plan.
- Applications elsewhere. If support has been applied for elsewhere, you should give the status of this application at the time of submission.

Project description

1. Summaries
The summaries should be clear to those active in the field.
Research summary
Summarize in half a page the context, problem statement, research method and expected results.
Utilization summary
Summarize the utilization potential of the expected results in half a page. Provide everything the reviewers should know about the utilization: the chosen approach, the chosen partners and the way results will be brought into practice.

2. Composition of the group
The current group
Describe in half a page the composition of the team (academic and industrial) that will perform the research as well as the reason this team is fit for this research. Indicate the supervisors of the project, the proposed staff, and how the tasks will be divided.
Available infrastructure
This information includes available laboratory room and equipment.
Candidate researchers
In case candidates for the proposed staff positions are already known, you mention them here. Give a short explanation of their suitability.

3. Scientific description
In this section of maximally four pages an expert in the field should find all information to assess the quality of the proposed research. Treat the following subjects:

Contents of the research
Provide the scientific objectives, the starting-points and the substance of the project. Describe the methods and techniques you will apply, the available knowledge in the team, the knowledge to be developed, and the instruments and models you will use for this. In-kind support of potential users must be an integral part of the research project.
Required personnel and equipment
Provide motivations for staff and equipment and possible other requirements for the research.
Time schedule and allocation of tasks
Describe the proposed course of the research over the years and how the different parts must interact. You give decision points (milestones) and moments research results are expected (deliverables). Further, you indicate which partner will perform which tasks.
STW will ask for a so-called "project plan" for all rewarded full proposals. This should contain a more detailed planning and budget.
Connections with other research
Mention similar research that is performed elsewhere, either in the Netherlands or in the rest of the world. Describe the relation with your own research and the contacts with these groups (or the plans to establish them).

4. Fit within the themes of the program

Describe explicitly the fit of the proposal in the program and its themes. These themes are described in Chapter 3 of the Smart Optics Systems program description. The program committee will use this section particularly for the assessment of the fit in the program.

5. Utilization plan

The utilization plan must be clear to those with general knowledge of the application domain.
The challenge from the practice and the proposed solution
Your research will address problems encountered in industry with not-yet-existing solutions. Indicate the industrial relevance of this problem and the impulse this research gives towards the solution. Indicate which steps you will take to bring the research results into actual practice. Provide details for assessment of the feasibility and the conditions for successful application.
The users committee
All Smart Optics Systems projects have "users committees". For further information on this you are referred to the STW website (see Open Technology Program) and the Smart Optics Systems webpage ('work in progress'). Mention the contact persons from companies and organisations that already accepted invitations to join the users committee, or that are willing to co-operate in another relevant way to realise utilization of results.

Past performance in utilization
Indicate the past successes that the academic team achieved in bringing academic research results into industrial practice, in relation with Smart Optics Systems or otherwise.

6. Contracts and patents

If there are any contracts relevant to the proposed research project, these should be mentioned here. Also provide patent search results, or the reason why such a search is not necessary for your proposal. Indicate if you have patents or running patent applications in the field of the research. This section takes maximally half a page.

7. Budget

In the main document you find a general explanation on which costs are considered for financing by STW and which are not. All amounts are without BTW (VAT). The length of this section is at maximum one page.

- ***Personnel***
  You can apply for temporary staff: PhD-students, post-docs or technicians. Staff is appointed by the executive institution. The actual appointment is subject to prior written permission of STW. STW may withdraw a grant if vacancies are not filled within a year after granting. The rates for staff can be found at www.stw.nl → infobalie

- ***Materials***
  The costs of office and laboratory goods, small instruments and appliances must be specified here. Internal travel expenses of the project are also part of this budget.
- ***External travel expenses***
  These are costs for travel and subsistence for congress visits abroad for the project.
- ***Investments***
  These are costs for necessary equipment and other investments for the project.
- ***Contributions of partners***
  Provide financial and technical (staff and material) contributions that the partners bring to the project. After granting STW will invoice the financial contributions and add them to the corresponding credit of the project. Present details on the capitalization of in-kind contributions as well. For in-kind staff contributions the maximum rates are 106 euro/hr for senior staff and 75 euro/hr for staff up to HBO-level. For material contributions, please explain the capitalization.
- ***Overview of the total project costs***
  Present a table with the planning of the staff appointments and the budgets per project year. Use the above mentioned headers. The partner contributions must be specified separately. The total project costs are the costs for STW as well as the contributions of the partners. The contribution requested from STW is at most € 750000. The partner contributions are at least 25% of the total budget.

8. Literature

In maximally two pages list all relevant and publicly available publications of the participating parties of the proposal, as well as relevant publications of others.

9. Key words, abbreviations and acronyms

Appendix. Confirmation letters.

These confirmation letters written by competent partner authorities, officially state their technical and financial contributions.

Appendix. Potential referees.

(not to be included in the proposal; please submit on separate page)

List four (inter-) nationally renowned referees that could review your proposal. The referees should be able to review the proposal objectively and therefore should not have participated as co-author in publications of the applicants.