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Outcome of the Open Consultation on the European Strategy for NANOTECHNOLOGY

December 2004

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The Nanoforum report "Outcome of the Open Consultation on the European Strategy for Nanotechnology" provides an analysis of the online questionnaire available on the Nanoforum website between August and October 2004. This questionnaire was in direct response to the EC communication "Towards a European strategy for nanotechnology" published on 12th May 2004.

Nanoforum has published a number of other reports, all of which are published online and free-of-charge at www.nanoforum.org.

Socio-Economic series

- Socio-economic report on Nanotechnology and Smart Materials for Medical Devices", December 2003.
- "VC Investment opportunities for small innovative companies." April 2003.
- "SME participation in European Research Programmes", October 2004.

General reports

- 1st Nanoforum General Report: "Nanotechnology helps solve the world's energy problems", first edition published in July 2003, updated in December 2003 and April 2004.
- 2nd Nanoforum General Report: "Nanotechnology in the Candidate Countries; Who's who and research priorities", first edition published in July 2003, updated in November 2003.
- 3rd Nanoforum General Report: "Nanotechnology and its implications for the health of the EU citizen", first edition published in December 2003.
- 4th Nanoforum General Report: "Benefits, Risks, Ethical, Legal and Social Aspects of Nanotechnology", first edition published in June 2004.

As background studies to policy seminars, the following have also been published:

- "Nanotechnology in the Nordic Region", July 2003.
- "Nano-Scotland from a European perspective", November 2003.

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Table of contents

1 Executive summary

Nanotechnology is emerging as one of the key technologies of the 21st Century and is expected to enable developments across a wide range of sectors that can benefit citizens and improve industrial competitiveness. Worldwide public investment in research and development in nanotechnology (R&D) has risen from around €400 million in 1997 to some €3 billion today. However, there are concerns that some aspects of nanotechnology may introduce new health, environmental and societal risks, which need to be addressed.

In May 2004 the European Commission published the Communication "Towards a European Strategy for Nanotechnology" in which an integrated and responsible approach was advocated. This Communication has been discussed at the political level in the European Council under the Irish and Dutch Presidencies. The aim of the survey conducted by Nanoforum was to assess the wider response to the Commission's proposed strategy and provide input to shape future European initiatives.

A total of 720 people participated in this survey via an online questionnaire at www.nanoforum.org, and an additional 29 wrote directly to the European Commission, bringing the total response to 749. The majority of the respondents were based in Europe (93%), with one third from Germany or the UK. From the respondents who filled in the online questionnaire, most respondents work in research (39%), or in a management role (29%) but a significant number of experts/consultants (13%) and journalists (12%) also participated. SME's and large companies were also well represented (33%).

Most respondents are very much involved in nanotechnology either in R&D, the issues, or both. For many of the technical questions, the participants could choose not to reply. In those cases, we have excluded them from the total such that the percentages given in this executive summary reflect only those who expressed an opinion. The results not only represent the personal opinions of individuals, but also the views of 107 organisations (see annex I).

There is a large consensus that nanotechnology will have a strong impact on European industry (90%), and on European citizens (80%), within ten years. In terms of sectors, respondents expect the greatest impact on chemistry and materials (94%), followed by biotechnology (88%), information and communication technologies, ICT (79%), healthcare (77%) and security/defence (58%). Energy, environment, equipment engineering and consumer products are expected to have a moderate to high impact.

North America is perceived to be the world leader both in nanosciences (76%) and the transfer of nanotechnology to industry (77%), with Europe and Asia falling far behind. Most respondents believe that investment in nanotechnology in Europe R&D is lower (80%) than in the USA and Japan. In terms of R&D areas in nanotechnology, the EU should reinforce support for sensor applications, information and communication technologies, and health, safety, environment and societal issues.

Broad support was expressed for a significant increase in funding for nanotechnology in the next EU Framework Programme compared to the current one (79%). Some respondents (25%) wanted to see a doubling of the budget or more, while only 12% wanted the same budget or less. Divided opinions were expressed as to whether the EU Framework programme should be oriented more towards basic or more applied R&D – it depends upon whether the respondent is coming from a university, research organisation or industry.

Europe appears to be lacking a coherent system of infrastructure and the need for a critical mass was identified as the most critical issue (90%). The responses indicate that there is a need to raise awareness and exploitation of existing infrastructure. At the same time, the majority of respondents highlighted the need for new large infrastructure at European (64%) and national/regional level (34%). A number of suggestions were also received stressing the need for cross-disciplinary infrastructure in fields such as nanomedicine, nanomaterials and information technology/nanoelectronics.

Human resources was identified as a priority with almost one-half of participants in the survey indicating that there is likely to be a shortage of skilled personnel for nanotechnology within ten years and another quarter of participants in even five years. There is also an urgent need for development of nanotechnology education and training with 90% of participants indicating that interdisciplinarity is considered to be crucial. The EU policy aims of 'mobility for researchers'; 'further training opportunities' and 'equal opportunities for women' are supported by a majority of respondents.

Consensus emerged that the EU needs an integrated strategy to be competitive in relation to other countries (85%), and that established industries must recognise the potential of nanotechnology early (70%). Almost half of the respondents feel that the EU, or international bodies, should regulate nanotechnology within 5 years (46%) or 10 years (25%). SME's and start-ups are crucial as the main source for new jobs and innovation but face many difficulties including a lack of highly skilled personnel, effective cooperation with universities and research centres, a lack of public or private funding.

Many respondents agree that Europe needs to take account of risks and societal impact of nanotechnology from an early stage (75%), which requires communication and dialogue with the public. All parties involved must engage in informing the public including national/regional governments, the media and the European Commission. The importance of establishing a dialogue and the need to take into account the disruptive character of nanotechnology was also highlighted.

With regard to public health, safety, environmental and consumer protection, over 75% of respondents agreed that risk assessment must be integrated as early as possible in the R&D process and that such assessments should be carried out at EU level (61%). The priorities for more R&D to address knowledge gaps include free manufactures nanoparticles. Human exposure to these is deemed most important (72%), followed by environmental release (56%). Many respondents highlighted that nanoparticles are already present in nature through e.g. high-temperature combustion processes.

International cooperation with industrialised countries is important (96%). The majority of respondents are in favour of an international 'code of conduct' for the responsible development of nanotechnology (87%). Over three quarters of respondents are also in favour of collaborations with less developed countries, in particular to help them build research capacity and ensure an equitable transfer of knowledge.

2 Background

In recent years there have been several activities taking place at European level to develop a coherent strategy for the successful development of nanotechnology in Europe. Aside from maintaining European R&D excellence and industrial competitiveness, the need to address any risks or uncertainties in terms of environmental, health, ethical and social aspects has emerged as a priority.

During the EuroNanoForum 2003 that took place in Trieste, Italy with over 1000 participants, the concept of an 'integrated and responsible' approach to nanotechnology was conceived[1]. This was followed by the publication of a Communication "Towards a European Strategy for Nanotechnology"[2] by the European Commission in May 2004, which was discussed on the political level in the Council of the European Union under the Irish and Dutch Presidencies.

The Commission's integrated and responsible strategy highlighted the need to:

- increase investment and coordination of R&D to reinforce the industrial exploitation of N&N together with scientific excellence and competition;
- develop world-class competitive R&D infrastructure ("poles of excellence") that take into account the needs of both industry and research organisations;
- promote the interdisciplinary education and training of research personnel together with a stronger entrepreneurial mindset;
- provide favourable conditions for industrial innovation to ensure that R&D is translated into affordable and safe wealth-generating products and processes;
- respect ethical principles, integrate societal considerations into the R&D process at an early stage and encourage a dialogue with citizens;
- address public health, occupational health and safety, environmental and consumer risks of N&N-based products at the earliest possible stage;
- complement the above actions with appropriate cooperation and initiatives at the international level.

On September 23 2004 the Competitiveness Council adopted their conclusions[3] in which the proposed integrated and responsible approach was endorsed together with the publication of an Action Plan for nanotechnology in early 2005 by the Commission following a wide ranging stakeholder debate. The purpose of the open consultation reported here was to gather the views of these stakeholders.

At the same time, with the publication of the Communication "Science and technology, the key to Europe's future - Guidelines for future European Union policy to support research", the debate has started on the Seventh European Framework Programme for Research and Technology Development (2007-2010). Taking into account the above, it is therefore crucial that the views of the nanotechnology community are heard and taken into account.

[1] Proceedings of EuroNanoForum 2003 : European and International Forum on Nanotechnology 2003 (downloadable from http://www.euronanoforum2003.org/ENF2003proceedings/index.htm)

[2] *Towards a European Strategy for Nanotechnology* COM(2004) 338

[3] *Conclusions of the Competitiveness Council*, Brussels 24 September 2004 12487/04 p.24-26

Attention was paid to ensuring that the open consultation was conducted according to general principles and standards set by the Commission[4]. Two channels were provided: an online survey was established by Nanoforum (www.nanoforum.org) and a dedicated email inbox at the Commission (rtd-nano-strategy@cec.eu.int). The open consultation ran for two and a half months from July 30 to October 15 2004.

To launch the consultation a press release[5] was issued on July 30 2004 and reported by 45 general and specialised publications. Information was also sent to many 'multipliers' including the Nanoforum contact list (around 2000 persons) and the Institute of Nanotechnology (almost 30,000). Many coordinators of EC-funded nanotechnology projects were also invited to participate.

The structure of the on-line questionnaire was based upon the structure of the Commission's Communication as listed above and covering all the elements namely research and development, infrastructure, education/training, innovation, societal issues, public health, safety, environmental and consumer protection, and international cooperation. A total of ten sections comprised all these aspects together with additional questions on the impact of nanotechnologies and perceived position of Europe.

In total, 720 people filled in the online questionnaire at www.nanoforum.org including 92 representatives of organisations and 623 individuals. In addition, 29 contributions were received via email or letter sent directly to the European Commission. With a total of almost 750 respondents, it is one of the largest surveys of its kind conducted in Europe and already indicates the high level of interest in nanotechnology. It should serve as a useful source of information for policy makers and the wider community.

4 *Towards a reinforced culture of consultation and dialogue – General principles and minimum standards for consultation of interested parties by the Commission* COM(2002) 704

5 http://europa.eu.int/comm/research/press/2004/pr3007en.cfm

3 Profile of Respondents

On Nanoforum 720 individuals responded to the survey, from 40 specified countries. 7 respondents came from an unspecified other country. 29 people responded directly to the European Commission, which brings the total number of respondents to 749. Among the 749 respondents, 689 were Europeans, including 639 out of the 25 EU Member States and there were also 60 respondents from outside Europe. About one-third of the total of responses came from Germany and Great Britain. The lowest number of responses came from non-EU countries and recently acceded members of the European Union. In the following analysis we will only include statistical information on the respondents which filled in the online questionnaire at Nanoforum. We do include analysis of the comments sent directly to the European Commission. Of all respondents, 107 expressed opinions on behalf of their organisation; the others expressed their own opinion (see annex I). If we divide the number of respondents per country by the million inhabitants in that country, relatively most respondents came from Iceland and Ireland, followed by Finland. (Source of country statistics = Eurostat or www.landenweb.com)

Europe (93%)

Country	*Nr. of resp.*	*Per million inhab.*	*Country*	*Nr. of resp.*	*Per million inhab.*
Austria	18	2/M	Latvia	4	2/M
Belgium	20	2/M	Lithuania	0	0/M
Bulgaria	2	0.3/M	Luxembourg	1	2/M
Cyprus	0	0/M	Malta	1	2/M
Czech Rep.	8	1/M	Netherlands	41	3/M
Denmark	6	1/M	Norway	8	2/M
Estonia	2	2/M	Poland	9	0.2/M
Finland	22	4/M	Portugal	4	0.4/M
France	55	1/M	Romania	8	0.4/M
Germany	154	2/M	Slovakia	5	1/M
Greece	10	1/M	Slovenia	3	2/M
Hungary	6	1/M	Spain	51	1/M
Iceland	2	7/M	Sweden	14	2/M
Ireland	24	6/M	Switzerland	18	3/M
Israel	5	1/M	Turkey	14	0.2/M
Italy	40	1/M	United Kingdom	135	2/M

Table 1a Number or respondents and the geographic origin of their organisation's country of establishment in Europe. Note that Europe is defined as the EU-25 and those countries associated with the EU's Sixth Framework Programme.

Rest of the world (7%)

Country	*Nr. of Resp.*	*Per million inhab.*
Canada	1	0.03/M
India	1	0.001/M
Japan	1	0.01/M
Russia	7	0.04/M
Singapore	4	1/M
South Korea	1	0.02/M
Taiwan	3	0.1/M
Ukraine	2	0.04/M
USA	18	0.1/M
Yugoslavia	3	0.3/M
Other	7	

Table 2b Number or respondents and the geographic origin of their organisation's country of establishment outside Europe. Note that Europe is defined as the EU-25 and those countries associated with the EU's Sixth Framework Programme.

Most respondents were working as a researcher (39%), which is also reflected by the relatively high share of academic institutes in the organisation from which the responses came (52% in University/Higher Education and Publicly Funded Research Organisation). The category "other" contained many management roles (directors, professors, heads, programme managers) but also added up to a surplus of 102 double answers. Among other roles mentioned were: PhD/student (16), lecturers/engineers (17), and business/marketing (8). Among the 62 organisation marked as "other" in table 3 were funding agencies, journalists, not-for-profit institutes and consultancies. An equal number of large and small and medium enterprises participated in the survey. The majority of all organisations appeared to maintain activities outside their country's borders (70%), most of them operating world-wide.

function	*number of respondents*
Senior management	102
Management	91
Researcher	260
Strategy/policy functions	34
Specialist/expert	48
Consultant	43
Journalist	87
Other (please specify below)	154

Table 3 Professional roles of respondents.

type of organisation	*number of respondents*
Self-employed	23
Governmental body	80
University/higher education	288
Publicly funded research organization	85
Commercial organisation (>250 employees)	81
Commercial organisation (<250 employees)	86
Association	11
Other (please specify below)	62

Table 4 Type of organisations from which the responses came. "Association" denotes e.g. trade association, trade union, employers association, chamber of commerce, or NGO.

area	*number of respondents*
International	376
European	95
National	121
Regional	25
Local	16
No response	40

Table 5 Organisations' geographical area of activities.

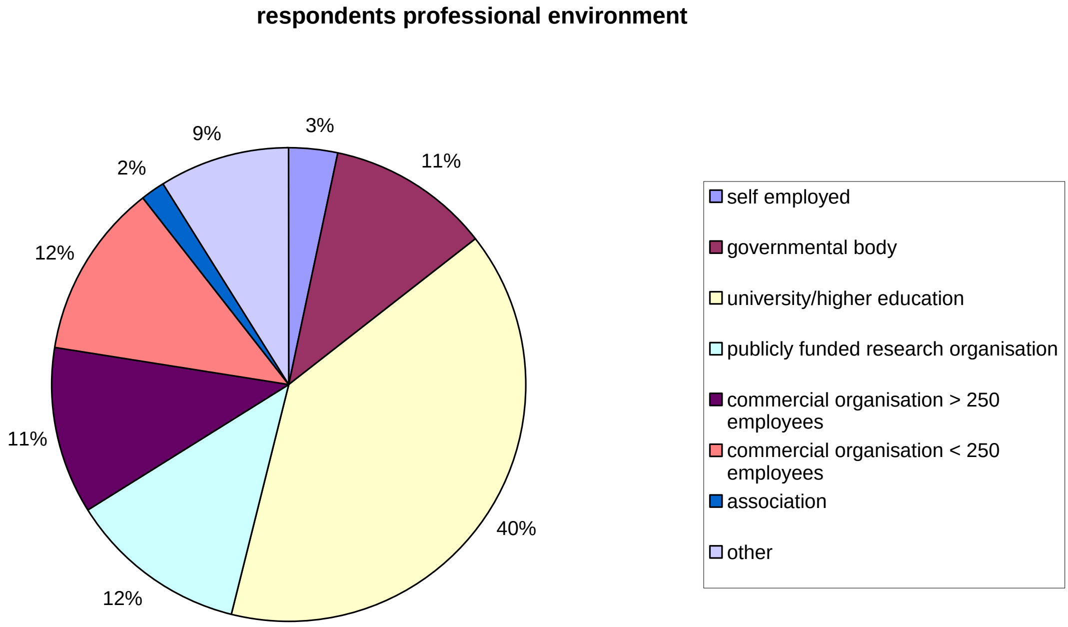

Figure 1: Respondents professional environment in %.

