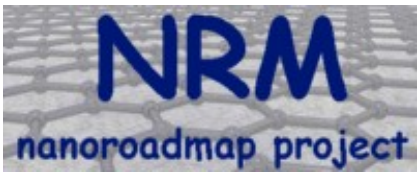

Project no.: NMP4-CT-2003-505726-1 NANOROADMAP

Project acronym: NANOROADMAP

Project title: Technological roadmaps till 2015 in nano science and nanotechnologies in the field of materials, health and medical systems, energy fields.

Instrument: Specific Support Action SSA

Thematic Priority:

PRIORITY 3–NMP "Nanotechnology and nano-science, knowledge based multifunctional materials, new production processes and devices".

Publishable Final Activity Report

Period covered: from 1/1/2004 to 31/12/2005 **Date of preparation: 20/03/2006**

Start date of project: 1/1/2004 **Duration: 24 months**

Project co-ordinator: Guido Frigessi di Rattalma

Project co-ordinator organisation: Italian Association for Industrial Research - AIRI (Italy)

1 Project Execution

This report summarises activities and results of the entire life of the Nanoroadmap Project (NRM) (**January 1st 2004 - December 31st 2005**), at which contributed a Consortium of eight leading organisations:

Coordinator	**1. Associazione Italiana per la Ricerca Industriale – AIRI, Italy**
Partners	**2. Willems & van den Wildenberg bv - W&W, Spain and The Netherlands**
	3. VDI/VDE-Technologiezentrum Informationstechnik GmbH - VDI/VDE-IT, Germany
	4. Institute of Nanotechnology – IoN, UK
	5. MATIMOP Israeli Industry Centre for R&D, MATIMOP - Israel
	6. Technology Centre AS CR - Technology Centre, Czech Republic
	7. Technical Research Centre of Finland – VTT, Finland
	8. Yole Développement - Yole Développement, France

The primary goal of NRM was to provide coherent scenarios and technology roadmaps up to the year 2015 to identify the opportunities most relevant for Europe that could materialise in this ten year time horizon from nanotechnology application in three specific sectors:

- **Materials**
- **Health and Medical Devices**
- **Energy**

When presented, the duration of project was indicated in 30 months, but well after the start (October 2004) the partners agreed to compress the activity to 24 months and complete the project by the end of December 2005, to comply with a request of the EC that asked to anticipate the end in order to have the results more timely for the preparation of FP7.

This change didn't influence much the activity of the first year, while it affected that of the second one which had to be reset to comply with the new deadline.

A specific feature of the project was, in fact, its two steps approach. A first phase, dedicated mainly to the collection of information to determine the general scenario to start from, followed by a second phase dedicated to the preparation of the road maps and dissemination activities, discussions and feedback. From the beginning the first phase was planned to be concentrated in the first year and therefore the new time schedule had little effect on the work of the first year.

On the contrary, the second phase had to be compressed entirely in the second year. To cope with this new situation, the number of themes to be roadmapped (12) remained unchanged, but the distinction in "golden" and "silver" themes, at first used to distinguish the themes to be roadmapped more thoroughly from those following a simplified scheme, has been eliminated. An unique methodology, based on a Delphi like approach, has been adopted for the preparation of the roadmaps.

As said, the main task of the first year (WP1, WP2, WP3 and WP7) was to assess the existing situation and forecasts in the field, both with respect to technology and applications/market, pin point the themes most relevant to focus on, identify experts to involve in the road map exercise, define the methodologies and the instruments to execute it.

The survey was based mainly on the analysis of available information (road maps, foresight studies, position papers, governmental documents, etc.), supplemented by search on the web, participation at events, personal contacts. The work was carried out by all the Consortium Partners and made it possible to draw a world wide picture of the activity under way in the field of

nanotechnology which has been condensed in **35 Country Reports** (only for internal use) covering the most important industrialised countries and several of the emerging ones (Table 1).

Australia	France	Korea	Slovakia
Austria	Germany	Latvia	Slovenia
Belgium	Greece	Lithuania	Spain
Canada	Hungary	Netherlands	Sweden
China	India	Norway	Switzerland
Czech Republic	Ireland	Poland	Taiwan
Denmark	Israel	Portugal	UK
Estonia	Italy	Russia	USA
Finland	Japan	Singapore	

Table 1: countries covered by NRM project Country Reports

The reports illustrates, for each country, the R&D initiatives under way and the players involved, national programmes and policies, funding, present applications and (when available) market data, forecasts.

