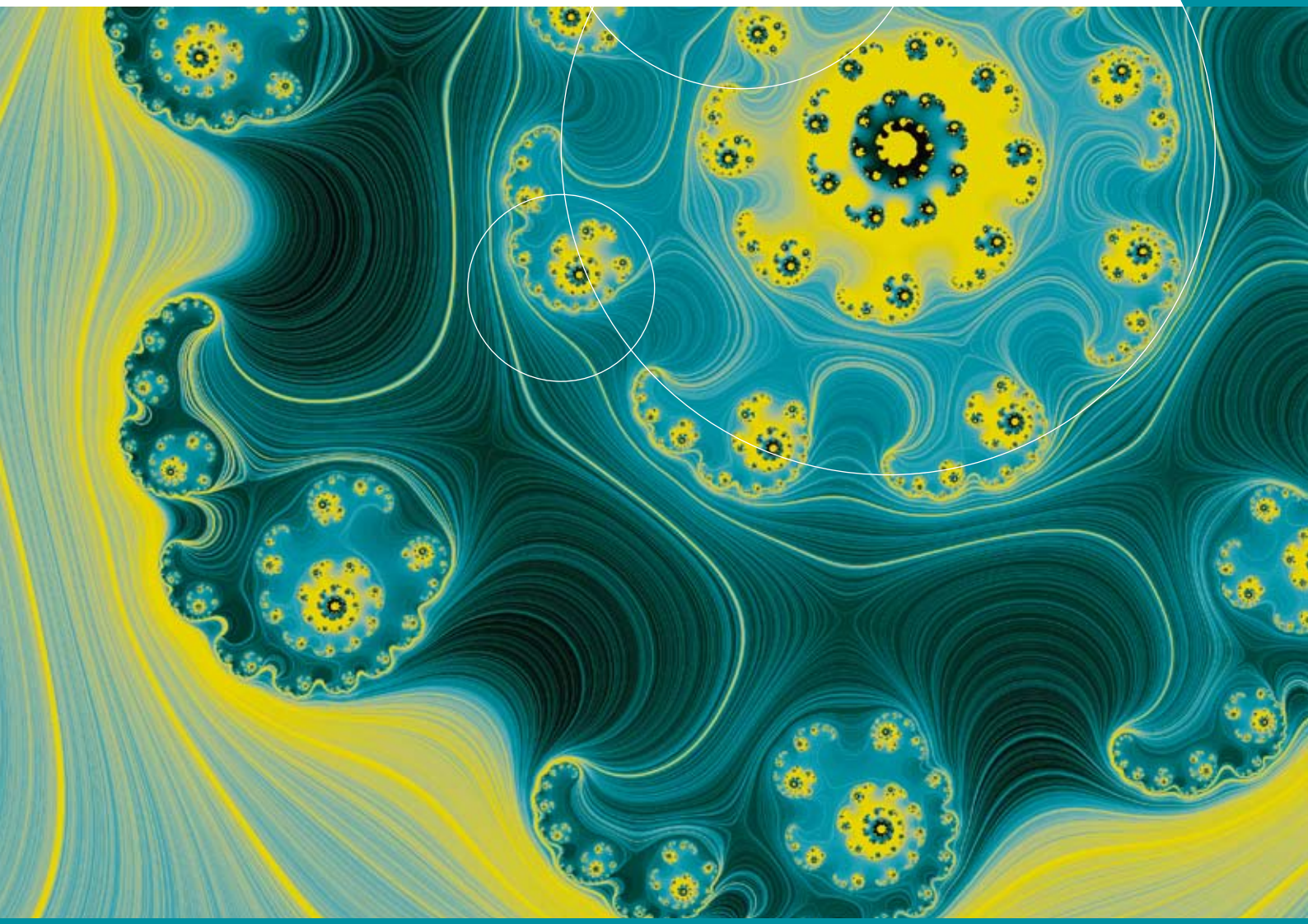
SenterNovem

IOP



2e Meerjarenprogramma IOP Zelfherstellende Materialen

Proposal for the 2nd National Innovation Oriented Research Program (IOP) on Self Healing Materials

In opdracht van

Ministerie van Economische Zaken

2e Meerjarenprogramma IOP Zelfherstellende Materialen

Proposal for the 2nd National Innovation Oriented Research Program (IOP) on Self Healing Materials

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Samenvatting

In 2005 heeft de Nederlandse regering ingestemd met de instelling van een Innovatief Onderzoeks Programma (IOP) Self Healing Materialen om de Nederlandse industrie en kennisinstellingen een kans te geven zich een prominente positie te verwerven in dit zich snel ontwikkelende veld. Conform de plannen in het eerste Meerjarenplan is er afgelopen jaren onderzoek verricht aan 5 Nederlandse universiteiten, TNO en KEMA om nieuwe routes te verkennen om te komen tot zelf herstellende plastics, metalen, beton, asfalt en composieten, d.w.z. materiaalvarianten die naast de gebruikelijke eigenschappen het vermogen hebben onder speciale omstandigheden (kleine) scheuren zelfstandig te doen verdwijnen. Een dergelijk vermogen biedt de sleutel om nieuwe materialen te ontwikkelen met sterk verhoogde betrouwbaarheid en duurzaamheid. Deze duurzaamheidsverbetering is vooral van belang voor constructies waarbij reparaties moeilijk uitvoerbaar zijn (bijvoorbeeld tunnels, pijpleidingen, booreilanden, windturbines op zee), waarbij een intact oppervlak behouden blijft (alle vormen van beschermende hoogwaardige coatings en verven), voor installaties waaraan hoge veiligheidseisen gesteld worden (zoals vliegtuigen) en voor die installaties waarbij reparaties grote maatschappelijke overlast veroorzaken (zoals wegen).

Het IOP-SHM onderzoek heeft aangetoond dat het voor alle onderzochte materiaalklassen mogelijk is om een vorm van zelfherstellend gedrag te creëren. Het heeft daarbij tevens geleid tot een uitzonderlijk netwerk tussen de kennisinstelling en een zeer breed geschakeerde doorsnede van de materiaalproducerende en materiaalverwerkende industrie. Het onderzoek mag zich ook verheugen in een grote maatschappelijke interesse.

In dit 2e Meerjarenplan (2009-2015) worden de contouren geschetst van het onderzoek dat noodzakelijk is om de succesvolle ontwikkelingen van het 1e Meerjarenplan te consolideren en uit te bouwen zowel binnen de eerder gekozen als naar nieuwe materiaalklassen voor de energieproductie, energieopslag en dataverwerking. Om deze doelstelling te kunnen realiseren is een vergelijkbaar budget nodig als toegekend voor het 1e Meerjarenplan.

Vanwege de internationale context waarin dit onderzoek naar de ontwikkeling van zelfherstellende materialen wordt uitgevoerd is dit 2e Meerjarenplan opgesteld in de Engelse taal.

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1. Introduction

Already in October 2004, the Dutch government defined 'High Tech Systems and Materials' as one of the focal points for innovation and active stimulation [1]. "High Tech Systems and Materials" covers an area with a yearly added-value of about 18 billion euro, generating over 200.000 jobs. Materials development as a precursor to new industrial activity was named explicitly as an important aspect. The relevance of material development as a key ingredient for high tech systems and integrated and multifunctional products was confirmed again in a governmental policy document in 2005 [2]. The strategic relevance of materials technology has long been recognised, and has led to the creation of successful Leading Technological Institutes in the field of materials (Materials innovation institute: M2i) and polymers (Dutch Polymer Institute: DPI) as well as a number of successful Innovative Research Programs in materials sciences.

In 2005 the Dutch government approved the Meerjarenplan for the 1st National (Dutch) Innovation Oriented Research Program (IOP), which detailed the research and research coordination towards the development of a new generation of materials with improved durability and reliability, covering all structural materials such as polymers, metals, concrete and composites [3]. The multi-material research program now involves five Dutch universities and 63 large and small companies and has received worldwide acclaim for its coherency and structure. It has led to the 1st scientific text book on self healing materials, with a strong contribution from the Dutch IOP-SHM partners [4]. Furthermore, the topic of self healing materials has even been accepted as a topic in the next national VWO (Voorbereidend Wetenschappelijk Onderwijs) curriculum and is to be included as elective courses in academic curricula. While direct industrial application of the new concepts developed is yet to take place (as is to be expected for ground breaking paradigm shifts), promising leads of virtually all material classes explored have been identified, and industrial support for the continuation of the IOP Self Healing Materials for a 2nd period of four years is very high. Furthermore, other industries and academic groups with an interest in functional materials, such as solar cells, microelectronics and batteries, topics which were intentionally not included in the IOP, have expressed an interest in an extension of the research into materials systems relevant to their core business to be made.

Given the positive results obtained and the outcome of the self evaluation [5] and external evaluation [6], the Advisory Committee (AC) of the IOP Self Healing Materials has formulated a new 2nd Meerjarenplan for IOP Self Healing Materials which should become effective in 2009. While the collaboration with other materials related programs such as DPI and M2i has been very good during the 1st Meerjarenplan of IOP Self Healing Materials, the collaboration is now formalised and initiatives are taken to set up to similar arrangements with Innovation Centres such as the MIP (Maritime Innovation Program), which would benefit from Self Healing Material systems being developed specifically for applications relevant to them.

a. Updated sketch of the field of Self Healing Materials

As mentioned in the 1st IOP Meerjarenplan *structural materials*, (i.e. materials which prime function is to support a mechanical load) play a dominant role in modern life. Wherever a structure or an object has to carry a mechanical load, to keep a constant shape or to guide away forces, structural materials come into play. Existing structural materials have always been

optimised for strength and toughness, and excellent material performance can now be realised by a tailored combination of material design and suitable production processes. Durability is the other key design issue for structural materials, as they are usually applied in structures (bridges, satellites, etc) that have to perform their task over a longer period of time in a reliable manner. Usually a high durability of a structure requires regular maintenance, i.e. manual repair of small scale damage in order to prevent catastrophic failure or premature rejection. Although over time the initial properties of 'man-made' structural materials have improved enormously, they are still susceptible to damage. Even long before fatal damage – e.g. fracture – occurs, the material will acquire a lot of 'invisible' damage on a microscopic scale: micro-cracks. These micro-cracks might accumulate into a major catastrophic crack.