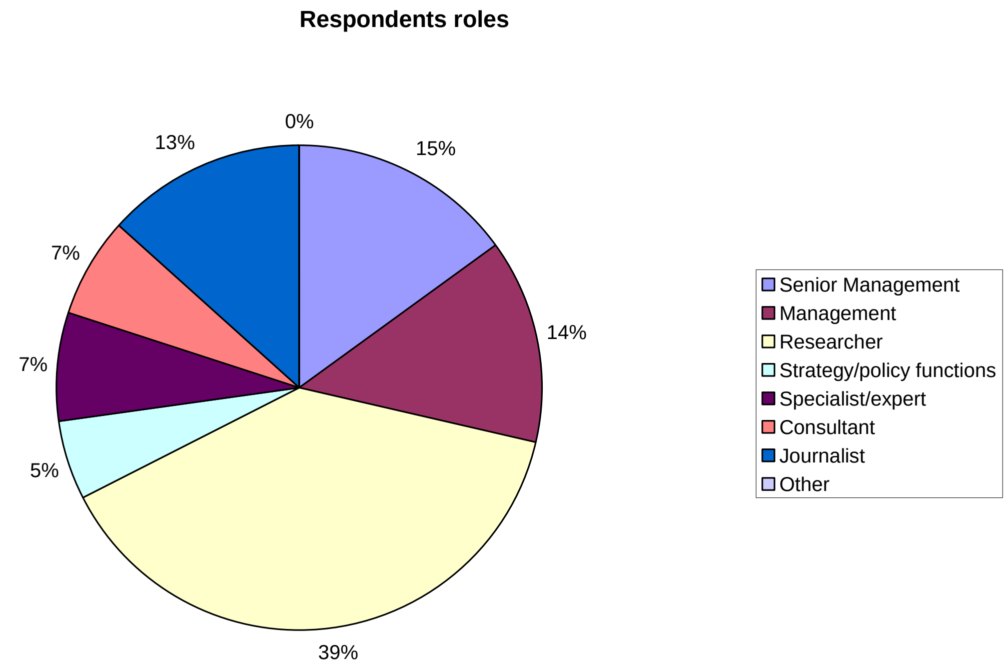

Figure 2: Respondents roles in %.

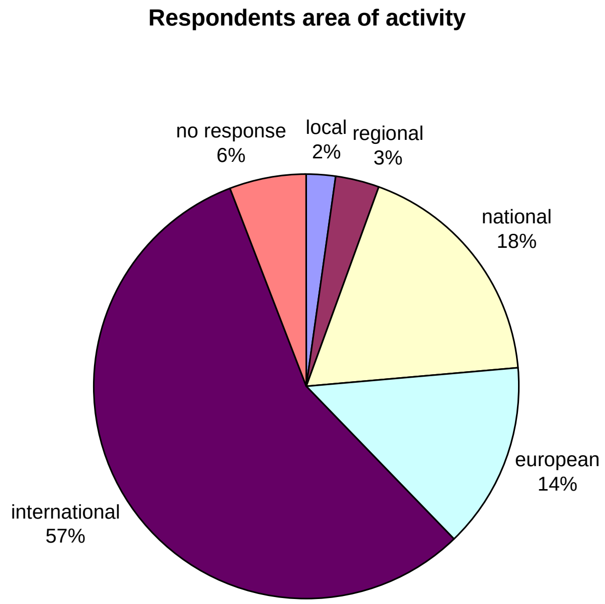

Figure 3: Respondents areas of activity in %.

The majority of respondents indicated that they were involved in nanotechnology to a large extent. 40% is very much involved in nanotechnology R&D as well as issues. Overall, the involvement in general nanotechnology issues is almost equal to the interest for specific topics of research and development. 64% of respondents are very much or quite involved in R&D, against 70% in nanotechnology issues. Given the large percentage of research organisations among the respondents (52%), this latter outcome is understandable. A relatively large segment of the respondents, about one-third, has moderate to no involvement in nanotechnology. These are likely to be the non-technical professionals such as journalists and consultants, who have a broad field of activities of which nanotechnology is one. It is encouraging that so many people who are less involved have nevertheless taken the time to fill out the survey, indicating that nanotechnology issues are important to the wider community.

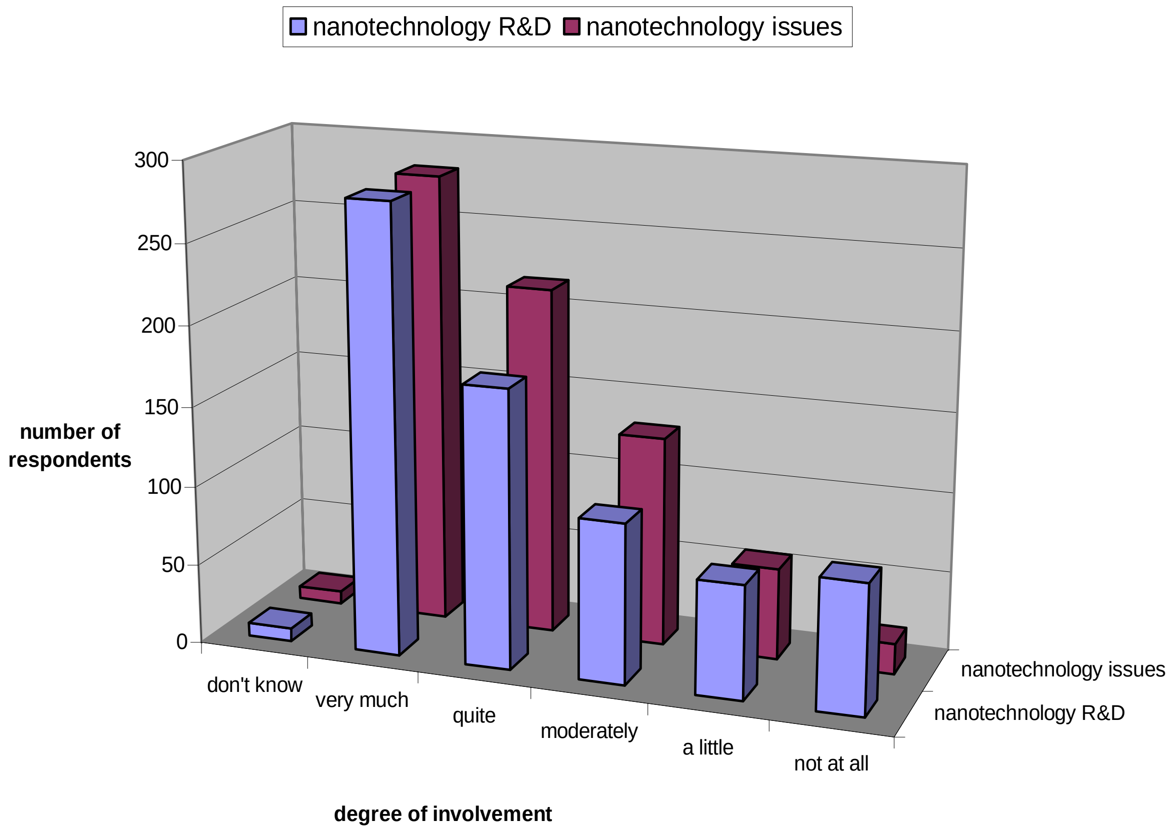

Figure 4 Respondents' involvements in nanotechnology issues in general and in nanotechnology research and development.

4 The impact of nanotechnology

The vast majority of the respondents think that nanotechnology is no longer science fiction: they expect nanotechnology to have an impact on European industry and its competitiveness within ten years from now (92%). The impact on the life of the average European citizen is expected to occur within a similar time-frame (79% in less than 10 years). Of these, 52% believes the impact on industry will occur in less than 5 years, and 45% expects the impact on the EU citizen to occur in 5 years. Only one respondent thought that nanotechnology would never have an impact. 2% of respondents were unsure of the forecast.

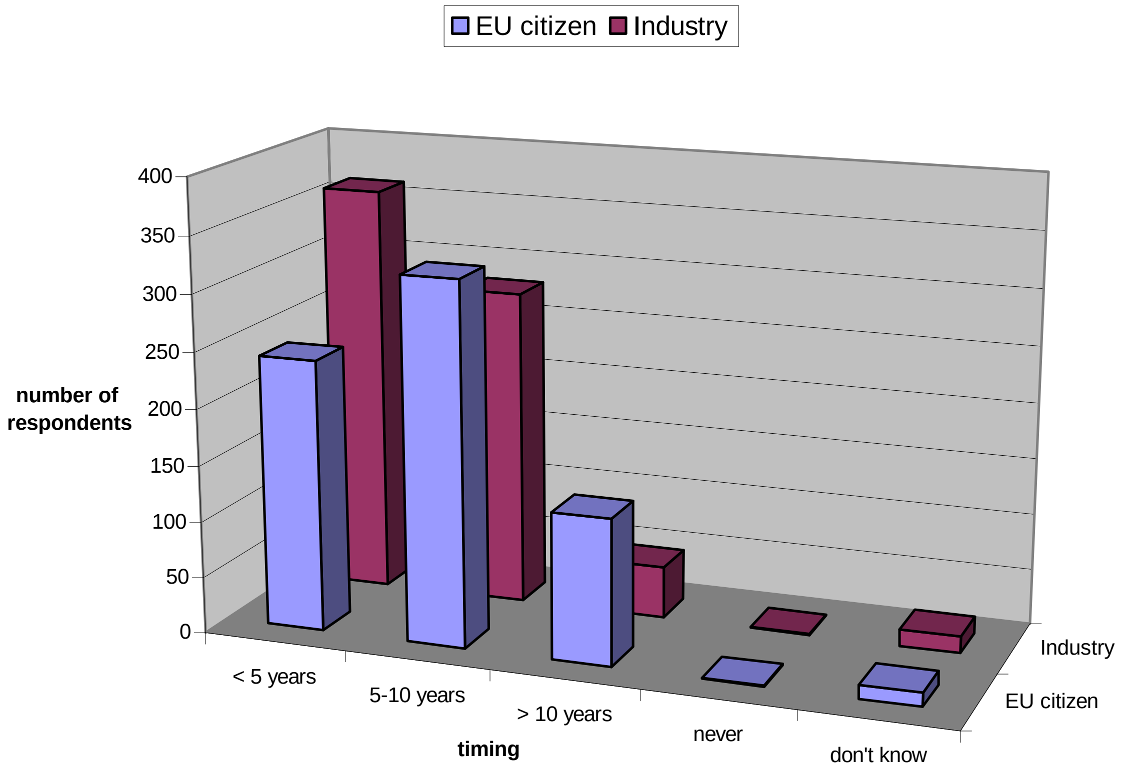

Figure 5 Expected time span in which nanotechnology will affect society and industry. The questionnaire asked: "Will nanotechnology have an impact on the life of the average European citizen?" and "Will nanotechnology have an impact on European industry and competitiveness?"

In addition to estimating the time span in which nanotechnology will have an impact, the respondents were asked to specify the amount of influence on each of eleven different sectors of industry. The areas that form the foundation of nanotechnology, namely chemistry and materials, are expected by virtually all of the respondents to be impacted (93%, purple and yellow bands in Figure 3). This was closely followed by the other two enabling technologies, biotechnology and ICT, which were expected to be influenced significantly by nanotechnology by more than 80% of the respondents who expressed an opinion. The important area of health attracted an almost equal ranking to biotechnology and ICT. About 65% of the respondents thought that security and defence issues are likely to be affected by nanotechnology. Lesser effects were expected on sectors in social infrastructure (energy, transport, and environment) and in supporting industry (construction, equipment) and in the broad area of consumer products.

Apart from the eleven sectors that were specified in the questionnaire, respondents cited several other sectors which nanotechnology was expected to play an important role. Space science was frequently mentioned, and so were food related issues (production, safety, packaging, agriculture). Furthermore a number of non-industrial sectors and issues were mentioned: education, entertainment, social interactions, political and administrative issues, and financial services. When considering the above analysis, it is worth bearing in mind that the responses cannot be related to the sector in which they are active. Interestingly, only one respondent made reference to "advanced nanotechnology", which has been the subject of much debate, in particular in North America.

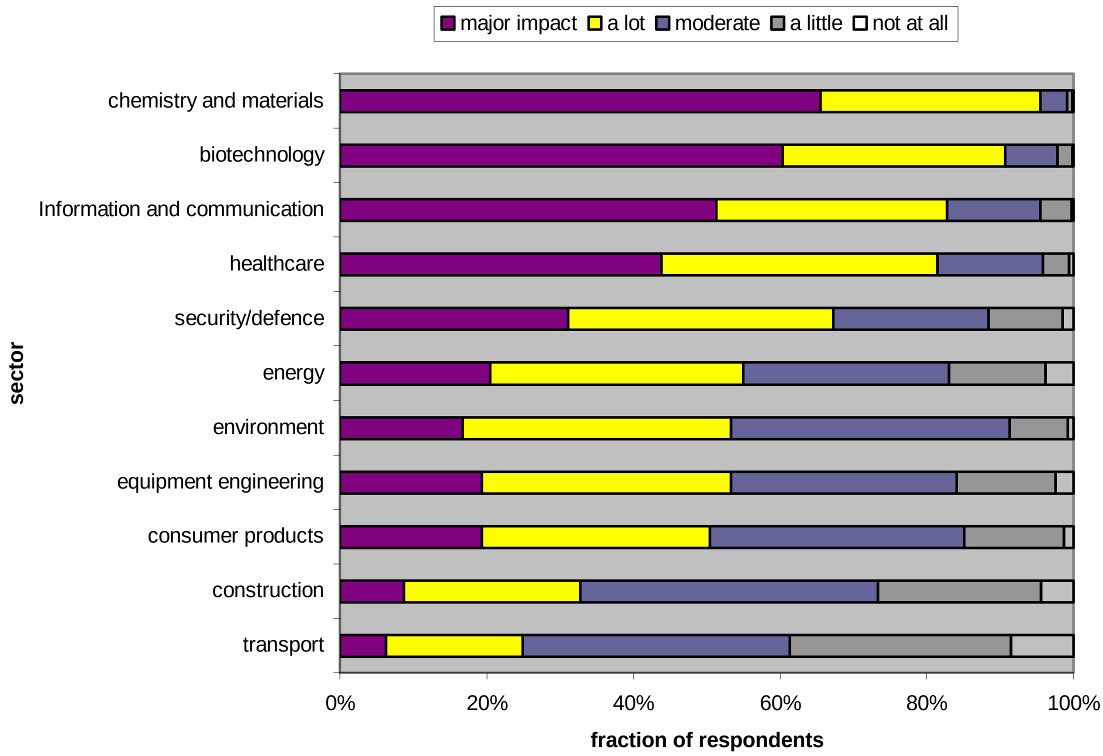

Figure 6 Respondents views on the question "Will nanotechnology have an impact on the following sectors?" Excluded are the respondents who did not express a forecast.

5 Research and Development

5.1 Who is leading in nanoscience and nanotechnologies?

Nanotechnologies have become wide-spread with research and development in this field is being undertaken almost everywhere. Nevertheless, most activity is focussed in four particular regions: Europe, North America, and the Asian countries, (Japan and China in particular). Respondents were asked which of these four regions is the current leader in knowledge production and nanoscience (e.g. in terms of scientific publications), and which is the current leader in transfer of nanotechnology to industry (e.g. in terms of patents and/or bringing products to the market).
The results in figure 7 show that North America is clearly seen as the leader in nanoscience (67%) as well as in the transfer of nanotechnology to industry (66%). Europe obtains a relatively good share in terms of nanoscience (14%) but is rated relatively poorly for nanotechnology transfer. This seems to indicate that the 'European paradox', where excellence in R&D is not translated into wealth generating products and processes, may occur for nanotechnology. In contrast, Japan has the image of being relatively good in technology transfer (15%).