The resulting picture confirmed the strong commitment of countries traditionally to the fore with emerging technologies such as USA, Japan or Germany, but it pointed out also the growing interest of emerging third countries such as Korea, Taiwan or China, confirming that nanotechnology is considered crucial for the future technological development and strategic for a competition that will be global.

The survey has shown also that at the moment the action in nanotechnology is mainly concentrated in public research institutions, but industry, both large enterprises and SMEs, are increasingly involved. Considering the world as a whole, it turns out that the level of private funding for R&D in this field is approaching the public one though public financial support will remain for the short - medium term essential for promoting the growth of nanoscience and nanotechnology.

From the information gathered, **3 Sectoral Reports** where eventually prepared by the sectoral leaders (VDI/VDE, VTT and W&W) which gave an overall picture of each one of the sectors considered with respect to existing R&D activities, future technical developments and markets/applications, useful to spot the themes among which select those to be roadmapped.

Pivotal to the activity of the first year has been the **NRM International Conference** of November 4th - 5th 2004, organised in Rome by AIRI with the partners giving a hand to identify the speakers to invite and to promote the event. At the conference were presented and discussed the results of the first 10 months of the project. Outstanding experts of the field, from both industry and public research institutions, participated at the event presenting their activity and view point. Their indications were useful for the selection of the themes to roadmap and the prosecution of the project.

The above initiatives were complemented with the preparation of a large list of experts to be used to select those to involve in the road map exercise (all partners contributed to it). The identification of the selection criteria for choosing the themes to focus on, which are based mainly on technological, economic and strategic (for Europe) considerations. The definition of the methodology to follow for the preparation of the road maps (as said, essentially a Delphi method).

The definitive choice of the four topics for each sector to roadmap was finally made according to selection criteria agreed upon by the consortium partners (degree of innovation, expected technological improvement, relevance of the sectors of possible application, positive impact on human life) and a thorough discussion which involved international experts (the International Conference in Rome offered a good opportunity for it). The final selection, indicated in the table below, was eventually validated in dialogue with the European Commission.

MATERIALS	*Nanoparticles/Nanopowders/Nanocomposites* *Nanoporous materials* *Dendrimers* *Nanostructured thin films and coatings*
HEALTH AND MEDICAL SYSTEMS	*Drug Encapsulation / Drug Delivery / Drug Targeting* *Molecular Imaging / Biophotonics* *Biomolecular Sensors* *Biochips / High throughput Screening / Lab-on-a-chip*
ENERGY	*Solar cells* *Thermo-electricity* *Rechargeable batteries and supercapacitors* *Insulation and heat extraction*

The second phase of the project dedicated to the preparation of the road maps, dissemination activities, discussions and feedback had to be adjusted, as anticipated, to the new time schedule.

The number of workpackages (WP) hasn't changed and the activity of the second year was concentrated in WPs 4,5,6 and 7. The first three devoted to the roadmap exercise, aimed at the preparation of three sectoral roadmaps (Materials, Health & Medical Systems, Energy), the fourth consisting in the dissemination of information.

A crucial part of the work of the (beginning) second year has been the definitive identification and selection of a consistent number of experts to be involved in the roadmap exercise carried out with a two steps Delphi-like approach. All partners concurred to this task and about 350 experts were finally identified.

Another crucial point has been the preparation of the questionnaire for the Delphi exercise. The coordinator has proposed the guidelines to start with, but all the partners contribute to its definitive form, in particular the three partners responsible for the preparation of the roadmaps.

The collection of the answers to the questionnaires from the experts resulted rather difficult and the coordinator asked all the partners to give their support to the roadmap leaders to get the answers from the experts, in particular from those in their own country. The response was mixed, but in the end some 230 experts participated at the roadmapping exercise. They were coming from all over the world (albeit the majority, around 60%, from Europe) and both from academia and industry.

A problem which caused some delay in the execution of the project rose from the decision, announced in July 2005, by VTT to give up the preparation of the Energy roadmap. IoN volunteered to take over the job and the Partners Committee accepted the offer so that the project could be completed and the Consortium could respect its obligations. The EC endorsed this decision.