The 'classical' approach to material improvement is by making the material stronger and hence slowing down the process of micro and macro crack formation. However, sooner or later even the best optimised material will fail due to crack accumulation.

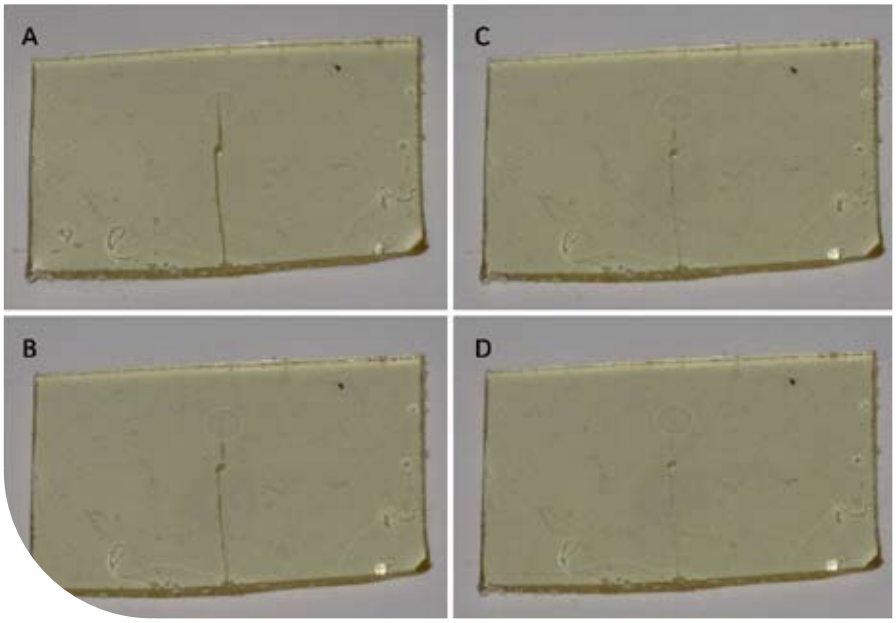
A radically different concept in materials optimisation can be found in biological materials: In these materials the occurrence of damage is accepted as an unavoidable fact of life, and the material has an inbuilt capability to fully or partially heal damage and to restore the functionality autonomously. Such materials are 'Self Healing'.

The 1st IOP Meerjarenplan aimed at defining a national research program to impart this self healing ability to such man-made structural materials.

In this 1st IOP Self Healing Materials Program two research tenders have been organised which attracted no less than 137 research proposals from Dutch universities and Knowledge Centres and two foreign parties.

Out of these proposals 28 research projects were granted, involving 63 companies ranging from multinationals to start-up SME's (Small and Medium Enterprises) including all leading material producing companies in the Netherlands. The research is being conducted at the three Technical Universities (at Delft, Eindhoven and Twente), the Rijks Universiteit Groningen (RUG) and Radbout University Nijmegen, as well as TNO (Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek) and KEMA (Keuringsinstituut voor de Nederlandse Elektriciteitssector in Arnhem).

TU Delft: Capsule made of porous sand containing oil used for self healing of porous asphalt.



TU Eindhoven: Self-healing via the interchange of disulfide bonds. The images show the self-healing process of a crosslinked epoxy resin at 60 °C. Pictures are taken at time 0 min (A), 20 min (B), 40 min (C) and 60 min (D).

The 1st IOP Meerjarenplan has demonstrated that it is indeed possible to create self healing behaviour in polymers, metals, civil engineering materials (concrete and asphalt) and composites. The mechanisms by which healing was obtained vary from materials class to materials class and show a very wide spectrum ranging from atomic and molecular diffusion, to Newtonian flow of a reactive liquid, oxidative reactions at high temperature and even to bacterial action. The identification of a wide range of potential healing mechanisms to be explored in a more industry oriented materials development program at a later stage was indeed the explicit objective of the 1st Meerjarenplan of IOP Self Healing Materials. Part of the scientific research in this IOP program, combined with those of other key players in the field, have been published in the first scientific monograph on self healing materials [4]. More results of the IOP program have been published in journal publications and patents. Their numbers are still relatively low, because of confidentiality and potential IP, but will grow rapidly in the coming year. As planned, the 1st Meerjarenplan of the IOP Self Healing Materials has led to a multi-material community of researchers and has brought together researchers from traditionally clearly separated fields (e.g. one of the most recent IOP projects is based on collaborative research between a leading experimental polymer chemist and a leading theoretician working in the field of metal plasticity. A second project involves the collaboration between a mathematician responsible for the development of a model for skin wound healing and the concrete research group focussing on self healing via bacterial action). It is interesting to note that this broadening of the materials community has been highly appreciated by the industrial partners and new contacts are regularly made during the IOP conferences.

These healing mechanisms identified have lead to new avenues for self healing plastics, new self healing coatings, new self healing concrete, road surfaces with extended life time, novel steels for high temperature reactors and longer lasting Thermal Barrier Coatings on turbine blades. All these projects and more information about the IOP Self healing Materials can be found on www.senternovem.nl/iop-shm. Clearly, the initial investment in the IOP program has paid off well and has positioned the Dutch industry in a favourable position. The information on the new developments was not contained within the research and development community but has received a wide exposure via a large number of interviews and feature articles in national newspapers (Financieel Dagblad, NRC- Handelsblad and Volkskrant, etc.) but also via branch oriented journals (Cobouw, De Dakdekker, Offshore Views, etc.) and even to the popular science journal for youngsters (Kijk).

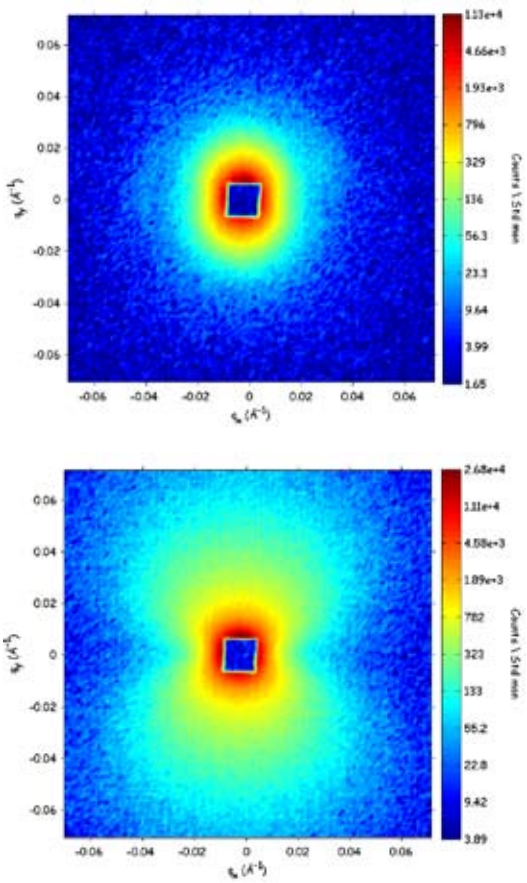
b. Ambition of the 2nd Meerjarenplan of IOP Self Healing Materials

Given the success of the 1st IOP Meerjarenplan in terms of new developments, research coherency, scientific collaboration and visibility to industry and society, it would have been natural and appropriate to continue along the research and policy lines set out in the 1st Meerjarenplan. However, the Advisory Committee (AC) has decided to restructure and broaden the research themes for the 2nd Meerjaren-

plan of IOP Self Healing Materials, to improve the potential industrial and scientific impact of the IOP-SHM research program even further.
Taking into account new scientific insights, lessons learned from the 1st IOP Meerjarenplan and the signals from the industry currently not yet involved in our research, a new distribution of research themes has been defined: 1) structural polymers & composites, 2) concrete & asphalt, 3) metals and ceramics, 4) coatings and 5) functional materials. The topics coatings and functional materials are new additions to the list of research domains, while the separate topics polymers and composites in the 1st Meerjarenplan have been merged into 1 domain Polymers & Composites. The field of coatings was added since it has been realized during the 1st MJP that coatings offer specific opportunities and constraints for self healing and more synergy is to be realized when all coating related projects are grouped into one field. As pointed out in the introduction there have been several requests from industry and academic groups to expand the working field of the IOP towards *functional* materials, i.e. materials with a prime non-mechanical function (such as materials for microelectronics, photonics, batteries or solar cells). Given the strength of the arguments, the AC has added this class of materials to the IOP-SHM research portfolio. A similar expansion of the working field from only structural materials to structural and functional materials has been made by M2i in its transition from its predecessor Netherlands Institute for Metals Research (NIMR). Also the Dutch Polymer Institute (DPI) has shifted a larger proportion of its research budget towards polymers for functional applications.

In view of the research fields and the planned expenditure in each of them (see chapter 4), the objectives for the 2nd Meerjarenplan of IOP Self Healing Materials have been formulated as follows:

1) to continue the research in successful or promising directions identified in the 1st phase of this IOP in order to make these concepts more suitable for industrial valorization and application;
2) to explore new routes for self healing behaviour in structural materials;
3) to conduct research into self healing concepts for functional materials (for instance solar cells, batteries and electronic materials);
4) to strengthen the innovative power of the Dutch industry by a close university-industry collaboration and a rapid dissemination of results;
5) to stimulate the field of self healing materials by regular public exposure in the popular and professional press and by stimulating the interest of future generations of scientists and engineers by tailored educational tools for VWO and HAVO (Hoger Algemeen Voortgezet Onderwijs), as well as the introduction of courses on Self Healing Materials in academic curricula. At this stage there is not enough incentive to set up a tailored educational tool for the HBO but the AC will keep monitoring the field and take appropriate actions as soon as a real opportunity arises.