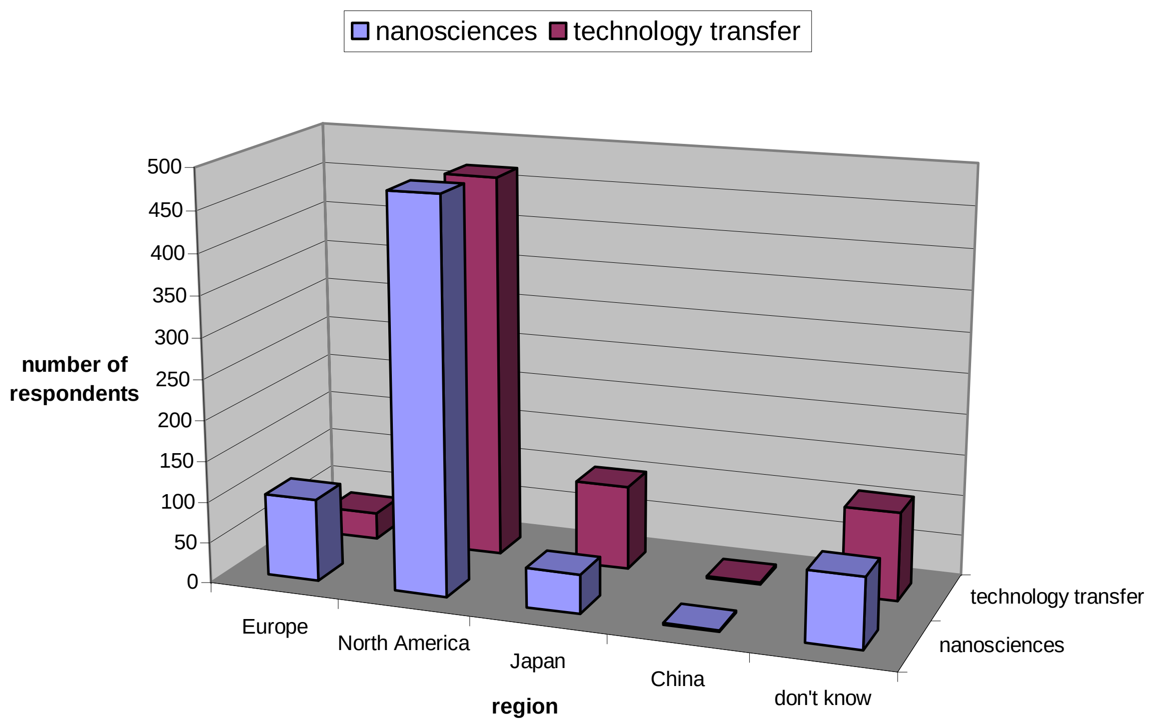

Figure 7 Regions perceived to be leading in nanoscience and the transfer of nanotechnology to industry.

In accordance with the perceived position of Europe in nanoscience and nanotechnology, the level of investment in nanosciences and nanotechnology R&D was estimated by the majority of respondents (57%) to be lower than in the USA and Japan (figure 8). Some respondents

(13%) even expressed the view that the EU invests much less than the USA and Japan. No distinction was made between public and private investment.

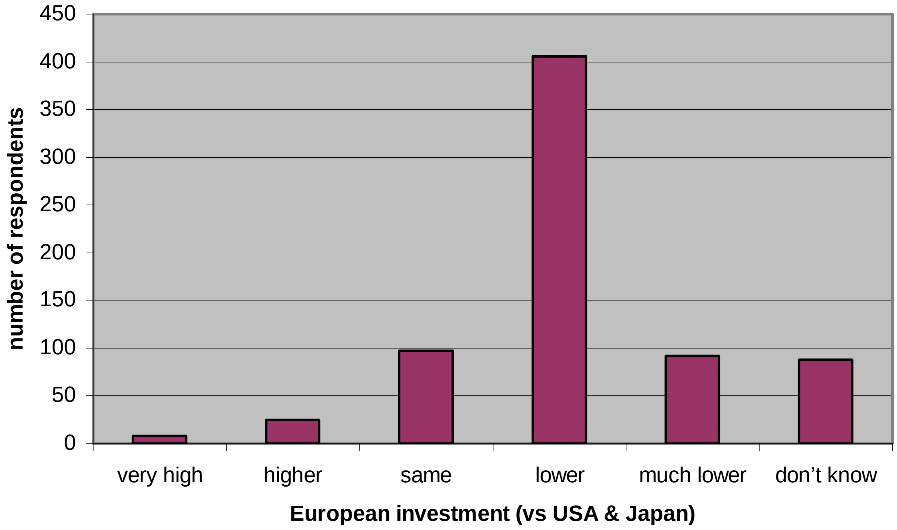

Figure 8 Perceived relative investment of Europe in nanotechnology R&D, compared with the USA and Japan.

5.2 Which areas of nanotechnology R&D should Europe reinforce?

Nanotechnology can enable developments across a large number of scientific and industrial areas. In this survey, eight main areas of nanotechnology R&D were identified, within which a variable number of sub-areas were provided. The respondents were invited to select areas (multiple areas could be chosen) for which they think Europe should reinforce its R&D capability.

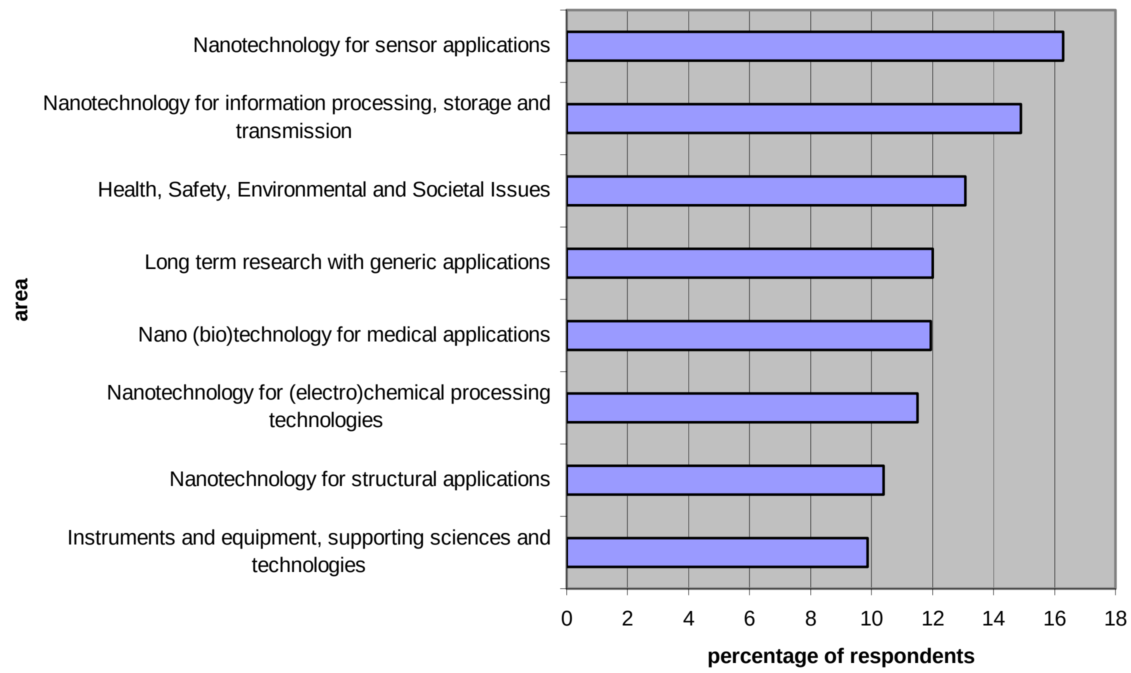

Figure 9 Relative emphasize each main area was given by respondents (the eight areas add up to 100%). The sub-areas "other" were not included here.

The respondents were also given the possibility to highlight areas that were not included in the list of options. Based upon the responses, the weight assigned to each area in terms of selections varied from about 10% to 16%, such that each area was considered to be of almost equal importance (fig. 6). Nevertheless, nanotechnology R&D for sensor applications, IST and health, safety and environmental issues were all rated above 12%.
The priorities given to the sub-areas of each of the eight main areas (shown in fig. 9) can be seen in the table below. No outliers are seen; each sub-area was checked by at least 20% of the respondents. This indicates that the majority of the respondents are of the opinion that nanotechnology encompasses a broad range of R&D and has an enabling character.

Nanotechnology for sensor applications	
1. Nano structured sensors	462
2. Sensors based on biological molecules	409
Other	18
Nanotechnology for information processing, storage and transmission	
1. Nano-electronics, materials and devices	512
2. Opto-electronics / optical materials and devices	426
3. Organic (Opto) electronics	331
4. Magnetic materials and devices	326
Other	12
Health, Safety, Environmental and Societal Issues	
1. Interaction of nanotechnology with living organisms	498
2. Public understanding of nanotechnology	428
3. Risk assessment of nanotechnology	420
4. Interaction of nanotechnology with the environment	415
5. Societal impact of nanotechnology	253

6. Ethical aspects of nanotechnology	235
7. Governance of nanotechnology	202
Other	0
Long term research with generic applications	
1. Self-assembly	396
2. Interfacing to organic / biological molecules	356
3. Molecular devices	326
4. Quantum physics, mesoscopic systems, chemical	311
5. Modelling and simulation	294
6. "Converging" technologies	246
Other	10
Nano (bio)technology for medical applications	
1. Targeted drug delivery, molecular recognition	467
2. Diagnostic systems	404
3. Drug encapsulation	356
4. Tissue engineering	295
5. Implantable systems	279
6. Imaging	242
7. Molecular motors	194
Other	14
Nanotechnology for (electro)chemical processing technologies	
1. Catalysts or electrodes with nano-structured surfaces	410
2. Filtration	206
Other	15
Nanotechnology for structural applications	
1. Composite materials containing nano-crystals or powders	393
2. Nano-particulate coatings	364
3. Nanotubes/nanowires	328
4. Nanoparticle production	306
5. Materials based on carbon tubes or fullerenes	289
6. Nano-powdered ceramics	269
7. Metals and alloys	212
8. Colloids	180
9. Textiles	163
Other	31
Instruments and equipment, supporting sciences and technologies	
1. Analytical equipment and techniques	407
2. Deposition equipment and techniques	287
3. Patterning equipment and techniques	279
4. Powder production and processing	217
5. Metrology	214
6. Beam methods	180
Other	6

Table 6 Main and sub-areas of R&D for nanotechnology ranked according to the number of responses (as given in the right-hand column).

As can be seen in table 5, the option "other" was checked on 98 occasions and respondents were invited to provide a free-text response. Many respondents used the “other” field to generally express their enthusiasm or anxiety about nanotechnology. Several respondents identified two important sectors:

Energy
1. Efficient lighting
2. Fuel cells
3. Batteries
4. Thermo-electric sources
5. Photovoltaic sources
6. Hydrogen motors
7. Energy storage
8. Hydrogen storage

Agriculture/Food
1. Food and nutrition processing
2. Encapsulation of nutrients
3. Quality assurance and food safety
4. Packaging and logistics of food
5. Nanosensors to detect pathogen infections (plant science / agriculture)
6. Controlling appearance/touch of food

In this context it was commented that “much of the technology described under "nano (bio) technology for medical applications" is of great relevance for the food industry as well. Bio molecules can, via the "delivery" technology described, form functional connections in food and feed, which can recognise and fight pathogenic micro-organisms.”

Several miscellaneous subjects were mentioned also, that could not be classified into one of the eight areas. These are:
- Stabilisation and formulation, i.e. making nanoparticles compatible with other matrices or surfaces
- Intelligent tyres
- Smart dusts
- Nanofiltration for energy conservation and improving the environment
- Micro chemical engineering

Other subjects were specifically addressed to the areas mentioned. More attention was asked for the role of nanotechnology in:

Nanotechnology for sensor applications
1. Sensors measuring interactions between biological molecules. High throughput biochemistry is required to be able to interpret data from genomics/ proteomics analyses. The flow of information will be: genomics to proteomics to high throughput biochemistry (using nanotechnology).
2. Sensors based on porous silicon
3. Wireless packaging and process sensors, especially in paper

processes

Nanotechnology for information processing, storage and transmission

1. Integration of Micro (MEMS) and Nano Technology
2. Hybrid media
3. Information storage by using water molecules
4. Quantum Information Computing/Processing

Health, safety, environmental and societal issues

1. Measuring physicochemical properties contributing to both hazard assessment and environmental fate modelling,
2. Novel toxicology methods; and environmental exposure monitoring in support of risk assessment and management
3. International research cooperation with emerging markets and developing countries.
4. Diffusion and adoption processes within general innovation processes
5. Techno-starters
6. Nanotechnology for environmental remediation
7. Utilisation of renewable resources
8. Analysing the life cycle of nanotechnology-based products

Long-term research with generic applications

1. Generic research: contamination control

Nano (bio)technology for medical applications

1. Delivery of DNA fragments for gene therapy
2. Brain/machine interfaces
3. Neural implants; neuroelectronics
4. Interface between electronic and living tissue

Nanotechnology for (electro)chemical processing technologies

1. Pulping process equipment
2. Micro reactor and separation technology
3. Separation / membranes

Nanotechnology for structural applications

1. Structural applications: paper and packaging
2. Glasses and ceramics
3. Structuring of surfaces through supramolecular polymer/nanoparticle chemistry
4. "Smart"/"triggered" colloids and arrested matter
5. Polymer nanotechnology (in context of medical applications, plastic electronics and nanoelectronics, and smart and functional structural materials)
6. Fibres, notably nanotube based fibres

Instruments and equipment, supporting sciences and technologies

1. Equipment for nanohandling, i.e. robots, manipulators and

	application-specific end-effectors
2.	Production up-scaling (including safety or time-to-market aspects)
3.	Equipment for new coating and printing methods

Several respondents commented on the interdisciplinary nature of nanotechnology and the overlap between the mentioned areas. "Due to complexity of the subject interdisciplinary research/networking is required but more funding is required for developing a network."
It made some respondents tick all of the available area boxes. One respondent clearly stated that "it is almost impossible to prioritise the R&D issues", an opinion that is well reflected by the evenness in the total response. A different respondent stated: "If we are to be competitive, ALL these things have to be investigated in a balanced manner. Furthermore, neglecting some areas can have unpredictable influence on others. One can decide if something is worth producing only when it is invented, made and tested!"

One respondent expressed the opinion that a "clear EU communication strategy why nanotechnology is necessary and how Europe and its citizens benefit from nanotechnology is absolutely mandatory…." Others wanted emphasis on the socio-economic aspects/influence of nanotechnology, to pay more attention to risk perception, and to take care to minimize the hype. A respondent stated “the philosophical issues and especially issues regarding the philosophy of science should be included. It is very important that one introduces standards from "normal" and "post-normal" science into nanotech since it is one of the easiest ways of getting both sound science and public acceptance." Regulatory aspects were also touched on, ranging from stating the issue to calling for a moratorium.

An American representative (who explicitly presented him/herself as such), said: "We believe that Europe should pick specific technologies (for funding) in each of the areas listed (e.g., nanotechnology for structural applications) rather than provide monies for all the technologies (thereby spreading the investment thinly). Furthermore, this can only be done by understanding the needs of the market place before allocating European R&D funds. The key question must be: How can Europe derive the greatest impact its research investment in nanotechnology? We also feel that investment in instrumentation, equipment; metrology, HSE and societal issues underpin any research and development activities undertaken in nanotechnology. These aspects must be adequately funded if Europe is to derive value (i.e. generate profits) from this burgeoning field. Hence, all the categories have been ticked."