To keep the activity on track numerous meetings were organised by the coordinator during the two years of the project. The schedule has been the following:

- Rome,15-16 January 2004 (kick off meeting);
- London,23 April 2004 (Partners Committee -PC- meeting):
- Barcelona,17 September 2004 (PC meeting);
- Rome, 05 November 2004 (PC meeting, in conjunction of the NRM International Conf.)

- Milan, 14 January 2005 (meeting with the roadmap leaders);
- Rome, 18 February 2005 (PC Meeting & Mid Term Assessment);
- Berlin, 25 May 2005 (meeting with the roadmap leaders);
- Brussels, 19 July 2005 (PC Meeting);
- Rome, 29 September 2005 (PC Meeting).

The anticipation of the end of the project demanded an extra work in particular for the 3 roadmap leaders (W&W, VDI/VDE, IoN) and the coordinator, but the activities planned were eventually completed and all the deliverables expected produced respecting the new deadline.

The result of the roadmapping exercise has been condensed in 12 roadmaps (4 for each sector) which were grouped by the three roadmap leaders (W&W, VDI/VDE, IoN) in **3 Sectoral Roadmaps Reports.** From these the coordinator prepared a **Synthesis Report** summarising all the roadmaps.

2 Dissemination and use

The dissemination activity went on throughout the whole duration of the project and it was also completed as planned. Several instruments were used.

A project website (http://www.nanoroadmap.it) managed by the co-ordinator, was set up since the beginning, having two main areas. One, open to the public, containing information about the project, the Consortium (with links to the partners web site), the NRM events and reports. The other, accessible only to the NRM partners, containing restricted documents and information for internal discussion (draft and final project reports, project's documents, list of experts, partner's meeting minutes, etc.).

Presentation at conferences, release to the press and personal contacts, were also used by the Consortium partners to disseminate information about the project and its progresses. **The 3 Sectoral Roadmaps and the Synthesis report will remain available for downloading in the project web site at least throughout the all 2006.**

The highlights of the dissemination activity have been the NRM Conferences. In the first year there was in Rome the mentioned before 1st International Conference, while in the second year there were 8 National NRM Conferences, organised by all the project partners in their own country, and the 2nd International Conference, organised in Cologne by IoN and VDI/VDE.

Those events took all place between the end of October and the end of November 2005 and their main purpose was the presentation for the first time of the roadmaps reports together with examples of the activity going on in the field illustrated by internationally known experts to enrich the picture. The time table has been the following:

October 25	Prague - Czech Republic (Technology Centre AS CR)
November 8-10	Cologne - Germany -2nd International NRM Conference &German National Conference- (IoN&VDE/VDI)
November 10	Padua – Italy (AIRI/Nanotec IT)
November 15	Helsinki – Finland (VTT)
November 18	Barcelona – Spain (W&W)
November 21	London – UK (IoN)
November 23	Lyon – France (Yole Développement)
November 29	Tel Aviv – Israel (MATIMOP)

The attendance at the events has been generally rather high offering scope for ample discussion and comments, helpful for the preparation of the roadmaps.

The roadmaps have put forward the strong correlation and potential cross fertilization existing among the three sectors surveyed which advocates the promotion of an exchange of information to share knowledge and speed up the transfer of the research results to application.

The roadmaps have, however, also made apparent that there are still quite few more years before the benefits of nanotechnology can be fully exploited. Ten years, the period taken into account by the project, seems the time span necessary for bringing to the market many of the applications considered but, for some of them, even this time could be not enough to attain full maturity, especially in the medical field.

Many challenges and bottlenecks, most of them common to the three sectors, have to be overcome within the next ten years. They are both technical and economic and the priority requirements to pursue in the forthcoming ten years can be summarized as it follows:

1) Fundamental research for understanding structure-property-processing relationship at the molecular level;

2) Computer modelling and simulation at the nanoscale;

3) On-line tools for characterization, process monitoring and control; metrology;

4) Developing a standard regulatory framework and common approval procedures;

5) Identify and pre-develop materials, applications and capabilities that respond to the stringent needs of mass production, thus reducing the risk associated with their development;

6) Production up-scaling;

7) Improving collaboration between academia and industry and technology transfer;

8) Provide education and skills both for young researchers and co-workers;

9) Answer to the increasing concerns regarding HSE issue;

10) Foster transparent discussion and information with all the stakeholders about benefit and risks of nanotechnology.