TU Delft: (a) "Before" figure (0 shape pattern), (b) "After" figure (8 shape pattern).

2. Self Healing Materials and the Dutch industry

a. Broadened industrial support for the IOP Self Healing Materials

In 2004 'Self Healing Materials' was chosen as the new central research theme for the Delft Centre for Materials (DCMat). Soon it was realised that the scope of the field was such that expansion into a national research program was necessary and major players in the material producing and processing industry (DSM, Corus, Akzo Nobel, Teijin, Shell, Stork Fokker, BAM, ENCI, ABT, SABIC and SME's like SupraPolix, Encapson) as well as the Dutch institutions responsible for the technological and fundamental research in the principal material classes, polymers (DPI), materials including metals (M2i), concrete (CUR Building & Infrastructure), technology in general (STW: Stichting voor de Technische Wetenschappen and FOM: Stichting Fundamenteel Onderzoek der Materie) and TNO were approached. All parties reacted very positively to the initiative, as they recognised the strategic value of Self Healing Materials and the need for a consorted national approach to this new field. They are now well involved in the 1st IOP Meerjarenplan. In fact, many new partners are keen to join the program and after extensive discussions with all partners it became clear that they all welcome the extension of this IOP along the lines outlined in this second IOP-SHM Meerjarenplan.

In the 1st IOP Meerjarenplan it was decided not to concentrate on involving small and medium sized enterprises in research activities during the start-up phase of this program, but to focus the effort initially on major companies. It was understood that smaller companies will be involved at later stages of the program once the principal concepts have been developed and the research shifts to more application oriented domains. That means that the now proposed next IOP Meerjarenplan should address the needs of these SME's more explicitly. Notwithstanding this, most of the attention will remain with companies capable of making new self healing materials available to industry at large, as this offers the best chances of broad utilisation of the results.

Since the start of Self Healing Materials research in The Netherlands, several international companies and institutes showed a keen interest and solicited for modes of co-operation. In fact the Australian research centre CSIRO and the Italian company Tecres already take part in existing IOP projects, but discussions are ongoing with industry in Belgium, Germany, Spain, the UK, the USA and Japan. At this moment, due to the IOP, Dutch universities and companies are involved in two major European FP7 project proposals (involving self healing concrete and self healing composites respectively, each with a requested budget of more than 4 million euro). More requests for collaboration have been received but it was decided to strengthen the Dutch position first before sharing part of the new knowledge with foreign parties.

b. Application areas and utilisation of Self Healing Materials

As stated earlier, the future application areas of Self Healing Materials are yet to be established and are likely to develop in the near future. However, it is most likely that the first generation of self healing materials will find their application in:

- products and installations, which once in operation are difficult to reach, such as high-rise buildings, marine applications (among them umbilicals, as was recently recognised in a joint workshop with the Maritime Innovation Program), underground piping and wind turbines, etc.;
- products where either a pristine surface appearance or a guaranteed protection of the substrate

TU Delft: Bee-eaters in the Rotterdam Zoo, where the sand-like structure for the nests of the birds has been fortified using limestone producing bacteria

under all conditions is important (such as painted surfaces, corrosion protective coatings, thermal barrier coatings);

- products, such as aircraft and spacecraft, where reliable use, even in the case of overload or unforeseen modes of loading is of crucial importance; this also applies to completely different application areas such as the long-term storage of nuclear waste;
- products with extremely long life-cycles, such as in major infrastructural applications, e.g. flood barriers, tunnels, piping networks, storage facilities for harmful species etc.;
- high-tech equipment for the production of high-quality products, machines that are usually operated the clock around, and where down-time due to repair should be kept to the minimum;
- products where major repair actions cause a lot of disturbance to the public, such as road surfaces and energy supply systems.

All such applications are in principle covered in this IOP. While Self Healing Materials could also find application in the medical field, no dedicated action in this direction is foreseen within the context of this IOP as the medical field requires different expertises and networks, and the final application in the human body puts serious constraints (in temperature and the absence of even micro toxicity, etc.) on exploring potentially interesting self healing mechanisms. However, self healing processes that occur in biological systems will continue to be used as a source of inspiration in the development of man-made Self Healing Materials.

To guide the research on Self Healing Materials, in this IOP the instrument of scenario committees has been established and it will be continued. A scenario committee describes the key application areas for a particular field and identifies which new tools should be developed for a successful introduction of these

new materials. Here one could think of intrinsically new approaches to designing structures, new philosophies towards risk assessment etc. Each scenario committee is based on a group of leading and visionary experts in that field. To maintain independence and objectivity, the committee members in general have no personal link with the ongoing IOP Self Healing Materials Program.

To date four scenario committees have delivered their visions on Self Healing Materials and the construction industry, SHM and the paints and coatings industry, SHM and the Offshore industry and SHM and the polymer industry. The visions have been recorded in SenterNovem publications which have been widely distributed in the respective industry fields.

In view of the new research fields in the 2nd phase of the IOP, scenario committees on Self Healing Materials and the electronics industry, Self healing Materials and the Solar Cell industry and a Scenario committee on Energy Storage are foreseen in the 2nd IOP Meerjarenplan. Furthermore, a scenario committee on legislative issues might be held once we approach the commercialisation stage for one of the new materials. The option to install scenario committees related to one of the topics of the Societal Innovation Program will be explored with stakeholders. Discussions with ESA are ongoing to initiate a study for the field of space technology, but no firm commitment has been made yet. New scenario committees not mentioned here may be established depending on developments in the field in coming years.

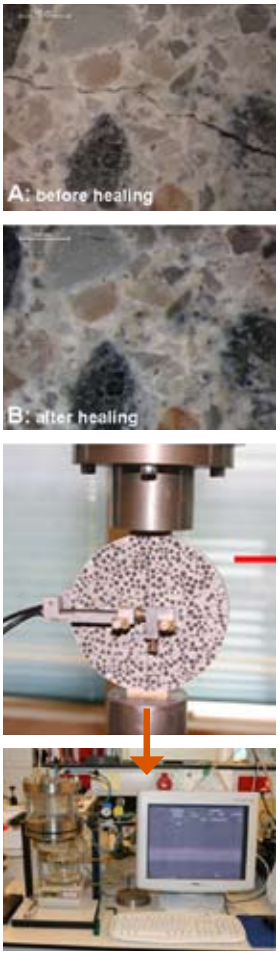
c. Absorption of the IOP generated knowledge in the Dutch industry

The IOP instrument, which celebrates its 29th anniversary this year, has been successful in the dissemination of knowledge to the Dutch industry and SenterNovem (an agency of the ministry of Economic Affairs; see chapter 6b) has developed a range of tools for this purpose. These IOP tools are also being used in the IOP Self Healing Materials.

In addition to these tools we also use the industrial network of the knowledge partners (universities, STW, FOM, DPI, M2i, CUR and TNO) as well as the network of experts provided by a.o. the Bond voor Materialenkennis, the Nederlandse Vereniging van Verftechnici (NVVT), and many materials related branch organisations. Other networks may be enlisted as the program develops.

As in the 1st IOP Meerjarenplan, a series of national conferences and workshops will be organised during the course of the 2nd IOP Meerjarenplan. To share newly developed knowledge and expertise effectively to smaller sized companies, SME's, a new tool will be developed: IOP-SME workshops. At these yearly one-day workshops, SME's are invited to consult the specialists working within the framework of the IOP program on all aspects of Self Healing Materials. Together they can assess the possibilities of applying the new knowledge to the benefit of the SME's products and processes. To facilitate the communication at these workshops between SME representatives and researchers within the IOP, postdocs or PhD students can follow a dedicated communication training (arranged by SenterNovem). Furthermore, a course on patent application will be offered to the researchers in this IOP. Both courses will be set up in conjunction with other IOP's.

3. Knowledge Infrastructure



TU Delft: Bio concrete in a permeability setup

a. Extension of participating partners

The 1st Meerjarenplan the IOP Self Healing Materials used the foundation laid by the Delft Centre for Materials of Delft Technical University, but has grown into a truly national research program with significant contributions from the Technical University Eindhoven, the Technical University Twente, the Rijks Universiteit Groningen and Radbout University Nijmegen. Given the strength of the materials research programs at these universities, it is foreseen that these universities will also play a major role in the 2nd Meerjarenplan of this IOP, but other universities are encouraged to play a role in the new IOP too, in particular for the field of functional materials. TNO and KEMA are already partners in the ongoing SHM research and it is expected that ECN (Energieonderzoek Centrum Nederland) will become active too, now functional materials in the field of energy conversion and storage have been added to the portfolio. It should be pointed out that TNO has been particularly active in developing its own research line in the field of self healing polymer systems, in particular self healing coatings. Some of their developments are made in collaboration with CSIRO (Melbourne Australia). CSIRO also maintains links with other IOP academic and industrial partners.

b. International scope extended

Given the coherency and scope of the 1st IOP Meerjarenplan, the Netherlands has established a leading position in this emerging field. This position was clearly marked with the organisation of the 1st International Conference on Self Healing Materials in Noordwijkerhout in 2005 and the prominent role in the 2nd International Conference on Self Healing Materials in Chicago (2009). With the extension to a 2nd IOP Meerjarenplan on Self Healing Materials this leading position will be reinforced. It will be the aim to mark the end of the 2nd IOP program by organising the 3rd International Conference in 2013, but competition to host this conference is building up.