6 EU Research Activities and the Framework Programmes

Since the consultation was initiated by the European Commission, one part of the questionnaire was devoted to gathering the opinion of the respondents on current research activities in the EU, namely the Framework Programmes (FP) and to obtain their views on future wishes. Of the respondents, 328 (46%) had already participated in one or more EC funded projects under the Framework Programmes.

Type of project	*Number of participants*
STREP	145
IP	125
NoE	117
SSA	58
CA	42
IP-SME	22

Table 7 Framework Programme project types the respondents in which the respondents participated.

Note that the choice of projects types was confined to those in FP6 so that there may be other respondents who were involved in previous Framework Programmes (e.g. FP5 and FP4). In hindsight, the project types for FP5 and previous FP's should have been included. Nevertheless, the figures above indicate that many of the respondents have a direct experience of the European R&D activities in the Framework Programmes and were well placed to provide their views on the topic.

6.1 How much should the EU invest in nanotechnology?

The respondents were clear about how much the European Commission should devote to R&D in nanosciences and nanotechnology R&D in the next Framework Programme compared to the current one (FP6): Figure 10 displays that a considerable increase is desired (79%). Out of those requesting this increase, 25% would like a doubling of the budget or more. These views are consistent with the perceived funding gap that was shown earlier to exist between Europe on one hand, and the USA and Japan on the other.

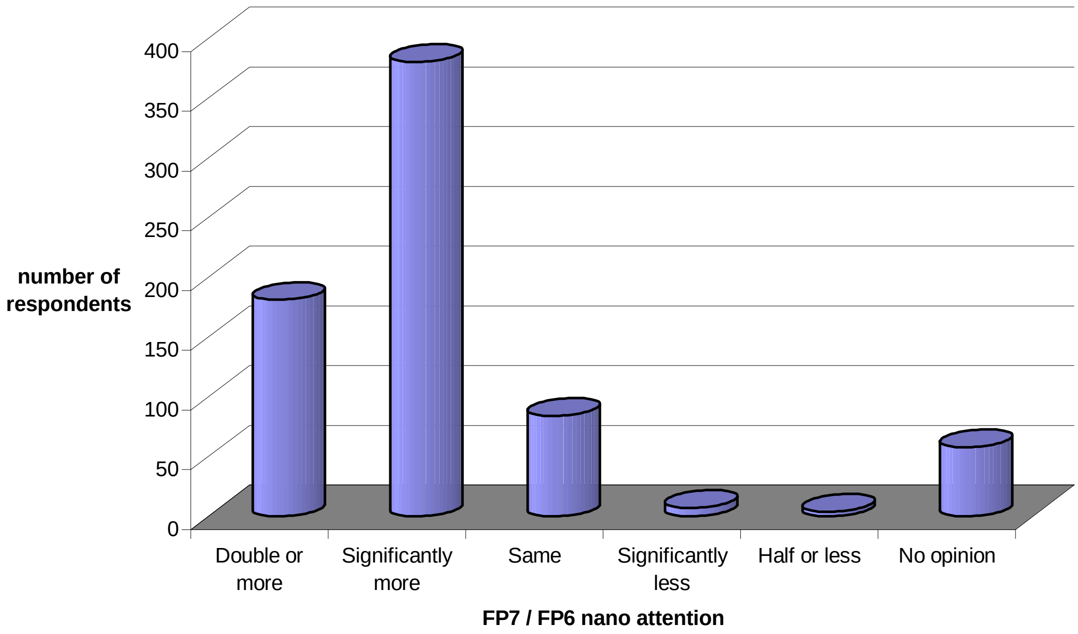

Figure 10 Desired amount of attention to nanoscience and nanotechnology in the next Framework Programme with respect to current FP6**.**

When the respondents were asked to estimate the balance between basic and applied research in Europe, their reactions were almost equally divided over the two categories. On the whole, this would appear to indicate that there is a balance in the community.

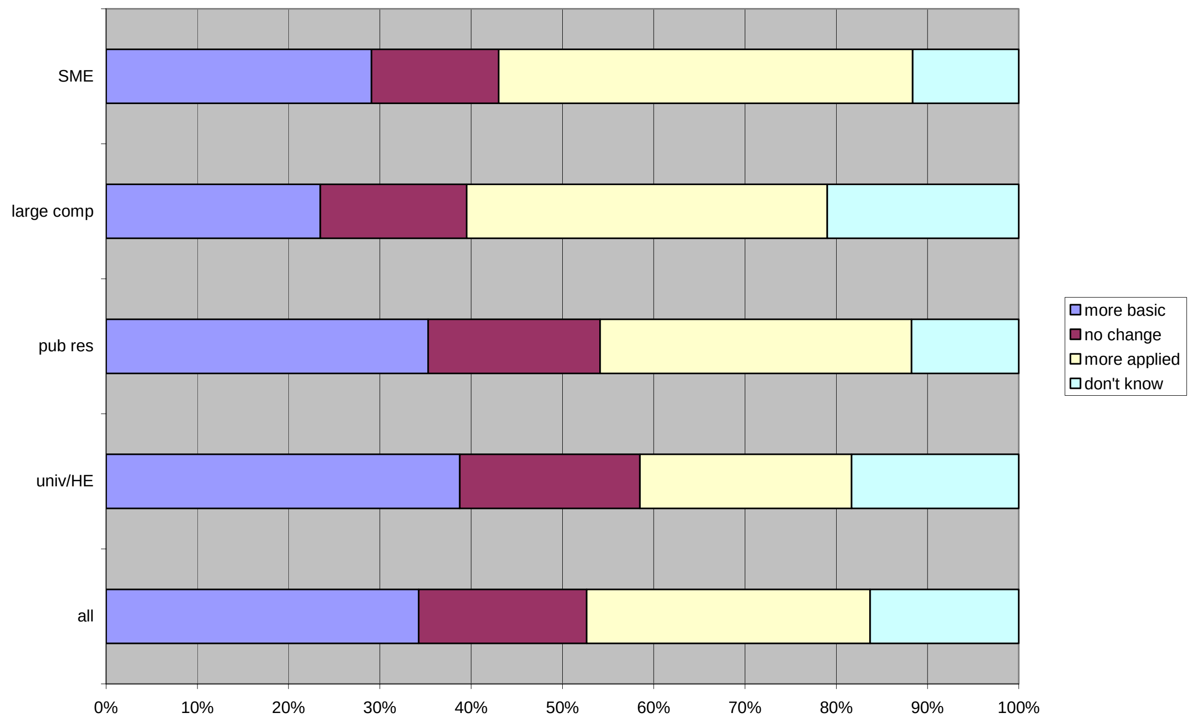

Figure 11 Perceived balance between basic and applied R&D in Europe.

Closer analysis of the question ‘basic vs. applied’ in terms of the profile of the respondent reveals that the responded depending upon whether the respondent was active in a research organisation/university or in industry. More basic research is requested by 39% of people in university or higher education compared to only 23% of respondents in large companies. On the contrary, 45% of SME-respondents wanted more applied research, compared to 23% of respondents in universities. Figure 11 above shows the responses for all respondents and those from University/Higher Education; Public Research institutes; large companies and SMEs.

6.2 Views on Future EU R&D activities in nanotechnology?

The respondents were given the opportunity to comment on the question "What would you like to see for nanotechnology R&D in future Europe research activities? (E.g. key issues to address, new areas, new instruments, special measures for SMEs/industry, practical operation of the programme, etc.)" Two-third of the respondents (481 people) used this opportunity to express their desires. Many subjects were addressed and lengthy comments were frequently provided. Taking the comments as a whole, the respondents asked for more attention to issues in the following categories:

1. Views on organisational aspects
    a. Strengths of Europe
    b. European collaboration
    c. Role of the private sector
2. Ethical, legal and social impacts of nanotechnology
3. Marketing and business aspects
4. Research related issues
5. Desired technological application areas
6. Supportive technology
7. Wishes with respect to the design of EC programmes

In all categories except for the first, the comments of the respondents were tallied. It should be noted that the answers of many respondents were guided by the examples that were given between brackets in the question. For example, "new instruments" and "special measures for SME" were often mentioned as such, without further commenting. One should bear in mind, therefore, that the comments on this open question might be somewhat unbalanced in quantitative respect.

1. Views on the strengths of Europe, international collaboration and the role of the private sector

a. Strength of Europe

There was a strong demand for "an analysis of Europe's key strengths and ways in which we can build on these with nanotechnology. This is classical 'differentiation' strategy. We need to find out what Europe is good at vis-à-vis North America and Asia and focus on this." And it was advised to "start with expected key needs of people, environment, the economy and society at large in Europe and worldwide, and develop roadmaps how nanotechnology can contribute to solving these needs. Then issue calls for proposals comparable to the US Grand Challenges (allowing the scientists and industrialists to propose creative approaches for the technology and science, but coaching their efforts toward public needs.

Examples of the needs often cited are: healthcare and mobility solutions for an ageing population; sustainable energy and building; building a truly global knowledge economy; technologies for peace. This demand to "concentrate in issues and areas (applied or fundamental) where Europe is strong" was expressed by several European respondents. It was felt that "there is a need to stick to the core issues in nanoscience, otherwise the area becomes too diffuse," and "increase the financial support in the area of nanotechnology in general to compete with NAFTA and Asian countries."

Other respondents, however, advised that one should pay attention to areas that are at an early stage but might become competitive: "nanotechnology R&D should address emerging technologies with global market potential where Europe can regain some competitiveness e.g. plastic electronics." "Introduce instruments focussed on industrial applications. We are lacking behind in this area relatively compared to for instance the US and Japan." "Special support of industry in fields where European R&D is strong, but industry is weak (e.g., magnetic data storage; optoelectronics)."

One respondent from outside Europe stated that “currently, research projects in this field are undertaken in a somewhat scattered and piecemeal manner. A major task facing Europe is to develop the diverse themes of research activity in the nanosciences into sharply focussed research endeavours whose results can be deployed in society. […] It is also vital to consolidate the research activities in nanotechnology of various organisations in the form of an activity map, then into 'value chains' or 'areas' (with the emphasis being on the markets that would benefit from the nanotechnology developments). This is with a view to ultimately commercialising and industrialising the pooled outcome of research efforts.”

b. European collaboration

A desire was expressed to set up "measures to improve international coordination of nanotechnology R&D in Europe, "such as "a European Research Council that can fund projects on their scientific merit alone without the imposition of political restrictions." "Establishment of a "European Research Centre for Nanotechnology" (EUNANO) is highly desired that would collect experienced researchers from all over Europe. Concentrating the research potential in an EU institution would greatly enhance our research potential and would help fight the gap between the European research level in nanotechnology and that in the US and Japan."

To join knowledge and actors, the creation of "one or more Nanotechnology Platforms (ETPs)" was suggested, in order to "gather together networking across the research areas". "More coordination of advanced research" is wanted, and "the introduction of Technology Platforms can be a step in the right direction." "The company BASF strongly supports the proposal of the Commission to create Technology Platforms integrating of all necessary actors, such as: researchers, industry, clients, end-users, regulators and social groups. These Technology Platforms could provide a forum to create new industry-academia partnerships and to manage research funding (coming both from industry and public sources) in an effective manner."

Without mentioning what role the EC should play in this, two respondents asked for more local concentration: "An improved network of German hotspots in nanoscience which does not exist as yet" and "A major research centre and development centre in the UK pulling through the excellence in science into products, to create wealth and high quality jobs." One respondent event wanted all regional projects governed by the EU: he asked for "Closer EU monitoring/administration of regional funded projects."

c. Role of the private sector

Several respondents stated that "university/industry partnerships should be encouraged", also expressed as a "synergetic effort between public & private sectors (the ecosytemic model)", by developing "measures to stimulate greater investment in R&D from industry". One respondent advised to "have industry to take the lead. Establish an industry board to formulate and evaluate the research programme". In general, it was felt that "more coordinated and centrally funded industry-public institution research grants are needed.” Financing and international competition appeared to be important motivations for this desire:

"Attract talented investigators. The competition from the US (higher salaries, more investment and independence for young scientist, much less bureaucracy, many more high-tech companies, etc.) makes it very hard to keep the European Union at the same level in either basic or applied research." "More communication between European research institutions (mostly universities) and industry should be stimulated by the programmes. Now, Universities do not know what is needed, and industry does not know in time what is possible.

On the other hand several respondents pointed out that academic R&D is beneficial for industry and there is a good case for more interaction: "More industrial participation could be done through addressing nanotechnology as a set of enabling technologies, necessary to rejuvenate the present industry in Europe and their existing products. Plus, of course, nanotechnology as a starting ground for the unborn/newly established knowledge based industry."

2. Ethical, legal and social impacts of nanotechnology

Within this category, five main topics were addressed by the respondents:

1. Social impact of nanotechnology

Attention was requested for the social impact for nanotechnology, and more emphasis on addressing societal needs was desired. In particular, issues such as the ethics and philosophy of science, more attention for the impact on the economic situation, and creation of jobs, were highlighted. In addition, attention should be paid to the evaluation of economical efficiency compared to the conventional macro technologies. (9 respondents)

2. Risks and regulation

Health and safety issues, toxicology, risk management/assessment, and establishing regulation were highlighted as crucial issues for which more R&D is needed. A wide span of views were given include one respondent who asked for "A complete moratorium on lab-research until compulsory safety protocols are introduced; and a strict "no patents" policy on new molecules." Among those who are positively minded towards nanotechnology, the patenting issue was addressed by asking for "one EU patent". (37 respondents)

3. Environmental impact

Sustainability and environmental impact issues were stressed by respondents that they should be more pronounced on the EU agenda (24 respondents). It was advised to "incorporate with Technology Platform for Sustainable Chemistry". Several respondents took the opportunity to reiterate calls for a moratorium on nanotechnology.

4. Public communication

Public communication concerned the issue of making the link between researchers and the public to raise public awareness. Well coordinated activities to foster public awareness and information were recommended, as well as to "address areas that will realise benefits that the public will notice, understand and embrace" (14 respondents)

5. Education

As part of public communication, science communication was considered as important to be stimulated, such as science education to young children, specific educational programs at European level, promotion of interdisciplinary education. Simplification of the science language was recommended. (13 respondents)

3. Marketing and business aspects

This category concerned marketing, business implications of nanotechnology (on industries, sectors, networks, companies (SME), products), and diffusion and adoption processes within general innovation processes related to nanotechnology. Five topics were highlighted for closer attention:

1. Special measures for SMEs

Several respondents wanted better conditions and support for SMEs including the scale-up, production and commercialisation of materials, devices and processes. One cited the need for EC contact persons to help foster SME participation. The size of SMEs was often pointed out as an advantage: "[the power of SMEs is] to produce working prototype for evaluation by larger institutions, i.e. less R & D and more applied work targeted to bring products to market earlier. […] A lot of real innovation is coming from SMEs and not by multinationals because multinationals are directed and aimed at controlling their current economic position as long as possible." (58 respondents)

2. Less attention for SMEs

In contrast with point 1, several respondents asked for "less weight on SMEs and collaborations. For an SME is not so easy to participate in basic research. Nanotechnology is not the SME business. Big companies are much more suitable. Actually the company can incorporate afterwards the results of the research." (4 respondents)

3. Knowledge transfer

One asked attention for: transfer of research results into applications, commercialisation, improving the process of linking the applied research (focus/specialisation) better to existing industry structure, increased communication between science and industry, technology transfer to industry from applied and basic research. "In general, it is very hard to cover the gap between nano research that is essentially basic, and industrial application. It would be more efficient to focus programs on new functions/concepts than on new specific applications; this would generate more input from partners as they would see the benefits of commercial realisation of long term programmes. This would also encourage more money to be put into R & D. To reduce the time-to-market from R&D to products where it is possible, and to support longer transition time from R&D to products where it is necessary. Get it into the hands of experienced engineers not just researchers. This is why there are very few commercially successful applications." (41 respondents)

4. Special measures for industry

Most respondents simply mentioned the need for special measures to help SMEs without going into more detail. One stated: "Special measures should be taken so as to promote the use of emerging technologies in the industry." (5 respondents)

4. Research related issues

R & D in nanotechnology was approached from eight perspectives.

1. More support for fundamental and innovative research

Many respondents stressed the importance of supporting fundamental and basic research support along with ‘risky’ projects because much of the best nanotechnology research is some way from marketable products. "It should become possible again to conduct research in a less directed and pre-defined fashion in order to be able to freely and creatively develop real innovations. More openness to "bottom-up" initiatives is vital in a subject whose scope is not yet fully defined." (36 respondents)

2. More interdisciplinarity

Several respondents drew attention to the need for multi- cross- and metadisciplinary research in nanotechnology. Better networking is seen as being essential together with (international) collaboration to generate synergy between research centres, SMEs and industries. Creating at least two worldwide leading interdisciplinary nanotechnology research institutes was advised by one of the respondents. (23 respondents)

3. Better integration of theory and application

Bridging the gap between basic R&D (in research institutions / universities) and applications (industry) was cited as an important issue. The need for closer interaction of academia and industry was highlighted along with the need for basic nano-scale science and materials chemistry to underpin applied areas. There is a perceived need for long term (>5 years) projects that span basic research through to applications, with tuning of the project and adding partners on the way. (7 respondents)

4. More support for applied research

As already highlighted, respondents did not have a unique view on the balance between theoretical and applied research – it appears to depend upon whether they are active in academia/research organisations or industry. However, more focus on applied research rather than on basic topics was requested. "Help applied research (spin off of university, institutes, SMEs). Applied research should have greater emphasis, but not solely industry lead." (17 respondents)

5. Better distinction between fundamental and applied research

"A clear distinction must be made between applied research in nanotechnology (a new technology where even the random exploration of possibilities can yield high rewards) and basic research, where an approach more guided by theoretical principles and the pursuing of scientifically interesting questions is called for. Much research is being done in academic research groups that do not have "nanotechnology" in their names (e.g. condensed matter research groups often do cutting-edge nanotechnology research following apparently more academic motivations). It is important to recognise that some of the leading nanotechnology research is being carried out by such groups and to channel some of the extra funding in that direction." (2 respondents)

6. Convergence of enabling sciences

Several respondents highlighted the need for the convergence of nanotechnology, biotechnology, ICT and cognitive sciences (4 respondents).

7. Extension of nano to micro

"Extend methods used in nano to larger /micro technologies. Nanotechnology should be seen as a way to improve Microsystems technology and therefore a merge with micro systems technology should be envisaged; a strong division between micro and nano makes no sense; micro nano integration should be the focus. A key issue will be to establish a workable interface between the 'nanoworld' and the 'micro- and macro-world'. Integration of nano devices into systems, i.e., an 'architectural' approach [is advisable]. Improve the link between nano and mesoscopic scales." (9 respondents)

8. Modelling and simulation

Some respondents pointed out that modelling and simulations of surface interactions and of crystal growth are important. In general, there is a call for more focus on computer modelling of nanomaterials. (7 respondents)

In an appreciably extensive comment, one respondent addresses all of the above topics:
"The focus of the present program is in many areas excellent, and well framed. It needs only time and effort on the part of the scientists.”

5. Desired technological application areas

Within the following14 application areas, the respondents asked more involvement of nanotechnology R&D:

1. Energy

This includes energy efficiency, new energy sources, e.g. materials for fuel cells and nanostructured / nanocomposite materials for advanced nuclear fuels. The need for a centre of excellence for the development of organic solar cells was highlighted. (11 respondents)

2. Sensors

This includes sensor related projects: detection systems, molecular recognition, 'lab on a chip', diagnostic technologies for on-line process monitoring and control were all noted. "Develop technology based on integration of very specific sensor elements on Si microelectronics with the ability to recognize biological (viral to molecular level), organic and inorganic substances. Specificity should be obtained by providing a combination of shape, chemical nature and size of the sensing elements. (8 respondents)

3. Nanobiotechnology

This includes topics such as biocompatibility, man-machine interface, ageing in humans, animals and plants, pharmacy (targeted drug delivery), medicine/healthcare, nanobioelectronics, molecular recognition biomimetics, diagnostics, novel ideas on neural circuits, cosmetics. Molecular technologies and bionano-oriented R&D were mentioned as more general nanobiotechnology topics, and also uses of biological templates, viruses, DNA, proteins, etc. for nanotechnology. A close link to pharmaceutical industries for the development of biochips was also advised. (44 respondents)

4. Electronics and magnetism

(Micro-) electronics and magnetic media were often mentioned in the context of information technology hardware. "Data storage is becoming more and more a major issue, all the more digital data archival for which no safe technology exist at the moment. EU industry is behaving well on some issues and is totally absent on others. This may become a real problem in the future."

Electrical resistance was mentioned as an important area to address via nanotechnology R&D to improve transmission and distribution problems. Specific points included "Addressing electrical contact resistance in nanoparticles." "Expand the electromagnetic property windows of essential materials and components in power transmission and distribution products. Thus, provide transmission and distribution network components with considerably lower losses and reduced weight and cost of systems and less environmental impact."

Greater attention to new structures and materials in electronics was requested: "Organic materials for electronics and optoelectronics." "Strengthening of the European industry in the field of electronics would involve research into nanoparticles." "Building real electronic devices based on nanostructures less than 50 nm." "A specific area which is of major importance for the future success of nanotech is the area of compounding. Focus on cost effective electron beam mask-less nanolithography and ion beam direct nanopatterning." "In electronics focus should be on realistic beyond pure CMOS solutions, such as CMOS/molecular hybrids etc." (23 respondents)

5. Optics

Here topics included optical materials and devices, and nanophotonics. A typical quote is "New optoelectronic device research providing the technology to realize new levels of solid state light generation and detection which will drive application areas ranging from data communications to solid state lighting." (8 respondents)

6. Agriculture, food production, nutrition

These issues were mentioned by 4 respondents.

7. Materials

Types of materials mentioned for more research and industrial attention were: novel materials, polymeric materials, bio textiles, nanotubes (and -wires, -fibres), metals and oxides. Different types of fields that are of interest in the scope of nanomaterials were mentioned: "Applications of nanomaterials and based on the needs of end-users and end-user industries (like construction)." "Combining nanotechnology materials and extreme environment conditions (such as high temperatures, high pressures, high magnetic fields)."

Demand was expressed for more interaction with other fields and industrial players: "Linking applied materials research to possible emerging application domains." "Bridge the gap between materials and biotech." "Linking raw material production and manufacturing into real applications at the end of the supply chain." "Increased R&D is needed to increase knowledge (including modelling) of how to mix nano particles in polymer matrixes in a robust and repeatable manner."

In the scope of materials, social issues were mentioned as well: "We need some clear 'demonstrator' projects that will allow both the public and other scientists to realise what really can be achieved and how it can benefit society." "Focus on new materials for markets with sustainable growth such as electronics, optics, and energy management." "Natural nanostructured materials for environmental applications." "Nanostructured materials aimed at enhanced performance and replacement of toxic materials." (34 respondents.)

8. Surfaces

For surfaces and coatings, reinforced investment on surface treatment engineering was highlighted for biocompatible surfaces, energy saving in buildings, enhancement of tooling service, optical communications. Other topics included: self cleaning surfaces for decontamination of a plant; more effort at the interface between the biological world and nanostructured surfaces; 2D effect materials and surfaces; nanolaminated and nanocomposite coatings; paints. (8 respondents)

9. Self-arrangement

Specified as: self-organised nanoparticulate arrays, self-assembling structures, self ordering processes, self-aligning production techniques (10 respondents).

10. Construction and physics

Here the importance of investigating the fabrication/physics/construction/production related technologies and how to bring fabrication costs down. Respondents wanted more emphasis on technology (i.e. mass volume production) rather than on science (i.e. understanding at the nanoscale) or techniques (i.e. single example demonstration in a scientific or academic setting). (8 respondents)

11. Miscellaneous application areas

These included purification/separation techniques, heterogeneous catalysis, car industry, nano-fluidics, powder processing nanotechnology for filtration (membranes), high resolution freeform generation from nanoparticles, molecular nanotechnologies, and nuclear waste treatment. (10 respondents)

12. New areas

Several "new" applications of nanotechnology were pointed out, such as ultra fast switching, nanocomposites, bio-inspired nanomaterials and nanosystems, assembly of actual nano-sized objects. "The new areas emerging should be considered, as no one of these regions (Europe, North America, and Asia) is a leader, and therefore an opportunity exists to become a leader." (15 respondents)

13. New instruments

Respondents interpreted this topic in two ways: new technical instrumental equipment, and new ways of funding research and development (according to the terminology used by the European Commission). Many respondents mentioned "new instruments" without providing further comments; it was therefore not clear which of the two interpretations they had in mind.

In terms of technical instruments, it was mentioned: new instruments for nm or sub-nm scale, new instruments in bio-medicine and telecommunications, analytical instruments, stronger support for the development of new nanoscale instruments - possibly in the centers of excellence. Smart robots for handling at the nanoscale appear to be a key for pursuing many applications of nanotechnology. (38 respondents)

14. General comments on application policy issues

Several respondents pointed out that far too much emphasis is placed on nanoscience for consumer/everyday applications. Similarly, there is too much emphasis on high profile topics such as electronics and medicine, when other things than can affect the daily quality of life, such as foods, personal care and textiles get ignored in funding calls. The development of methods for the chemical synthesis of nanoscale devices is crucial. In this area we are falling behind the US very seriously. At the moment the Framework Programmes do not support chemistry or chemical synthesis in any direct form, only its applications.

6. Supportive technology

Here, the topics of measurement and infrastructure were addressed. With respect to measuring procedures, attention was paid to the standardization of measurement procedures, definitions and regulations. Greater attention is needed to "focus on measurement systems" and to "make metrology a topic of its own". "Pre-normative research for standards development in metrology and characterisation of nanotechnology materials and systems" should take place, possibly by "making metrology means available in European centres of excellence".

In terms of "analysis and quality control", the need for "new methods of characterisation" and "new instruments of detection" and "novel instrumentation" was highlighted. "This is crucial to make sure that EU scientists working in nanotechnology have access to instruments for advanced characterisation and testing properties of nanostructures and nanomaterials (i.e. high resolution microscopes, spectrometers, equipment for assembling nanodevices etc.)." Some more specific issues were raised including measurement of nanomaterials in real time, more accessible fabrication and characterisation facilities and methods for the detection and identification of nanoparticles. (13 respondents)

7. Wishes with respect to the design of EC programmes

In the latter part of the section, we highlight specific observations of the respondents about their experience of the existing Framework Programme. In the following we discuss wishes and suggestions for future EC programmes. Three respondents copied the example text "practical operation of the programme". The remarks of remaining respondents could be classified into four categories: a very strong call to decrease the size of the projects; wishes with respect to existing programmes; demand to define a clearer focus of nanotechnology; and several miscellaneous requests.

Decrease size of projects

With regard to project size, many respondents called for smaller projects and greater emphasis on STREP (Specific Targeted Research Projects). One typical view is “Smaller and individual project should be supported. It would be great to see a range of smaller grants available for fast turnaround / more trial projects - smaller sums of money but sufficient for a small collaboration between two or three sites to test out an idea, with the intention that if it proves promising they could then go on and use this as a basis for a larger IP or other application.” (24 respondents)

Nanotechnology Focus

Several respondents asked for "a clearer separation to the non-nano sciences". "The research activities should be aimed at areas where there is a real potential application issue. In most cases research is carried out in any area in which the applicants just add the word 'nano' to make the project more attractive. Care should be taken that that does not happen in the future." "Nanotechnology as a separate area is misleading."

Structure of the Programme

A diverse range of wishes were expressed in this regard including some regarding the structure e.g. “the NMP research priority should be more explicitly a coordinator of various divergent and perhaps convergent nanotechnologies.” Some called for better coordination of research applications and thematic areas - possibly the oversight of a European Research Council.

Two respondents stressed the importance of reinforcing, in the framework of the European Research Area (ERA), the relationship between the Framework Programme and other intergovernmental organisations such as EUREKA and COST as well as other ad-hoc organisations including the European Science Foundation (ESF), the Comité européen de normalisation (CEN), the Alliance for Chemical Sciences and Technologies in Europe.

Three respondents supported the focussing and coordination of European R&D in nanotechnology e.g. the creation of “roadmaps at the highest level of expertise in Europe are desperately needed. These roadmaps at European level would challenge the R&D activities on a national level in order to achieve a higher degree of convergence and collaboration within Europe as a whole”. One participant added the caveat that “there is also an agreement that the coordination and centralisation should be based upon the bottom-up advice of the scientific community”.

Other requests

Others noted that “making a serious attempt of establishing real excellence centres, who are then essential partners in new projects” was important. Other respondents emphasised the need for opening-up European Technological Platforms to other stakeholders and the importance of the EC Marie Curie programmes and the possibility of dedicated ones for nanotechnology.

On the subject of the international dimension of EC projects, several respondents noted the need for “More collaborative projects with countries which have expertise in various advanced areas like computational software etc. like India or China.” Similarly, there should be “More support for researchers from east European countries.”

6.3 Experiences of the EU Framework Programmes

The respondents were given the opportunity to comment on the question "What were your experiences of applying for and participating in the project? E.g. finding information, evaluation, support and partners, project management, etc." Almost half of the respondents (356 people) used this opportunity to express their views. An overwhelming amount of complaints concerned the amount of bureaucracy and the costs associated with this. While more than 130 (37%) respondents referred (very) negatively to this issue, only 6 respondents thought the cost-benefit balance to be acceptable.

Frustration arose from an experienced excess of documentation, difficulty in accessing information, and complicated and time-consuming procedures. Several respondents decided not to apply for EC funding anymore for this reason. The people who persevered often found themselves unpleasantly confronted with a surprising evaluation process (over 115 remarks were made on this issue) which was often thought to be ambiguous and politically oriented rather than scientifically.

Several comments were related to the difficulty to find suitable partners, and the lack of real collaboration. The partnership was often experienced as being purely administrative. Cultural and language differences caused a further estrangement between the partners. It can take a long time to establish a good interaction, and the funding period is relatively short. Of those who saw their application rewarded, several gave comments concerned the management of a project. Several respondents suggested solutions for the reduction of bureaucracy and for speeding up the processes. Specific comments are mentioned in the following.

Burden of bureaucracy

Given the fact that many respondents complained about "too much paperwork" or "too much administrative hassle" associated with EC projects, we are pleased that so many people still made the effort to participate in the open consultation. Many respondents elaborated in detail on their experiences. Typical excerpts include:

> "The EC framework programs are a great forum to bring academia and industry together on research topics that matter for Europe and the World. The large administrative burden and the low chances for success may become counterproductive with respect to motivating participation."

> "Guidelines for the management for even relatively small projects are really exorbitant. Necessary involvement of private companies for writing the applications and performing the auditing is redirecting precious research funds to non-productive sectors."

> "Great project partners for research - but incredibly time consuming funding scheme, university administration is intimidated by EU regulations."

> "Application: Lots of forms to be completed with overlapping information. Unnecessary work required for transferring information from application to contract preparation."

> "It takes an enormous investment effort to prepare proposals, with a lot of time to be spent on non-scientific aspects. Project administration is overly cumbersome and does not really help in reaching the objectives of the project."

> "Whole procedure is quite confusing and hardly manageable if the team has no thorough experience with EU proposal writing and applying."

> "I contributed to building the consortium from the very beginning, and writing the project. Submission is very time consuming and I am sure it could be simplified."

> "The bureaucracy is certainly not less than in FP5."

In contrast with this last statement, one respondent writes:

> "As the coordinator of a Research Training Network over the last four years I found that the administrative procedures at the EC have improved dramatically."

Cost-benefit balance of applying and participating in EU projects

Numerous respondents weighed up their investment in time and money to prepare a proposal compared to the benefit of funding, if successfully evaluated. Often they, or their company or institute, appear to be considering whether they should continue to do this. Some comments include:

"Experiences of our institution of participating in projects are rather good. Nevertheless my personal experience as NCP makes me to express a few comments on projects. The number of funded projects presents a too low part of the number of the received proposals in the 3rd priority. Due to the insufficient indicative budgets for individual calls even not all retained proposals can be funded. This situation discourages some potential proposers or participants."