At this moment Dutch universities are involved in two European research proposals (FP7 program) on self healing concrete and self healing composites. In the case of the self healing concrete the Technical University Delft will lead the program while the University of Bristol will be the program leader for the composites program. Both European programs have a requested total budget of over 4 million euro.

To date the Netherlands is the only country with a coherent program on self healing materials covering all structural material classes. Other countries have established smaller programs on individual material classes only (Australia on light metals, Japan on self healing high temperature ceramics, UK on self healing composites and Self healing polymers, Germany on biomimetic materials), but we are aware of planned Italian and Spanish initiatives.
The extension of the research domain to include also functional materials will again give the Netherlands a new competitive edge. As far as we are aware only two USA based universities have initiated research in the field of self healing photovoltaics and other photonic materials.

During the 1st IOP Meerjarenplan serious contacts have been established with a number of foreign companies, such as WellStream (umbilicals, UK), Toyota (cars, Belgium, Japan), Grace (concrete adhesives, USA), Samca, (ceramics and polymers, Spain), Shell Global Solutions (oil drilling, worldwide). While they have not led to tangible results yet, they hold enough promise for further development in the period of the 2nd Meerjarenplan. Of course, other industrial contacts will develop too. Given the international character of the materials world and the heavy involvement of materials companies based in the Netherlands in this IOP, the internationalisation of the research will be beneficial for the Netherlands on a longer time scale.

4. The contours of the new Self Healing Research Program

a. Presentation of the new research matrix

A key and novel concept in the 1st IOP Meerjarenplan was the definition of a research matrix which indicated the fractional expenditure on each of the four selected material fields and the work packages material development, theory and application oriented research. This research matrix proved extremely valuable as a tool to select the best research projects for each field and to maintain the overall balance in the program.

Hence in this 2nd Meerjarenplan a similar research matrix is included, now taking into account the five research fields identified: 1) structural polymers & composites, 2) concrete & asphalt, 3) metals and ceramics, 4) coatings and 5) functional materials. In contrast to the research fields distinguished the work packages distinction was essentially kept unchanged and still consists of i) Materials development and property appraisal, ii) Theoretical framework and iii) Pre-application research.

The distribution of the total research budget over these 5 domains and 3 work packages was discussed and agreed during a lively national workshop on 19th February 2009, with all relevant stakeholders and representatives from the Ministry of Economic Affairs and was accepted as such in a separate meeting by the existing AC.

Given the nature of the rapidly developing field and the wish to be able to respond adequately to successful developments, as well as to select the very best research proposals, rather than specifying the planned research effort in each cell of the matrix, only the planned cumulative fractional effort in each column and row is indicated. This procedure has also been used in the formulation of the research matrix for the 1st IOP Meerjarenplan.

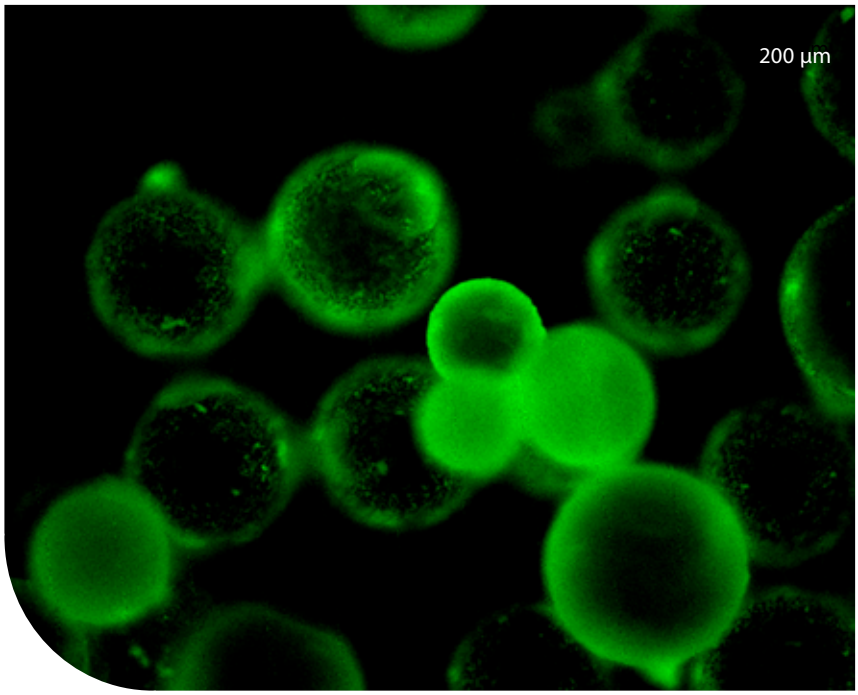
The justification for the distribution over the five fields can be summarised as follows (a full scientific and industrial justification is outside the scope of the text of this Meerjarenplan):

- The new field of Coatings is relatively well endowed since in the 1st IOP Meerjarenplan it was observed and realised that coatings (be it metallic, ceramic or polymeric) are probably the most relevant near future application for self healing materials. Their prominent position is the consequence of the fact that coatings are easily damaged because of their large surface to area ratio, are exposed to an environment which can be tailored to provide an ingredient of the healing process, and the coating thickness limits the crack size in at least one dimension. So, all future IOP research proposals involving coatings will be funded out of this budget, irrespective of the material class.

	MATERIAL DEVELOPMENT AND PROPERTY APPRAISAL	THEORETICAL FRAMEWORK	PRE-APPLICATION RESEARCH	FRACTIONAL EFFORT
POLYMERS AND COMPOSITES				20%
METALS AND CERAMICS				10%
CONCRETE AND ASPHALT				25%
COATINGS				30%
FUNCTIONAL MATERIALS				15%
FRACTIONAL EFFORT	50%	30%	20%	100%

Table 1: Fractional distribution of the total research budget in the 2nd IOP Meerjarenplan.

- The field Concrete & Asphalt is allocated the same percentage of the budget as in the 1st IOP Meerjarenplan as this field has developed relatively rapidly and holds very good potential for early commercialisation.
- The fields Polymers & Composites is granted a seemingly lower budget than in the 1st Meerjarenplan, but it should be realised that a large fraction of the coatings budget is likely to involve polymers. Given the close collaboration with DPI it is foreseen that additional funding might become available for promising research in the field of polymers via that organisation.
- The field Functional Materials (covering all materials which have a primary non-mechanical function, such as materials for microelectronics, batteries, solar cells, photonics etc.), receives an adequate budget to make a good start with the research and to establish promising routes for self healing behaviour in these material classes.
- The field Metals & Ceramics receives a seemingly low budget because the options of self healing behaviour in bulk metals seem to be restricted to age hardenable aluminium alloys and other light metals and to high temperature creep steels and high temperature ceramics. Furthermore, part of the research on metals will focus on coating applications and will be funded out of the coatings budget. Given the close collaboration with M2i it is foreseen that additional funding might become available for promising research in the fields of metals and ceramics via that organisation.



Liquid filled microcapsules for self-healing visualizing the embedded fluorescent filled particles.

The increased attention for formation of the theoretical framework with respect to the research matrix in the 1st MJP was at the request of the industry, and stems from the fact that such models will allow them to develop their own self healing grades for their own field of materials more efficiently.

It should be pointed out that the fractional distribution of the research budget only applies in case the quality of the submitted projects for each domain meets the required level. In case the planned funding for a particular domain is not fully used, the remainder may be transferred to other domains and used to fund attractive and high ranking proposals in other material classes.

During the workshop dedicated to this research matrix the industry confirmed its earlier advice given for the 1st IOP Meerjarenplan that the IOP research should be focussed on exploring new concepts as well as the quantification of self healing behaviour and on building theoretical models for self healing behaviour. The models should give guidance to the optimisation of the various concepts as well as to deepen our understanding of the mechanisms.
The models can either be fundamental or more descriptive. Validated models are seen as extremely important in enabling the transition of the academic research to the commercial industrial environment.
The application oriented research is to focus on making a step from the original concept to a real application smaller and to explore technological or scale up issues, rather than on applications itself. In case the Self Healing Materials research develops less fast than anticipated, (part of) the budget reserved for application oriented research can be transferred to the Material Development work package.
In case of projects intrinsically belonging to two

work packages (such as a mixed experimental-theoretical project) or to two material classes, the AC might decide to split the budget to be allocated accordingly.

The funding distribution over the various domains indicated applies to the total budget. As to budget will be allocated via two tranches, the allocation in the first tranche may deviate from the distribution indicated, as long as it does not make meeting this distribution over the entire period of the IOP impossible.

The organogram of the Self Healing Materials, shown in chapter 6 of this report, provides additional information on how the research in the various fields is initiated and monitored.

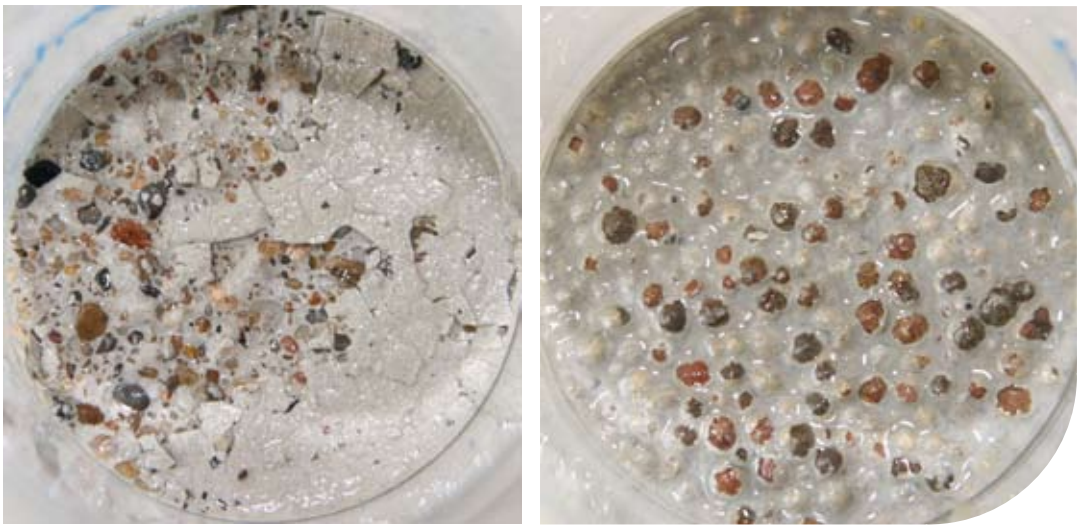
b. Project selection procedure and selection criteria

Project proposals within the framework of the IOP Self Healing Materials will be collected through open calls for proposals that will be advertised in the appropriate media as well on the IOP website.
The IOP Program Office at SenterNovem will be responsible for the administrative processing of the applications. The procedure to be followed is in line with the new IOP guidelines but is tailored to the existence of the research matrix specifying the fractional budgets. Full details of the procedure will be published in the Staatscourant.

Decision phase 1. Up to a publicly announced final submission date project pre-proposals of maximum three A4 pages long (and of a predefined format and structure) can be submitted to the IOP Program Office. Out of the pre-proposals of this A4 round received the Advisory Committee will select those project proposals for further detailing which individually and collectively best meet the selection criteria detailed below and fit within the research matrix given in table 1. The same procedure for allocating a positive or negative response as used in the 1st Meerjarenplan will be applied. This basically means that the number of proposals invited to be detailed in full, is no more than 3 times the budget that can be allocated to that particular domain.

Applicants with a positively appraised proposal will be invited to submit a full proposal and details of the consortium. Applicants with a negatively appraised proposal will not be encouraged to submit a full proposal but any such full proposal legally has to be evaluated. Only full proposals which have been submitted in abbreviated form in the A4 round can be considered in the final evaluation round.
Decision phase 2. This phase concerns the selection of the best of the full project proposals submitted, while taking into account the IOP funding intentions as highlighted in the research matrix. The procedure is essentially the same as in the 1st IOP Meerjarenplan. Full project proposals are sent to the Proposal Ranking Committee (PRC) for that particular field. Each material field distinguished in the research matrix will have its own PRC. Hence the IOP-SHM will have 5 PRC's. The applicants indicate in their proposal themselves, which field applies best to their research proposal. In case their proposal applies to more than one field, the proposal will be sent to the relevant PRC's.

Each PRC ranks the various research proposals in that field on the basis of the criteria formulated and the procedure developed in the 1st IOP Meerjarenplan of Self Healing Materials. In addition to the quantitative ranking the PRC will make a brief statement on the merits and weaknesses of each proposal. The Pry's send their results to the AC.
Each PRC will consist of an equal number of specialists from industry and academia and will be chaired by a specialist member of the AC. Procedures will be set up to safeguard a maximum input from the specialists on the one hand but to prevent conflicts of interests on the other hand. In no case experts can vote on projects in which they are involved directly or indirectly. Each PRC is only appointed for one call for proposals, but PRC members may be re-invited for the 2nd call for proposals.



TU Delft: Frost scaling performance comparison. Left: Control mortar; Right: Mortar with self-healing media

Having received all recommendations of the various PRC's the AC will grant the proposals on the basis of these rankings as well as the budget for that field. The budget requested for a particular proposal may be split by the AC over more than one field in case the research to be conducted justifies such a re-distribution. The AC may deviate from the field rankings by the PRC's on the basis of overriding strategic arguments. Such strategic arguments should find their foundation in the overall coherency, quality and efficiency of the IOP program as well as the constraints imposed by legislation. The AC has to report its decision to deviate from the PRC ranking order in an explicit manner, when sending its final proposal for project funding to the Director Innovation at SenterNovem.

The criteria for assessment of pre- and full proposals are to be refined in further discussions within the AC but should at least contain the following elements:

a. Scientific and technical quality of the research proposed in relation to its 'self healing content', and the likelihood of the results indicated actually to be achieved. Furthermore, in determining this score also the scope and potential strategic value of the promised results in relation to the subsidy requested will be taken into account;
b. Estimate of the likelihood of the outcome of the research being implemented by industry at a later stage;
c. Fit of the proposal to the overall targets of the IOP self healing materials, i.e. the possibility that the research in one proposal can contribute to the knowledge generation in other projects within the IOP.

As Self Healing Materials are intrinsically aimed at improving both durability and reliability, these criteria are not named explicitly here, as they will play a major role in all and every Self Healing Material proposal. The final judgement of each proposal will be based on the ranking on each of the three elements multiplied by their weight factor. The expected weight factors are 50%, 30% and 20% respectively. A final discussion whether the weight factors should be the same for all material classes and whether they should be the same in the 1st and 2nd tender is yet to be held. The AC will have this discussion at its first board meeting and the weight factors will be made public at the official call for proposals.

In order to maximise the actual research efforts, it has been decided that, as in the 1st Meerjarenplan, major investments in equipment can not be part of the research proposal and will not be granted. However, unlike the 1st Meerjarenplan, proposals for 4 year PhD positions, as well as 2 year postdoc positions, can be submitted. Although the IOP program retains its focus on funding and enabling research, it is possible to include requests for funding of technical support staff as well.

5. Knowledge transfer, network extension, embedding and concentration

For the ultimate success of the program the dissemination, absorption and utilisation of the newly established expertise by the Dutch industry is of major importance. In this way the impact of the IOP Self Healing Materials will outlive the time span of the total 8-year IOP program and will find solid anchors in the Dutch technology cluster. In this chapter we describe the general outline of how this objective will be met within the IOP Self Healing Materials.
Generally, the process of knowledge transfer will be guided and managed by the Knowledge Transfer Committee (KTC see chapter 6). This committee will also identify existing and emerging stakeholders in the field and formulate strategies towards them. The committee will comply with existing and emerging IOP guidelines, and will deliver to the AC a separate report with details of knowledge transfer in the summer this year.

a. Knowledge transfer

The field of Self Healing Materials is a truly interdisciplinary area in its essence. Therefore, an ambitious strategy to transfer knowledge between researchers within the program and between researchers and industrial parties is of major importance.

The dissemination of expertise and new concepts to industry will be stimulated by an active IP policy: the target within this IOP is set to at least three patent applications yearly. These patents will be transferred to existing industrial partners or start-up companies depending on the nature of the development and invention.

The SME sector will be engaged by organising a yearly workshop during which not only information about the ongoing research will be presented, but during which the IOP researchers will also provide advice to parties interested in the potential impact of Self Healing Materials for their own products and/or organisation. The exact format of this part of the workshop is yet to be arranged in consultation with SenterNovem and the KTC.

The exchange of new knowledge between the researchers in the IOP program and researchers in industry will generally be arranged per materials class, with researchers in the field of theoretical developments playing an important role in the inter-material knowledge dissemination. Progress meetings will generally be held on a 6 monthly basis under conditions specified in chapter 6. The cross-fertilisation between the knowledge gained within the separate materials classes will take place through the organisation of open national and international conferences / workshops and summer schools for researchers that will address the topic of Self Healing Materials in its full width.

b. Network extension

An essential ingredient in the knowledge chain is the creation of sets of interpenetrating networks involving key organisations created in the context of the Innovation Platform. The IOP network started up with the 1st IOP Meerjarenplan and is to grow further into a strong network by itself but also to have good interaction with existing national materials and technological networks.
The contacts between IOP SHM and DPI and IOP SHM and M2i are excellent and regular formal and informal strategic meetings between IOP-SHM and the two materials Innovation programs are held. Where appropriate the organisations present themselves together (such as in a joint pavilion at the Materials Engineering Exhibition 2009). Both the M2i and the DPI have indicated their full support to the submission of a 2nd IOP Meerjarenplan, as they see the opportunity of a lot of synergy. Such synergy has

IOP SHM researchers during there summer school in Vlieland, May 2009.

already been demonstrated during the period of the 1st Meerjarenplan, (in particular in the field of self healing engineering polymers, thermal barrier coatings, organic coatings and fatigue insensitive aluminium alloys). Partners have discussed the option of setting up jointly funded research programs (IOP-DPI and IOP-M2i or even an IOP-DPI-M2i) but as the funding and IP schemes of the organisations involved differ such that a formal joint research program add more administrative and legal complexity than that the research is stimulated, at this stage a formal joint research program is not proposed. However, in line with the active interaction, a representative of both DPI and M2i will be appointed in the AC of the IOP, while the chairman of the IOP holds a position on both Program Committees of M2i and is regularly invited for strategic discussions with the board of DPI.
While, for the legal/administrative reasons indicated above, there is no *formal* organisational collaboration between IOP, DPI and M2i, there is very good collaboration at the research level, in materials such as thermal barrier coatings (where the IOP research is a direct follow-on from earlier M2i funded research), liquid based healing systems (where the DPI funded project on self healing thermosets formed the basis of the IOP program on self healing asphalt) and the research on novel aluminium grades in which the M2i research on novel rolling strategies is complemented by a companion IOP effort on new alloys chemistries.