"It is a very time and resource consuming process. It is hardly worthwhile in return of investment aspects."

"Writing a proposal and getting it accepted is very time consuming. Chance of success is too low compared to the effort put in this."

The unfavourable cost-benefit balance especially put off commercial organisations. This may explain the relatively high participation of research institutions in this survey (52%):

"Too much work compared with the likelihood for getting your proposal through, very expensive for firms to seek EU funds."

"Currently, applying for projects is too time intensive to be attractive for SMEs."

"Oversubscription is too high, especially in NMP, but also in IST; massive waste of efforts. In their current form, direct participation in NoEs is not attractive to industry."

"SME leaders would be fine, but this is not encouraged enough at evaluation stage."

Only very few (six) respondents were positive about their investments. e.g.:

"It implies a lot of administration effort but very interesting new collaborations."

"Proposal process is complex, time consuming, and at times frustratingly opaque. But when it gets funded, it’s worth the trouble."

Hampering factors with applying for EC projects

Several respondents perceived that too many partners are required for a project, and that there was no clarity about the desired number of partners. There are, in fact, no ‘rules’ about this from the EC (apart from a usual minimum of having three organisations from different countries):

"There are very little chances of obtaining financing. IPs seems too big, with too many partners and little (usable) output is expected compared to the FPV instruments."

"The consortia are too large for effective management."

"There was a requirement for far too many members."

"I am disappointed with the changes between FP5 and FP6. The projects are now too large and decisions arbitrary."

The time periods lapsing between the several stages of project handling (i.e. evaluation, negotiation and final approval) is often thought to be too long, e.g.:

"The contract negotiation time was too long and uncertain. The amount of time and money requested to finally get to a signed contract is out of proportion. In general I agree with all of the comments stated in the Marimon report."

> "It is a very long and complex application and contract negotiation process."

Another hampering factor was the difficulty many respondents experienced in finding information in CORDIS (the Community Research and Development Information Service at www.cordis.lu). This will be discussed in detail below.

Information from CORDIS

Most respondents had complaints about this issue, of different kinds. Some felt that the total amount of information was too abundant, the information was hard to find, the information was scattered:

> "Finding information is very difficult because of the huge amount of information, distributed on a large number of webpages."
>
> "Keeping track of reliable information from the EC was difficult (near to impossible)."
>
> "Finding information: the web site is not well organized. It is not easy to find relevant information."

Information was apparently missing:

> "I found a lack of information in the different EC funded projects under the framework."
>
> "Information on individual funded FP6 NMP projects in the CORDIS database is incomplete (if any)."
>
> "Information on results of completed projects would be useful for future proposers and for an industrial exploitation as well. Therefore, the CORDIS projects database should contain the item 'Achievements' filled in and not blank as it is now."

The information was not clear or not helpful:

> "The language of the application forms is often difficult to understand."
>
> "The same questions/problems are addressed in different points."
>
> "The guidelines are not well defined and changing within the first year."
>
> "The description of type of research to be funded and details about general conditions should be much more precise."

The electronic system not functioning properly or required uncommon software:

> "Electronic pre-registration and electronic submission was not made available, although it has been promised all time long on the web-page. […] After the approval of the grant, filling out of the pre-contract questionnaire was a nightmare. The electronic format contained serious errors (rather than providing a simple Word questionnaire) with unfillable fields. After signing the contract, actual funding of the project started four months later that has significantly complicated the starting."
>
> "Electronic tools caused problems."

One often felt that information retrieval was unfeasible without the help of a contact person, which help was in general well appreciated:

> "Support by local EC-liaison office is essential to get information on tenders and project requirements, and to support writing of proposals."
>
> "In general the Community officers are helpful."

Only a few respondents (seven) were contented with information issues, e.g.:

> "Information and systems available in the EU to support applications are excellent. No change necessary."
>
> "It was good to use the electronic submission system."
>
> "Good partner searching facilities, good help facilities."
>
> "Information is readily available on CORDIS. Some problems with the CPF but the helpdesk provided excellent support."
>
> "Finding of information was easy, CORDIS offers good service, and support of the national contact point was excellent."
>
> "Finding information was easy."

Evaluation process

Many respondents (109) strongly commented on the evaluation procedure. Several aspects were mentioned. One often felt that evaluation was not based on scientific criteria but on political or other criteria instead:

> "The evaluation principles also seem too skewed away from the quality of the science. If we want to compete with the rest of the world we need to focus on scientific / technical quality, not political issues of integration."
>
> "The most important failing is that political and other factors have a dominant role in determining the outcome of proposals; scientific quality is not the pre-eminent consideration and this is wrong.

Irritation arose from the fact that the reports of the reviewers were often inconsistent and contradictory:

> "Evaluation criteria applied are unclear and inconsistent."
>
> "I found the evaluation inconsistent."
>
> "Evaluation takes too long and often gives contradictory results."

The evaluation criteria were often found unclear. The above mentioned criticisms may have contributed to this:

> "Criteria of evaluation are not clear enough."
>
> "Evaluation criteria are in practice not very transparent."
>
> "Not very clear evaluation criteria."
>
> "There is confusion when matching evaluation criteria with actual evaluation report."
>
> "Evaluation of proposals seems to be a bit random in result. The outcome of a particular proposal seems to be quite dependent on the particular reviewers engaged in evaluating the proposal."

The whole process of evaluation was often too long:

"It is a lengthy review process."

"Very slow evaluation and approval process."

"Evaluation and negotiation periods took very long time."

"Evaluation process is too long-winded."

Several other comments:

"Project evaluation is often based too much on basic scientific expectations and too little on practical applicability."

"Evaluation process should be improved (I've been on both sides of the desk); presently it is not clear that best projects get funded."

"Generally bad. In spite of very good project rating, we received no funding because of bias of responsible committee."

"An unbiased and independent external project expert body is needed for project evaluation."

Only four respondents expressed themselves positively about the review process, e.g.:

"The evaluation was OK and reasonable."

Partner search and the role of the partners

"Partner search was not easy, preparation of projects consumes a lot of time, due to big consortia, and support of the EU-Commission was not so good"

"It is difficult to find partners for SMEs."

"Participation in project: disappointed in the cooperation of some of the other partners and lack of enthusiasm to work together."

"It is very difficult to communicate with other members of consortium since we all come from very different backgrounds."

"We have difficulties stemming from language/culture differences."

"Although the partners in the research network were all willing to collaborate, it was still difficult to establish fruitful collaborations. This kind of interaction only started to work after two years and then there was only one year of funding left. In my view, longer-term networks will be more fruitful."

Management of a project

"Experiences applying for a project are very bad due to the non-professional paid coordinator within FP6."

“(EC) project officers insisted on complicated management structures."

"Project officers ask more questions than they are entitled to (micromanagement)."

"Self-management of projects is highly appreciated and should be kept in mind also by EC during running projects."

Funding

> "The cutting/negotiation phase of the contract is rather displeasing because it results in a lot of shifts in the internal politics of a group which just came together."
>
> "Balance has to be found between funding of excellence and fresh new ideas."
>
> "Funding must be freed more in advance in order to fasten project goals."
>
> "It is a splendid opportunity for EU collaborations and knowledge exchange, problematic for bodies that receive only 50% funding."

Project Specific Comments

With Integrated Projects (IP) and Networks of Excellence (NoE), the so-called 'new instruments' of FP6, it was generally felt that these projects are far too big. In contrast, Specific Targeted Research Projects (STREPs) were received well. With NoE often the complaint arose that rules and goals were not clear and changing in time. The experiences with Marie Curie Actions were generally positive:

> "These [new] instruments are too big so that they cannot be managed in an effective way and in our own experience the smaller national programmes are more focused and thus more effective when it comes to the production of results. The Networks of Excellence are instruments leading to the integration of research activities in Europe and not to the creation of knowledge. Industry cannot really contribute actively to this goal and it normally has an only passive role as an observer.
>
> "In general we have good experiences. However the change in strategic orientation between FP5 and FP6 was of the character of a paradigm shift. […] The "overweight" of IP's should be reduced in favour of medium and smaller projects."
>
> "The Instrument IP is not acceptable for small University Institutes and small companies."
>
> "IPs: far too complicated, no real added value compared to STREPs."
>
> "Good appreciation on STREPs which are the most "human sized" instruments."
>
> "Rule for NoEs changed with time. Originally these were supposed to be large scale networks with possibly 1000 scientists. Later the concept changed and only smaller NoEs were funded."
>
> "NoE concept is diffusive, too large."

Miscellaneous comments

> "Patent applications for academic institutions are practically impossible, because the costs of patenting can't be covered from the project budget when the project is finished."
>
> "Now the emphasis is too near-market. From a University perspective, these projects make a loss and may no longer be sustainable."
>
> "IPR is key issue; even more difficult with different industry sectors (e.g. pharma and ICT) within a project. The projects are demanding (more demanding than national programs)."

Proposed solution: Two-stage application process

Several respondents indicated that they are longing for a two-stage application, thus reducing administrative efforts. In this context, it should be noted that the EC has been using two-stage evaluation already in FP6 for the evaluation of 'new instruments' in the main part of the programme dealing with nanotechnology:

> "Initial proposals that are submitted to the EU frameworks are required to be much too long. Initial proposals should not be required to exceed 20 pages. The present procedure of proposal submitting is a nuisance that steals a lot of valuable time and resources from our European colleagues."
>
> "A lot of work to prepare a complete project, with reduced chances to succeed. Why not two preliminary steps? 1- A small report (20-25 pages) based on scientific propositions only. Then make an important selection. 2- A second proposal for the happy few, longer and more precise, with all the issues including gender and ethics issues..."

On the other hand, one respondent feared that the introduction of a two-step procedure would extend the time from call to contract, which he thought to be already too long.

Some respondents provided positive worded brief remarks like "Good" or "Sufficient" or other brief statements (22 in total): "Very positive experiences"; "Enriching experience"; "No problems"; "Good (financial) support"; "Quite efficient"; "Application procedure well prepared". Nine respondents emphasised in a positive way the international character of EC projects, mentioning the useful opportunity for networking and building new networks, exchanging knowledge and information, establishing contacts with private and public organisations, European co-operation, finding partners, and improving technical knowledge.

7 Infrastructure

7.1 Current situation for nanotechnology infrastructure

Infrastructure is widely viewed as crucial for carrying top quality R&D in nanotechnologies and bringing together researchers and entrepreneurs. We therefore asked respondents about the availability of such an R&D infrastructure in Europe for nanotechnology. To gain an overall picture, the question was posed: "Is there a coherent system of infrastructure for nanotechnology R&D ("poles or centres of excellence") in Europe that is competitive at world-level?" Very few respondents (4%) answered positively indicating that there is no European system of nanotechnology infrastructure.

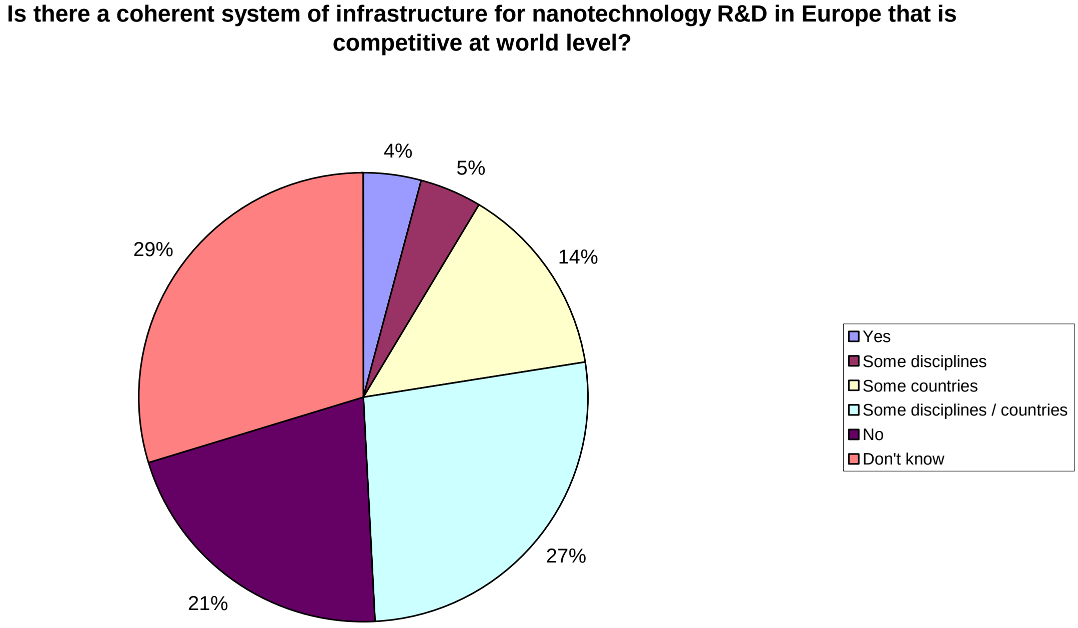

Figure 12: Opinions on the existence of a coherent system of infrastructure for nanotechnology R&D in Europe that is competitive at world level.

Many respondents believe there is a coherent system of such R&D infrastructure in some countries or disciplines (27% of all respondents), and 5% believed it exists for some disciplines. There are no significant differences in the responses per profile of employing organisation. One could infer that there are 'hotspots' for infrastructure in Europe for certain disciplines and/or countries and this will be analysed in more detail below.

In fact, the largest group of respondents (29%) did not know the answer which is either indicative of the number of non-specialists that participated in the open consultation or that there is a lack of awareness about nanotechnology. In any case, there is clearly a need to identify the available R&D infrastructure for nanotechnology in Europe and to assess whether this meets the need of the various stakeholders.

To investigate the situation perceived by those in certain countries, we compared the responses originating from the UK (133) and from Germany (150). There were sufficient responses from these two countries to make a statistical analysis meaningful. The German respondents were more optimistic than the British. This may be related with the different national situation. If Europe is to invest in new R&D infrastructure, it appears unlikely that a 'one size fits all' approach would be successful since the situation appears to be quite varied according to the country and/or discipline.

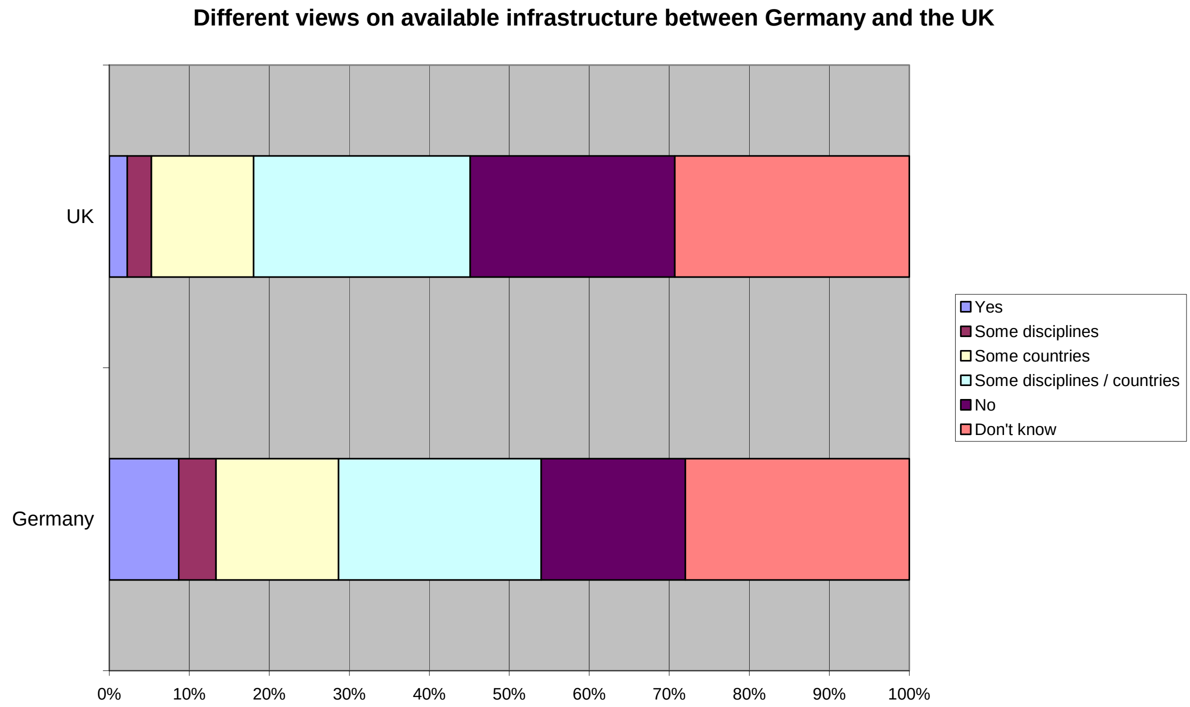

Figure 13: Different views on the availability of a nanotechnology R&D infrastructure from British and German respondents.