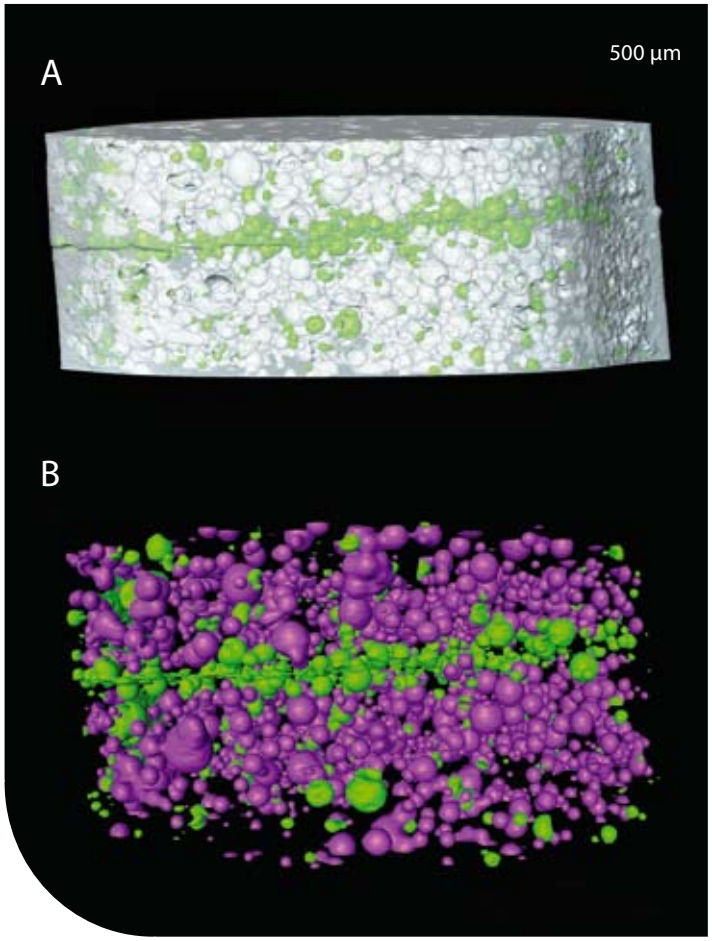
During the 1st Meerjarenplan very good interactions with the Maritime Innovation Program (MIP) have been established. These contacts will be intensified and similar contacts will be made with other organisations created in the Innovation Platform. New opportunities arise with the definition of the field of functional materials as part of the IOP-SHM research portfolio.

Earlier discussions with the board of STW have been very positive and it is the intention to submit a so-called '*Perspectief Programma*' proposal for a yet to be selected subdomain of self healing materials and/or their applications in the course of this 2nd MJP. At this moment two open technology STW projects in the field of self healing asphalt and durable concrete are already operational and some other proposals are

under review. The topic of self healing concrete is also included in a recently granted STW *Perspectief programma* on durable and sustainable building materials.

c. Further embedding of knowledge

The IOP instrument aims at creating networks and systems for co-operation that have a more permanent character than the life-span of the IOP program itself. It should be pointed out that the 1st IOP Meerjarenplan SHM has already led to the appointment of two Assistant Professors at the Technical University Delft with specialisations of Self Healing Concrete and Self Healing Materials for High Tech Applications respectively. Such an embedding of the IOP domain in the context of permanent academic positions is exceptional and a clear sign of the lasting impact of the IOP SHM Meerjarenplan.



TU Delft: X-ray tomography image showing filled (purple) and emptied (green) capsules in a plastic matrix; At the crack microcapsules have opened, spilling their reactive contents inside the crack where it can heal the damage.

Within this IOP SHM this is realised by:

- Stimulation of young researchers to continue their work after their IOP project within other funding environments. (The submission of VENI and VIDI proposals by high-potential IOP researchers at the end of their contracts will be actively stimulated). In this way the Dutch universities may be offered a new generation of researchers with a common background in an emerging and promising field of materials science and engineering;
- The creation of scenarios for future applications and design strategies with Self Healing Materials will lead to a long term focus;
- The provision of active support for the creation of start-up companies in niche applications that emerge from the IOP program, via existing channels.

d. Concentration

The chosen concentrated approach of the field favours an active co-operation with relatively big industrial partners. The dissemination of knowledge to smaller parties is more likely in the case of well established and successful co-operation with bigger partners. Given the field it is expected that a lot of smaller innovations and unexpected niche applications will result from the mainstream research effort which will be offered to SME-companies.

The clear identification of research fields to be addressed in this 2nd Meerjarenplan leads to a concentration of the research efforts in the Netherlands. In its self evaluation the AC for the 1st Meerjarenplan made it clear that concentration should be in topics and a strategy of intentionally concentrating research fields in specific universities would be counterproductive and not lead to quality improvement.

6. The organisation of the IOP

In this chapter the role of the different organisational entities involved in the implementation of the IOP Self Healing Materials are described. The organogram of the IOP Self Healing Materials shown in figure 1, is explained below:

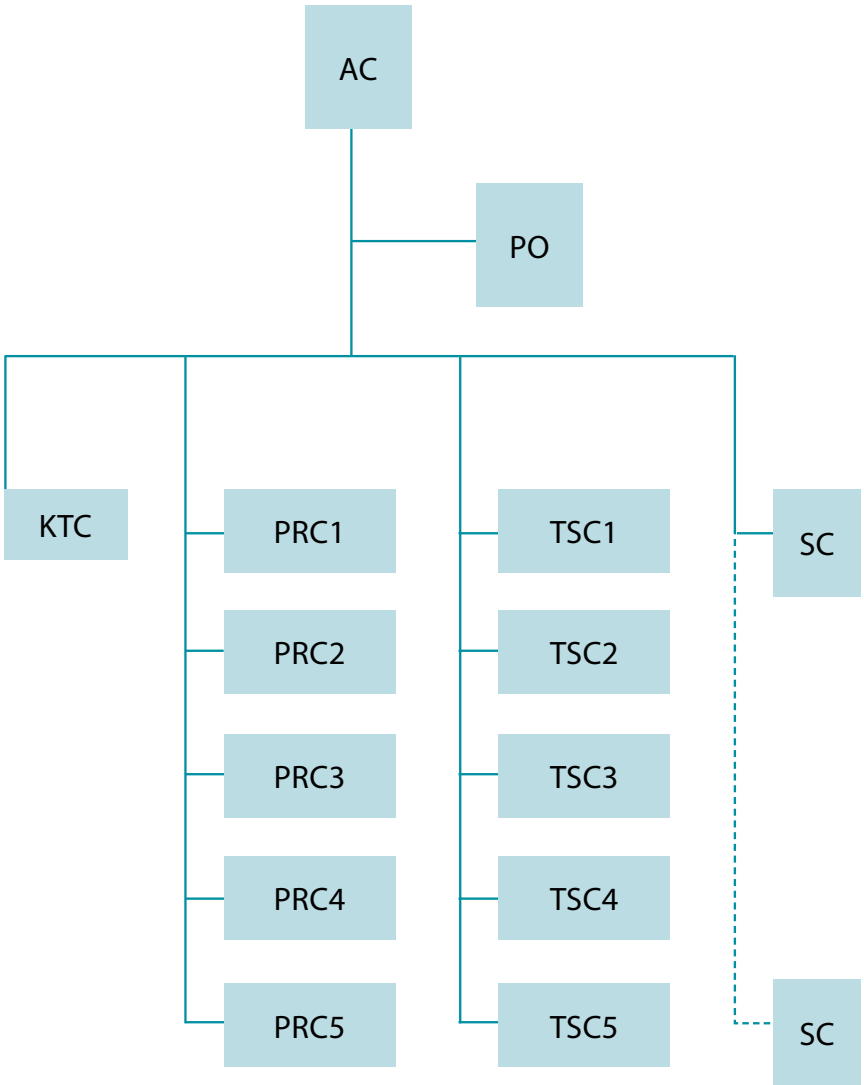


Figure 1: organogram of the organisation of the IOP

a. The Advisory Committee (AC)

The IOP Self Healing Materials will be managed by the Advisory Committee (AC). This AC will take the strategic decisions concerning the research areas, the clustering of research, the research projects and the development of a knowledge transfer strategy. The AC is also responsible for effectively incorporating the industrial research questions within the program and for encouraging researchers to base their research proposals on these questions. The Advisory Committee will consist of a chairman, industrial members, representatives of universities and TNO and an IOP Program Officer (SenterNovem). The activities which the AC initiates are aimed at the implementation of the long-term planning (Meerjarenplan) and are formulated in the annual plans (Jaarplannen) which are presented for approval to the Director of Innovation of SenterNovem.

More specific, the Advisory Committee has the following tasks and responsibilities:

- Stipulate the research program of the IOP Self Healing Materials.
- Publish calls for proposals with the aim of generating research project proposals.
- Select projects for funding, using the criteria that have been formulated in chapter 4 of this report.
- Monitor and stimulate the progress of the total research program and the activities and recommendations of its various Committees.
- Initiate activities outside the scope of the projects, with the aim of knowledge transfer, network formation and creation of a higher critical mass in successful areas (concentration, see chapter 5) and anchoring of the results obtained.

- Write the annual report and, if necessary, adjust the objectives within the long-term planning or the annual plans.
- Make recommendations to the Director of Innovation of SenterNovem with regards to stimulating additional research as well as the application of results from the IOP Self Healing Materials research program.
- Build, expand and maintain a network with research organisations, researchers, companies and other intermediate agencies in relevant areas.
- See to it that researchers will attend presentation trainings, organised by SenterNovem, with the aim that they can present the results of their research in such a way that the attention of industry will be attracted and knowledge will be transferred and used for developing products.
- Stimulate that researchers, via the Technical Supervisory Committees (TSC's) will present the outcome of their research to the AC on a half yearly basis.
- Initiate activities to work in an early stage on transfer and valorisation of knowledge and embedding the knowledge according to paragraph 5c of this report.

Based on the scope and ambitions of the total 2nd IOP Meerjarenplan defined here, as well as pending regulations concerning the size of the AC, we have the pleasure of proposing the following candidates for the AC (see table 2).