Several respondents provided additional information to support the answer to the above question. The majority of the 222 people who gave comments to this question believed there is a nanotechnology infrastructure in some countries (116) while 35 people believed there is an infrastructure for some disciplines, and 33 for some disciplines and some countries. 27 people gave comments on EU infrastructure, and five people commented on the absence of such a coherent system of research infrastructure. Three people criticised the idea of establishing an infrastructure for nanotechnology altogether.

Of the 116 comments on the existence of a coherent infrastructure in some countries, 16 individual countries were mentioned. In table 6, we list the numbers of comments on the existence of a national research infrastructure per country. Most people only mentioned countries with a good infrastructure or good centres, but some people commented negatively on the existence of such a research infrastructure in a country, suggesting that there is a differing opinion over what constitutes good infrastructure. Note that the numbers are not representative for all stakeholders, since one third of respondents came from the UK or Germany, and a smaller numbers from other countries.

Country	Yes, there is a nanotechnology infrastructure	No, there is no nanotechnology infrastructure
Germany	59	
France	33	
UK	33	3
Switzerland	15	
Netherlands	9	
Sweden	6	1
Belgium	5	
Italy	5	
Finland	4	
Spain	4	2
Ireland	3	
Austria	2	
Denmark	1	
Romania	1	
Russia	1	
Czech Republic		1

Table 6: Comments on national research infrastructure or centres per country.

In the comments provided by those respondents who believed there is a coherent system of nanotechnology R&D infrastructure in Europe for some disciplines, the following were mentioned:

- Nanomaterials (including carbon nanofibres, ceramics, nanostructuring of materials, functional polymers, nanostructured coatings, nanoparticles)
- Nanochemistry
- (Nano)electronics (including theory)
- Biotechnology/bionanotechnology
- Optoelectronics
- Nanoanalysis (including sensors)
- Catalysis
- Structural analysis
- High field magnet labs
- Scanning Probe Microscopy
- Ion nanobeam technology
- Nanolithography
- General physics, chemistry, biology/biotechnology
- Molecular motors
- Sol Gel technology
- Self assembly
- Pharmaceutical R&D
- Nano-aerosols at workplace

Several respondents believed such a coherent infrastructure is lacking for these disciplines:
- Metrology
- Interdisciplinarity
- Nano for biology and health

Some respondents commented on the availability of a coherent system of R&D infrastructure in other parts of the world. In this regard, Asia was noted as being very active in optics and coatings, while China and Japan are leading in carbon nanofibres.

Some people provided advice to the European Commission on the installation of new nanotechnology R&D infrastructure. This advice covers two aspects:

For existing centres:

- linking the infrastructure with industry,
- partnerships or joint ventures for industrial/commercial development of promising results,
- better public relations
- better dissemination and development of niche activities
- more cross-disciplinary infrastructure,

EU and national:

- coordinating national infrastructures at EU level,
- EU (or more national) funding for national infrastructures,
- opening national facilities to all member states,
- a one-stop nano-EU site for SMEs etc listing centres of excellence and large scale equipment
- fund visiting researchers to existing centres of excellence

EU framework programme:

- have another call for expressions of interest to identify the key areas for new EU infrastructure
- reserve funding for academics, not industry
- not only supporting centres of excellence, but also newcomers and less developed regions
- improve IPR rules in EU projects
- investigate how USA and Japan do it

Some general comments were “one of the open questions in this context [of infrastructures] is the issue whether “poles of excellence” should be built from scratch or by using existing facilities”. Two respondents highlighted that infrastructure is one of the most important factors to stimulate progress in nanotechnology. One cited the example “Think how much CERN meant for nuclear and particle physics in Europe!”

Several respondents warned against administrative burdens. Others were afraid the support for poles or centres of excellence would lead to the formation of closed groups, excluding newcomers or people who were not friends with the initiators. Some people did not see the need for specific or new nano-infrastructure. One respondent highlighted that the improvement of research infrastructures should place emphasis on the New Member States.

7.2 Needs for New Nanotechnology Infrastructure in Europe

Clear results have been obtained from the consultation regarding the appropriate level for new R&D infrastructure at European level. We asked: “At which level(s) should possible new large infrastructure for nanotechnology be established?” More than half of the respondents (56%) stated that the European level would be the most appropriate. A smaller but nevertheless significant number of respondents highlighted the need for infrastructure national (18%) and regional (13%) governments have a responsibility. It is interesting to note that of the 133 respondents from the UK only 44% believed this infrastructure should be developed at European level, whereas 61% of the 150 German respondents favoured European infrastructure.

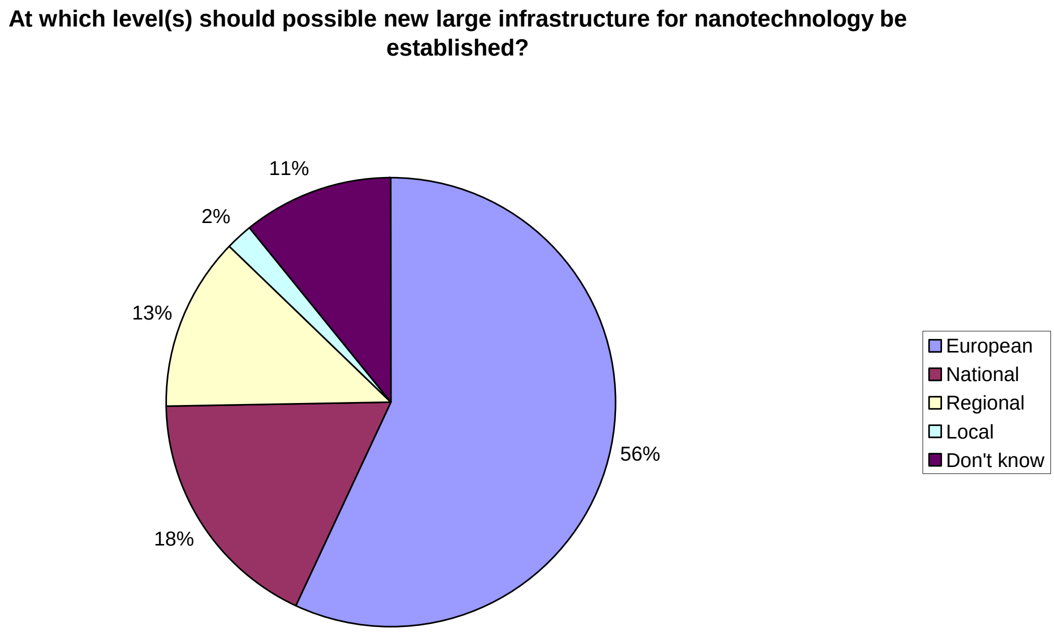

Figure 14: Preferred level for new large nanotechnology R&D infrastructure**.**

Before investing in new R&D infrastructure, the European Commission, governments and other stakeholder need to know what this infrastructure will be used for and the needs of potential users of these new facilities. We therefore asked respondents to rank five possible aims which might be achieved by investing in such R&D infrastructure. All options were considered crucial to important by more than half of the respondents. “To mobilise a critical mass of interdisciplinary researchers”, is most popular, over 45% thought it crucial, and another 40% important. “To gain access to unique equipment and facilities” ranked second, followed by “To set up networks of experts around emerging themes in nanotechnology”.

While most respondents appear to be viewing infrastructure from the viewpoint of academic research, a good majority also wants new infrastructure “to reduce the time-to-market from R&D to products”, or “to establish private-public partnerships”. These aims are more focused at technology transfer to industry and SMEs, and the uptake of nanotechnology in real products. As can be expected, the 373 respondents working in University/Higher Education institutes or public research centres were less interested in time to market reduction and private-public partnerships. The 167 respondents from large and small commercial organisations found time to market reduction most important, closely followed by the mobilisation of a critical mass of researchers. Access to facilities ranked third and the establishment of private-public partnerships and networks of experts followed last. It is clear that there is more interest in R&D infrastructure relevant for technology transfer to large and small companies among commercial people, than among public sector researchers.

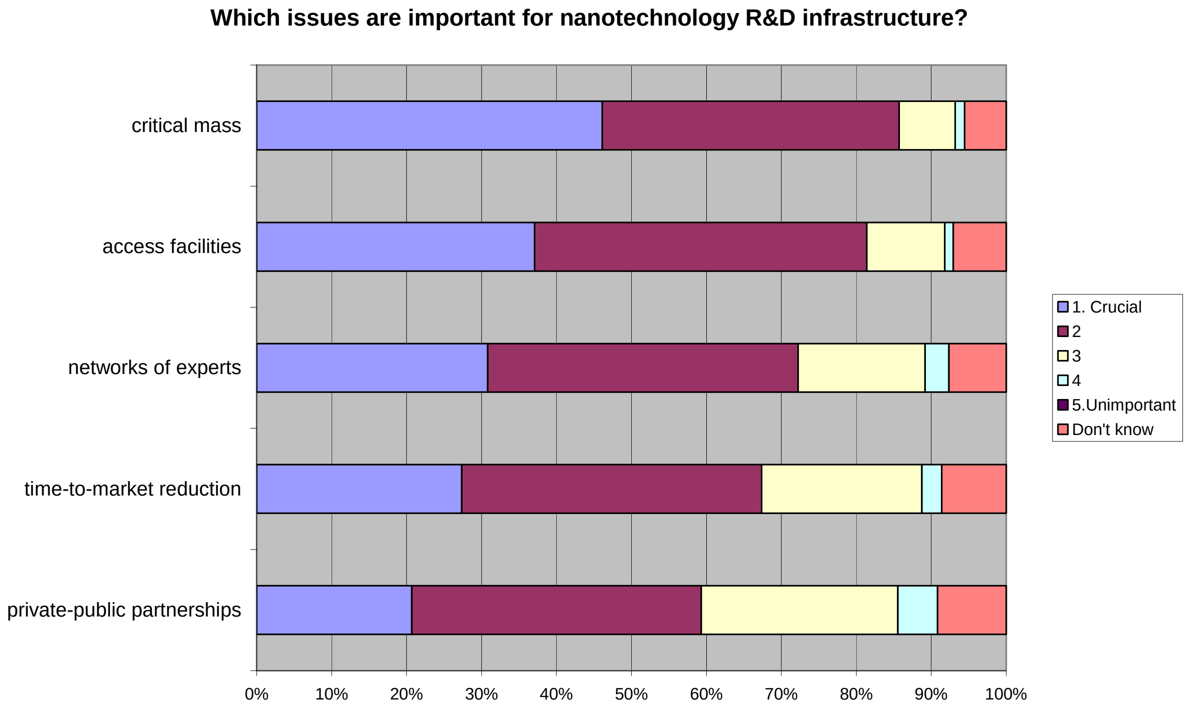

Figure 15: Ranking of the importance of issues for nanotechnology R&D infrastructure according to all respondents.

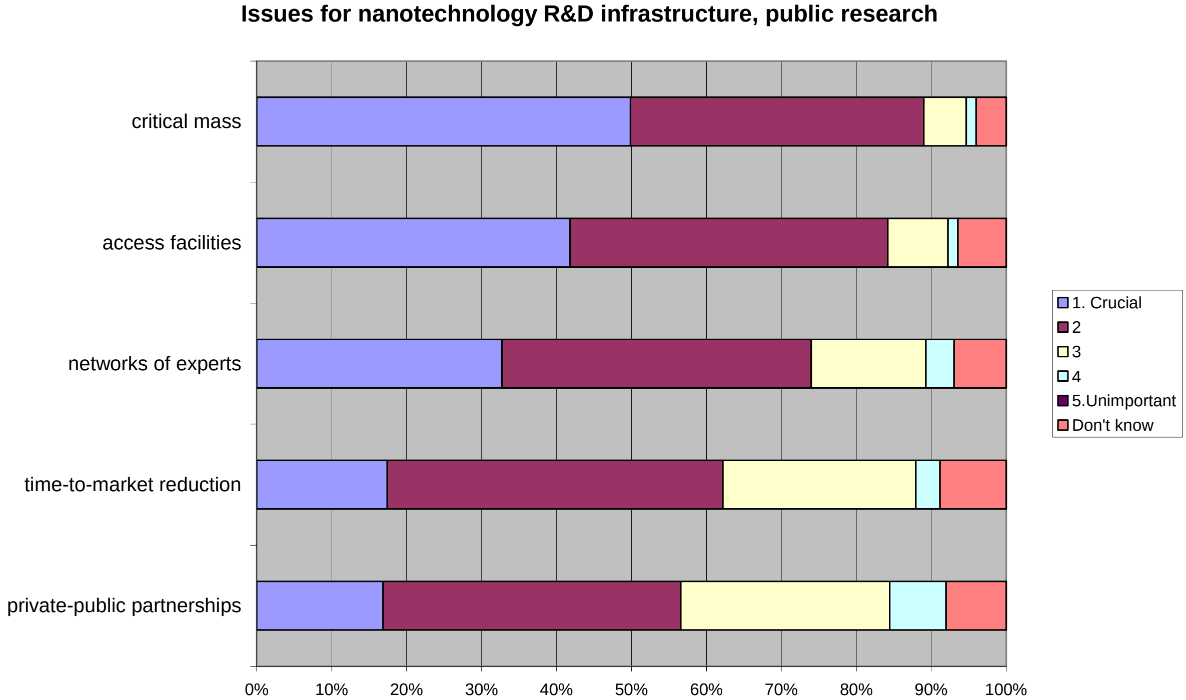

Figure 16: Ranking of the importance of issues for nanotechnology R&D infrastructure according to respondents in universities and public research centres.