The candidates were selected on the basis of their personal expertise in key domains of the research proposed in this 2nd Meerjarenplan, their position in their own organisation and their public reputation for managing complex research programs involving multiple partners effectively and fairly. Each field is represented by a representative from the industry and the universities. Furthermore, all technical universities, the RUG and TNO are represented in the AC to make full use of the existing materials expertise in the Netherlands.

b. The Program Office (PO)

The Program Office (located at SenterNovem, an agency of the Ministry of Economic Affairs) will support the Advisory Committee and ensure the correct implementation of the IOP. The Program Office will take care of the organisational, financial and administrative side of the implementation of the IOP regulations. The Program Officer of SenterNovem is the main contact of the IOP SHM Program. The tasks and responsibilities of the Program Office and the Program Officer are:

- The daily functioning of the IOP.
- Publishing the annual plans and annual reports.
- The organisation of meetings of Advisory Committee, PRC, TSC and Knowledge Transfer Committee.
- The organisation of the calls for proposals.
- The financial and administrative control of the research projects.
- The organisation of activities which are not project-related.
- Contribute to the reputation of the IOP and the field of Self Healing Materials, in particular.

NAME	AFFILIATION	FIELD OF EXPERTISE
Prof.dr.ir. S. van der Zwaag	TU Delft	Chairman
Prof.dr.ir. K. van Breugel	TU Delft	Concrete science
Ir. J.P.G. Mijnsbergen	CUR	Concrete technology and industry
Prof.dr. J.T.M. de Hosson	RUG	Metals and functional materials
Dr. R. van de Moesdijk	M2i	Metals industry
Dr. P. Geurink	Akzo Coatings	Coatings
Prof.dr. C.E. Koning	TU/e	Coatings and Polymers
Prof. dr. ir. A. de Boer	UTwente	Polymer composites
Ir. R. van den Hof	DPI	Polymer industry
Prof.dr. S.J. Picken	TU Delft	Eng. and functional polymers
Dr. J.J. Michels	TNO	Functional materials
Ir. drs. C. Kleemans	Corus	Ceramics and metals industry
Dr. G.J. Jongerden	Nuon Helianthos	Solar cell industry

Table 2: Candidates for the Advisory Committee for the 2nd IOP Meerjarenplan.

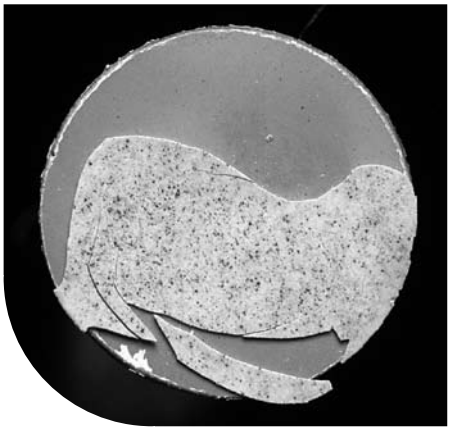


foto volg

TU Delft: Cracks developed in TBC which ultimately leads to delamination - One-time only event: no autonomous self-healing

- Organise and maintain a network with research organisations, researchers, industry and other intermediate agencies in the field of Self Healing Materials.

Moreover, the IOP Program Officer safeguards a correct implementation of the IOP regulations, by the standards which are set by SenterNovem and the Ministry of Economic Affairs. The Chairman and Program Officer will keep regular contact with the Director Innovation of SenterNovem, as well as his counterpart at the Ministry of Economic Affairs to inform them about on-going developments.

c. The Proposal Ranking Committees (PRC)

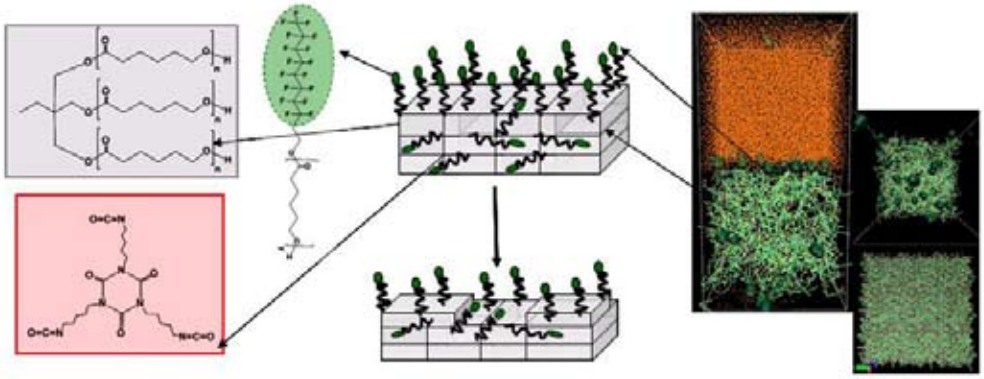
As already mentioned and described in chapter 4b the ranking of the full research proposals to be received in the two calls, will be done by the 5 Proposal Ranking Committees, each responsible for one research field. Each PRC will be chaired by an AC member. Each PRC will consist of typically 6-8 members, with a proper balance between members from industry and academia.

d. The Technical Supervisory Committees (TSC)

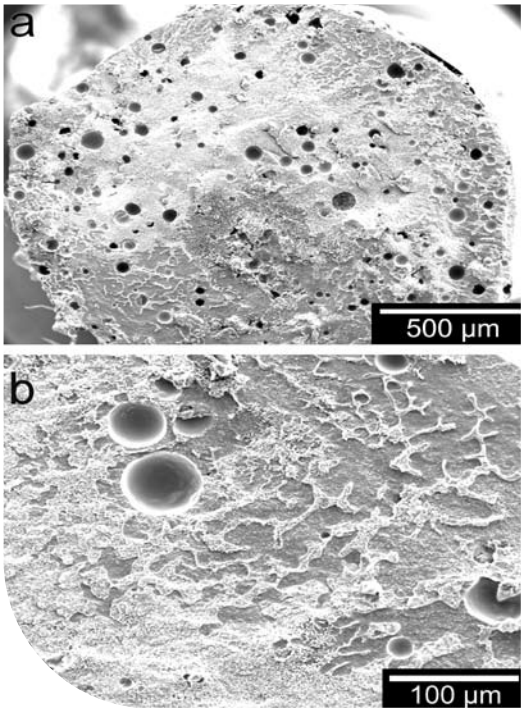
To guide and monitor the progress in the 5 fields identified the IOP will install 5 Technical Supervisory committees, which supervise all IOP_SHM research projects in their respective field. Typically twice a year, progress meetings for each field will be organised in which the project leaders report to the TSC on the latest developments. At these progress meetings also the researchers and the companies involved in the various projects will be invited to be present. Each TSC will be chaired by an AC member. Each TSC consists of typically 6-8 members, with a proper balance between members from industry and academia. The Technical Supervisory Committees have the following tasks and responsibilities:

- Provide active guidance and appraisal of projects. For example, it will make suggestions for further research and help with the making of choices. It can give scientific input or information concerning the industrial feasibility and relevance.
- Monitor the objectives of the projects, and the allocation of time and (financial) resources. Attention is paid to the progress of the project and the need for readjustment of the project plan.
- Assess if aspects of the project are patentable.
- Help spread the results under a broader public.

Self-replenishing of low-surface energy groups on polymer coatings



Experimental approach | **Surface recovery after removal of the top layer (~ 5-10 nm)** | **Modeling approach**



Re-fractured surface of a healed interface (a), showing the large healed region in a rough white texture whereas the non-healed part is smooth grey. (b) A magnification shows the rivulets that mark the border of the healed area.

- Stimulate follow-up studies.
- Safeguard the success of a project and contribute to the success of the IOP Self Healing Materials.

The instrument of Technical Supervisory Committees did not exist in the 1st IOP Meerjarenplan and has been created to strengthen the monitoring of the progress in the various projects, which in the self evaluation of the 1st Meerjarenplan was considered to be suboptimal. Furthermore, the progress of the program as a whole will be monitored using the suggested parameters listed in the external evaluation report. New criteria, more relevant to emerging technologies, to monitor the valorisation will be formulated. The monitoring parameters and levels to be achieved will be formalised at the 1st AC board meeting.

e. Knowledge Transfer Committee (KTC)

The Knowledge Transfer Committee (KTC) will outline the market for the new knowledge and develop knowledge transfer tools (e.g. conferences, workshops, written documentation etc). Also, activities concerning network formation can be initiated by the KTC. The KTC consists of persons with an affinity for the topic, one or more representatives from the Advisory Committee and the IOP Program Officer. An AC-member will chair the KTC. Furthermore, the knowledge coordinator of the IOP can be consulted about new knowledge transfer instruments developed at IOP or SenterNovem. The KTC is to present a detailed working plan to the AC during the 1st year of the 2nd MJP and to update its workplan annually.

f. Scenario committees (SC)

Scenario committees were a novel feature of the IOP Self Healing Materials. The scenario committees consist of 'visionaries' with a broad view on the materials industry in general and the field of Self Healing Materials in particular. Their role is ad-hoc and only involves the creation of a scenario report to guide the development of their particular field. The scenario committees are chaired by a representative of the AC. Apart from designating new application areas that could profit from the research outcome of this IOP, scenario committees also identify which new tools should be developed for a successful introduction of these new materials. The AC is responsible for identifying appropriate topics and approaching potential members for these committees. Furthermore, the AC, through the help of the IOP Program Office, is responsible for the publication and distribution of a public document presenting the outcome of the meeting by the scenario committee.

g. Project leaders and researchers

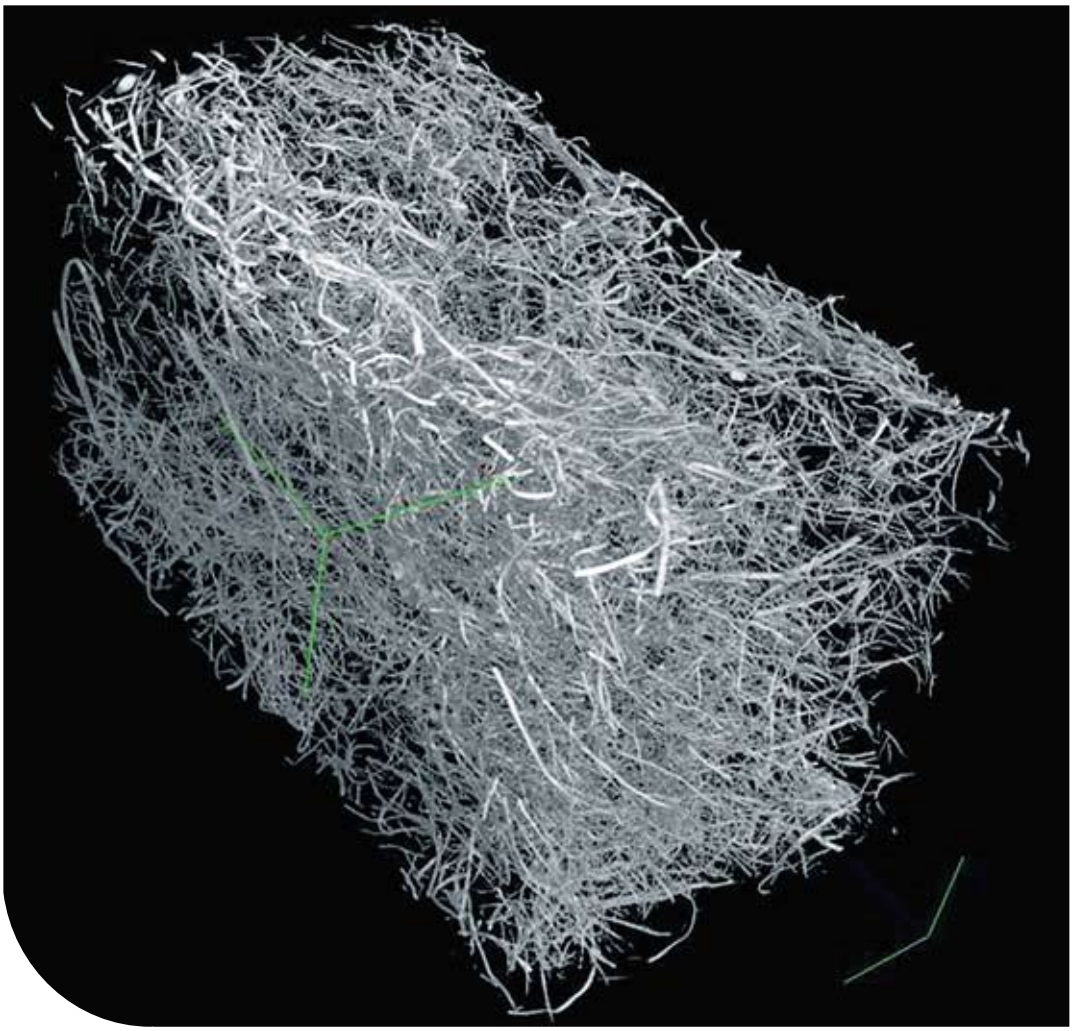
The project leaders and researchers are responsible for carrying out the research projects. Every half year a written report will be submitted to the PO and a presentation will be given during the meeting with the TSC. The project leaders and researchers are jointly responsible for the knowledge transfer, both in the context of the IOP program and in their own organisation. In order to enhance the knowledge transfer, several IOP-SHM wide activities will be organised and the available funds will be used for this purpose. Project leaders and researchers will be encouraged to participate in these activities.

7. Finance

The financial planning for the 2nd IOP Meerjarenplan Self Healing Materials covers a period from the second half of 2009 until that of 2015, (or so much later as is necessary to maximise the results of ongoing research funded by this IOP). A total budget of 9.875 million euro is requested to fulfill the ambitions formulated here in this Meerjarenplan and to leave the Dutch industry in a very strong position to capture a major share of the self healing materials market at the end of this IOP program.

a. Knowledge development

Of the total budget of 9.875 million euro, 8.500 million euro will be allocated directly to research projects. This budget will be divided over two tenders, one in 2009/2010, and a second tender two years later in 2011/2012.
For both tenders the Advisory Committee aims at funding (2 year) post-doc positions as well as (4 year) PhD-positions. The postdoc positions are intended for the exploration of new concepts while the PhD positions are intended for further knowledge



TU Delft: Capsule made of porous sand containing oil used for self healing of porous asphalt.

BUDGET COMPONENT (X 1.000 EURO)	2009	2010	2011	2012	2013	2014	2015	TOTAL
Research activities	-	4400	-	4.100	-	-	-	8.500
Stimulation activities	300	150	150	100	100	100	160	1.060
Management expenses	75	40	40	40	40	40	40	315
Total x 1.000 euro	375	4.590	190	4.240	140	140	200	9.875

Table 3: Finances of the IOP Self Healing Materials, 2nd Meerjarenplan.

expansion on projects with a proven self healing potential. There is no a-priori distribution of the research money over post-doc and PhD positions. With a budget of 8.500 million euro for research up to about 30-40 researchers directly funded via the IOP budget can be employed over the four year period. The exact number will depend on the budgets of the projects to be granted.

b. Stimulating other activities

To stimulate companion activities to the actual research but which are crucial for the success and lasting impact of this IOP program on the Dutch industry and ultimately the Dutch society, an amount of 1.06 million euro (10%) has been reserved in the requested total budget.
This budget will cover the costs for stimulation activities, such as symposia, events organised by the AC or the Knowledge Transfer Committee, presentation courses for the researchers, workshops, summer school, newsletters, yearly reports etc.
In the budget for non-research related activities in the 1st IOP Meerjarenplan funds were allocated to formation of the so-called Advanced Network, which aimed at bringing together the wide diversity of researchers in the field of self healing materials.
The support for the Advanced Network will not be continued in this 2nd Meerjarenplan as our evaluation has shown that the instrument has been used insufficiently by the current researchers and that the research community in this new field is now well enough established to rely on its informal network. The expenses of stimulating other activities will be more or less equally divided over the period of the coming years.

c. Management expenses

A budget of 315.000 euro is reserved for the management of the IOP Self Healing Materials. This budget covers the costs of the Advisory Committee, compensation for the chairman and other organisational costs, hiring of meeting rooms, etc. The level of this budget component is based on experiences of other IOP's.

d. Cofinancing

Finally, IOP SHM proposals to be granted have to meet the financial requirements as formulated in the *Kaderbesluit EZ-subsidies* and the *Regeling Sterktes in Innovatie*. These requirements imply fixed percentages for cofinancing of the different types of research respectively experimental development. The current requirements will be made clear in the tender information.

8. Summary and Conclusions

In this document the very promising new developments as a result of the research conducted in the 1st Meerjarenplan IOP Self Healing Materials are summarised. It is shown that the concept of self healing materials can become a reality for a wide range of materials, and can open a wide range of new developments and products. Given the potential of the field and the attention given to the exposure of the work, the industrial interest in this research remains very high. The leading and crucial role of the IOP program in opening the field of self healing materials is widely acknowledged both by the industry and the universities.

It will be clear that, for the full development of the self healing material concepts already identified and demonstrated under laboratory conditions into concepts which can successfully be transferred to the industry, as well as the development of new routes for materials classes not yet explored, funding of a 2nd Meerjarenplan IOP Self Healing Materials is crucial.

During the lifetime of this 2nd Meerjarenplan the collaboration with other partners in the materials field, such as M2i, DPI and MIP, will be further intensified in order to ascertain that the development of these new material classes with their unique improvements in durability and safety will not halt at the end of this program.

The collective and sustained efforts of all parties concerned should ultimately give the Dutch industry a strong position in innovative and valuable self healing materials and products made thereof. This result is in line with the governmental target of protecting and strengthening the reputation of the Netherlands as a centre of knowledge and expertise.

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6 'External evaluation report IOP-SHM by Technopolis, Amsterdam, April 2009.

List of abbreviations
(Abbreviations in bold pertain to this IOP organisation)

AC	Advisory Committee
CSIRO	Commonwealth Scientific & Industrial Research Organisation
CUR	Building & Infrastructure
DCMat	Delft Centre for Materials
DPI	Dutch Polymer Institute
ECN	Energieonderzoek Centrum Nederland
ESA	European Space Agency
FOM	Stichting Fundamenteel Onderzoek der Materie
HAVO	Hoger Algemeen Voortgezet Onderwijs
IOP	Innovatiegerichtonderzoeksprogramma (Innovation Oriented Research Program)
IP	Intellectual Property
KEMA	Keuringsinstituut voor de Nederlandse Elektriciteitssector in Arnhem
KTC	Knowledge Transfer Committee
MIP	Maritiem Innovatie Programma
M2i	Materials innovation institute
MJP	Meerjarenplan
NIMR	Netherlands Institute for Metals Research
NVVT	Nederlandse Vereniging van Verftechnici
NWO	Nederlandse Organisatie voor Wetenschappelijk Onderzoek
PO	Program Office
PRC	Proposal Ranking Committee
RUG	Rijksuniversiteit Groningen
SC	Scenario committee
SenterNovem	Agency of the Ministry of Economic Affairs
SHM	Self Healing Materials
SME	Small and Medium sized Enterprise
STW	Stichting voor de Technische Wetenschappen
TNO	Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek
TSC	Technical Supervisory Committee
TTI	Technologisch topinstituut
TUD	Technische Universiteit Delft
TU/e	Technische Universiteit Eindhoven
UIUC	University of Illinois at Urbana-Champaign
UTwente	Universiteit Twente
VENI/VIDI	Grants from NWO for young doctorates (VENI) to develop their ideas, and for more experienced researchers (VIDI) to establish their own research line
VWO	Voorbereidend Wetenschappelijk Onderwijs

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