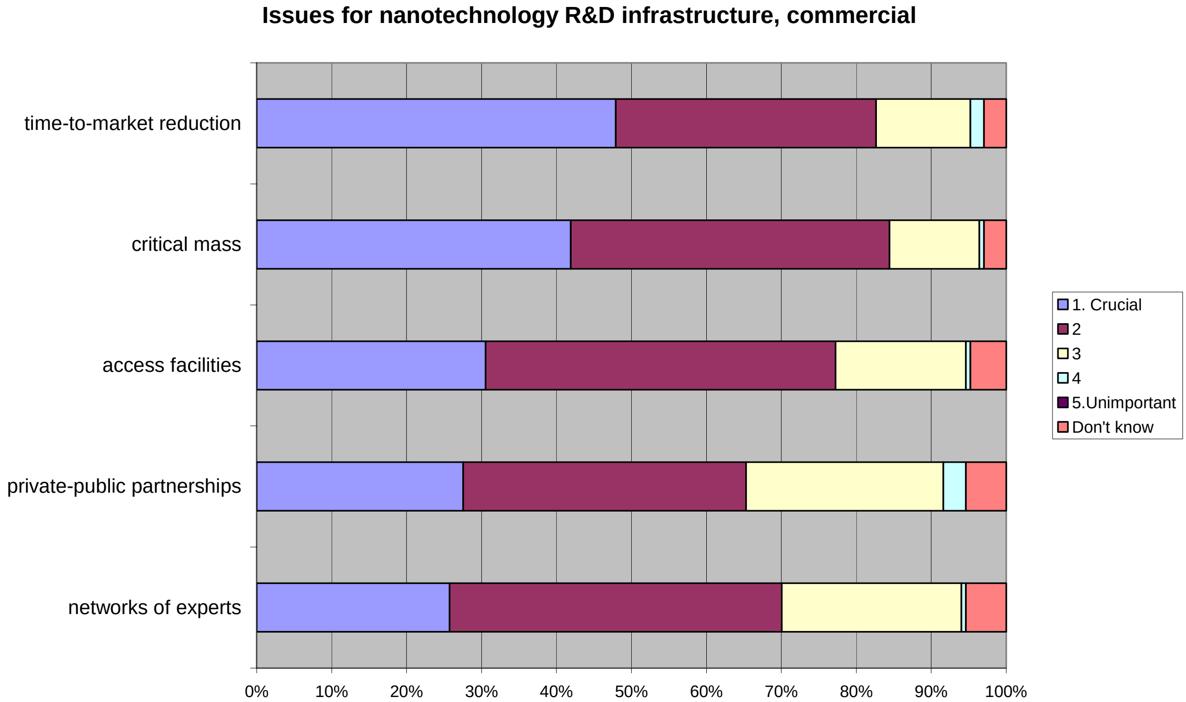

Figure 17: Ranking of the importance of issues for nanotechnology R&D infrastructure according to respondents in commercial organisations.

To conclude the section on infrastructures, we asked the open question: "Please indicate technological areas and market sectors, for which new nanotechnology-oriented infrastructure is needed, if any. How might these be addressed at European level?” Several technological areas and market sectors were mentioned. These were related to:

- Health/medical (83),
- Materials (78),
- IT/electronics (77),
- Manufacturing and Instrumentation (31),
- comments on priorities in FP7 (31),
- Bio(techno)logy (29),
- Energy (27),
- Environmental (19),
- Transport (16)
- Chemical (16),
- Risk assessment (13),
- Telecommunication (13)
- Metrology (11)
- Defence (6),
- SMEs (6),
- Technology transfer (1),
- Construction (4),
- Agro food (3),
- Consumers (4),
- Ethics and science communication (5),
- Finance (1),
- Optics (1).

In general, there were many comments in favour of new infrastructure, giving suggestions on organisational issues for future European research activities. These include:

- The introduction of any new nanotechnology-oriented infrastructure must ensure that it is easily accessible and responsive to industrial needs, helps to accelerate the R&D process, and reduces time to market. Business intensification is a crucial if European companies are to engender innovative enterprise, and beat the competition at delivering products/processes to the market place.
- Infrastructure is important but some fields do not require the same infrastructure as others. Some require clean rooms while others large computer connections. The policies implications are very different.
- Advancement could be achieved by creating European (Intra-national) Centres of Excellence, which include both basic and applied research capabilities and experts, with a high interaction level and access to direct implementation of basic research into small scale pilot/ testing programs. Such Centres could be funded and coordinated in collaboration with private European partners capable to apply in relatively short time the results of R&D first in small production lines, followed by mass production and distribution.
- Set up hub-and-spoke networks in individual countries that give rapid access to experts and facilities and then network the hubs at a European level.
- Big European Centres are good for the strength of some regions however the added value of these centres are stopped in their region, for that it is necessary to create smaller regional or national R&D centres.

- The interdisciplinary approach of nanotechnology needs scientist from all different disciplines to work together from the start. This cannot be provided on a standard university level. Institutes for integrated nanosciences should be necessary.
- Set up clearly identifiable centres of excellence within Europe which are networked together through projects. (and not connected for the sake of coordination) It must be project driven.

Several albeit fewer comments were also given against the creation of new nanotechnology infrastructure at European level:

- We don't really need an 'infrastructure' as such. Those working in the field already know what is out there in their field (or they should if they are good researchers!).
- I think that these already exist and you don't need to set up new ones simply to support existing ones.
- It is too early to establish which sectors will be most affected by the impact of nanotechnology. Development of ideas in basic research will be followed immediately by the development of infrastructure if needed. Nanotechnology should be clearly and will be less expensive and less infrastructure demanding than the classical approach.
- Local funding - efficient; European Centres - notoriously inefficient and bureaucratic.
- Infrastructure depends more on expert use than on large equipment and should be regional/local where qualified users/operators are concentrated. As nanotechnologies are multifaceted a single or few central European Nanotech facility are not productive. Preference should be given to regional centres with varying foci of expertise.

For **health / medical** applications of nanotechnology, respondents see a need for new infrastructure related to the following technology areas:

- **Pharmaceutical industry**
  - Pharmacology
  - Drug delivery
  - Drug synthesis
  - Therapies
- **Medical devices**
  - Nano-engineered bio implants
  - Tissue engineering
  - Biomedical imaging
  - Medical textiles
  - In vitro or in vivo diagnostics /analytical devices/ micro fluidics
  - Nano structure based radiotherapy
  - Interfacing living neural networks in vitro and in vivo

Respondents included several comments on the organisation of such an infrastructure at European level:

- Support for SMEs in the field.
- Better information exchange about results and studies
- More coordinated approach needed
- Addressed at EU level by research projects, and/or specific calls.

- Need: new interdisciplinary research facilities.

Other respondents gave more details about the topics and focus the new infrastructure for Health and Medical applications should deal with. These included basic research:

- The need for physicists and chemists with understanding of self-assembly to interact with molecular biologists and pharmacists is clear, and people are attempting to bridge that gap but a major effort along these lines would be very helpful.
- Basic knowledge of the processes at nanoscopic scale by theoretical and spectroscopic methods.
- Bio-compatibility issues.

Other ideas were specific for pharmaceutical applications:

- Dosing and testing of pharmaceuticals.
- Need to focus on key areas in biopharma and medical that could make a difference while increasing public understanding and diminishing some of the SCI FI publications in the press. Both need to be tackled if this area is not to unnecessarily scare the public.

Yet other ideas dealt with medical devices:

- Device design and development.
- Diagnostic of organic systems (viruses, bacteria).
- Infrastructure is needed for university research groups in the fields of biomedical engineering and development of medical sensors/diagnostic devices. On the European-level, additional travel expenditures on a single journey base could provide valuable support.
- Development of mimickers of biological tissue in a European data bank to be used for implants.

For **nanomaterials,** respondents foresee a need for new infrastructure in many different topics including:

- Nanoparticles (incl. magnetic)
- Nano-structured materials for aeronautic and space
- Mechanical applications
- Inks
- Nano-engineering
- Organic/inorganic interface
- Composites
- Processing
- Formulation
- Soft matter R&D centres
- Coatings (incl. lotus effect)
- (Electro)ceramics
- Fabrics coated to resist stains and control temperature, bio / technical textiles
- Carbon nanotube/fibres infrastructure for structural and electronic applications
- Biocompatible materials

- Nano-particle paint to prevent corrosion
- Mesoscopic materials
- Supramolecular structures
- Biomimetic materials
- Materials for MST
- Thin films, quantum wires, quantum dots
- Functional polymers
- Fibre based hybrids
- Metals

The following remarks were made regarding the organisation of a European infrastructure for **nanomaterials**:

- Interdisciplinarity and project-oriented approach are key.
- Successful commercially-focused scale up of materials/concepts taken from EU-funded academic research. Currently, risk is too high for a company to internally develop an untested material currently available in tiny amounts.
- More projects involving academic and industrial partners should be founded.
- Materials applications has a very bright future if there will be the necessary back up from the EU. There has to be an initiative that will promote technology transfer from research facilities to the European industry, by providing tax breaks to the industry and other motives to employ the emerging technologies.

The following comments related to production of **nanomaterials**:

- Problems associated with the production of nanomaterials. Transfer of R&D results from lab to industry.
- Fabrication of lateral nanostructures, fabrication of nanostructured bulk materials, fabrication of nanoparticles.

Some comments covered more fundamental issues related to **nanomaterials** research:

- Formulation - i.e. making different materials compatible with each other at the nanoscale - needs a forum on formulation at the European level.
- Coatings formulations and structural characterisation.
- Deposition or growth of these materials is critical and there is little support in this area. We are basically making do with what we have already. It requires a complete rethink on how we produce these materials and compounds.
- Supramolecular structures, displays, organic transistors, photovoltaics. Addressed by funding of networks including money for manpower (students and postdocs) and some equipment.
- Centre for investigation of electronic and optical properties of new organic materials, with ordering on the nano-scale.
- Something like the "Nanotechnology particle project" in Hiroshima, Japan.
- Research in the area of Molecular Nanomaterials should be significantly strengthened in the EU by creating multi-disciplinary research centres on national or regional scales. Chemists, Physicists, Material Scientists and Engineers should be working together on synthesis and study properties of new molecular nanostructures, and their integration and exploitation in the areas of electronics, quantum computing, catalysis, molecular machines etc.

Other comments dealt with infrastructure for making **nanomaterials** for specific applications:

- High-performance material systems for energy, sensing and construction, including bulk volume cost-effective production.
- Use of mesoscopic materials should be moved from lab to real use. Might be in catalysis or absorption etc. Look for electronic/optical devices that might be built from current nanotechnology
- Infrastructure is the "classical" microelectronics one, but open and devoted to new materials (their use is often impossible in existing equipments because of cross-contamination problems).
- Novel materials to avoid adhesion of dirt and dust on surfaces (i.e. windows), thus relieving not only daily household-chores.

For **information technology (IT)**, respondents asked for new infrastructure relevant to these diverse topics:

- Robotics
- Nano/bio sensors (quantum well, quantum dot detectors etc)
- Biochips
- NanoElectroMechanical Systems (NEMS)
- (Nano, micro)Electronics
    - non-silicon nanoelectronics
    - plastic electronics
    - opto-electronics
    - molecular electronics
    - photonics
- Computing:
    - quantum computing
    - DNA Computing
    - logic circuits
    - ASIC, FPGA
- Data Storage:
    - spintronics in magnetic QD technology
    - magnetic storage
    - non-volatile memory
- Displays (incl. OLEDS)
- Packaging

The following comments related to the organisation of nanotechnology for **IT** applications at EU level:

- Interdisciplinarity and project-oriented approach are key. See US "Nanotechnology Initiative" (nano.gov) / NSF as a model. Huge need for Private/public partnerships (ex: CNRT label in France, to develop exchanges between public basic research and private applied research in an attractive manner for students/researchers), and clusters (both network of excellence + SME/industries & investment funds)
- Networking regional nodes with pronounced and successful nanotechnology R&D and possibly industrial transfer.

Some respondents asked for infrastructure for more fundamental research in **IT**:

- For basic research of non-silicon based Nanoelectronics and Nanoelectronic hybrids for Microelectronics. They might be addressed as service centers at national level for equipment and technology (like in the US).
- Nanoelectronics will require increasing investments in infrastructures. Alternative technologies could benefit from common infrastructures to help synergy among researchers.
- Europe should aim for a few large nodes in nanoelectronics (LETI, IMEC) surrounded by a limited number of high-quality university labs.
- Molecular electronics the infrastructure needed is mostly new lithography methods at the nanoscale and analysis techniques like HRTEM. International cooperation should be increased with ``new instruments" which could complement the NoE.

Other respondents were more interested in infrastructure for applications of nanotechnology in **IT**:

- Nanosensors of various kinds (magnetic, temperature, biomedical, etc.)
- Sensor science for ALL market sectors - from healthcare to space stations.
- Plastic electronics: large scale cheap processing of nanostructured materials based on self-assembly
- Nanodevices development by university-industries support and collaboration.
- Electronic device fabrication.
- Optoelectronics will be one of the first volume markets in nano-semiconductors.
- Information processing and storage -the silicon-to-carbon interface: interaction between micro/nanoelectronics and the human body -micro/nanosensors and actuators in the widest meaning -addressing should be done in concerted actions between leading universities, institutes and the industry.

Respondents highlighted the need for infrastructure to enable **environmental** applications of nanotechnology for remediation and environmental protection (e.g. in the domestic environment). Regarding organisation of this infrastructure, they asked for "Support for SMEs in the field', and someone thought that these issues "could be best addressed by small STREPs.". A topic for such new infrastructure could be "Environment protection by substituting more and more macro technologies with well designed nano ones."

Infrastructure for nanotechnology for **telecommunications** should focus on:

- Nanophotonics for chip scale optical networks
  - Nanowires
  - Quantum communication

Infrastructure for nanotechnology for **defence and security** should focus on:

- The topic of smart dust;
- Quantum computing / security / one EU reference lab.

Infrastructure for nanotechnology for **nanobiotechnology** should focus on:

- Nanobiotechnology
- Biophysics
- Nanosystems biology
- Protein chips
- Artificial viruses,
- Nano-bio-robots,
- Genetics

The following comments related to the organisation of **nanobiotechnology** applications at EU level:

- In general nanobiotechnology is a true multidisciplinary area that requires the non traditional grouping of biologists, chemists, physics, etc.
- The infrastructure's administrative centre should be located at a specific research centre where major resources should be delivered. In addition the structure should include a net of satellite labs in different countries and a programme of mobility for those researchers adhering to the initiative.

Comments on topics that require new **nanobiotechnology** infrastructure at European level include:

- Nanobiotechnology basics
- Medicine and Biology need centres that coordinate systems biology and computational biology approaches. One kind of European support centres should be "Nanosystems Biology" that focuses on novel (nano) techniques required for systems biology
- Pan-European centre for biological samples examination and manipulation - using the most advanced instruments and expertise. This could be achieved with the collaboration with the manufacturers who clearly have an interest in it.
- In the area of nanobiotechnology a lasting infrastructure is needed to ensure a critical mass in interdisciplinary research.

Infrastructure for nanotechnology for **chemical industry/ chemistry** should focus on:

- Catalysis
- Filtration
- Surface chemistry
- Nanochemistry
- Self assembly

The following comments dealt with technological topics of infrastructure for **chemistry**:

- More fundamental understanding of catalyst structures and catalysis mechanism in chemistry is essential. The use of molecular modelling for the design of catalyst molecules is paramount important and needs to be better addressed at a European level
- Surface chemistry groups integrated with biological / biochemical / cell biological groups. This can be achieved by providing support for specific local collaborative projects and expanding those that prove successful.

- Self - assembly of materials fabrication of micromechanical/nanomechanical probes handling and manipulation on the 1-10nm scale.

Energy:

- PV cells
- Alternative energy production and storage
- Fuel cells and nanopower sources to power electronics and vehicles
- Nanoenergetics (new fuels, enhanced propulsion)
- Renewable energy production systems
- New kinds of electrical generators, and coolers
- Lithium batteries
- Nanodielectrics

Transport:

- Automotive
- Hydrogen based vehicles
- Aerospace
- Filtration
- High speed trains

Aerospace:

- Combination of priority areas NT and Aerospace
- Development of space exploration projects (new materials for environmental control and life support systems under harsh environments)
- Space miniaturization for exploratory probes

Manufacturing and instrumentation

- Micro/nanoreactors
- Ion beams (incl. direct nanopatterning)
- Electron beam mask less nanolithography
- Analytical equipment
- Controlled self-assembly
- Powder synthesis & processing
- Nanomaterials characterization
- Technologies to visualise the nano world

Some specific comments on topics for nanotechnology infrastructure for **manufacturing**:

- Manufacturing of nanostructures and nano based products; integration of "nano" into systems.
- Simple nanotechnology production plants and test plants, pilot infrastructure with excess for those who are involved in nanotech projects.
- I think the main gaps are in scaling up from lab bench to development/pilot scale in order to provide enough of a product to satisfy product development cycle.
- Provision of access to expensive nano rapid prototyping and manufacturing facilities.

- The take up of nanotechnology for traditional industrial sector, which were and still are the creators of wealth in EU.
- New process technologies and large manufacturing sites for economy of scale.
- Equipment for nanohandling e.g. carbon nanotubes
- Manufacturing systems for good control of quality in nanoparticulate and nano-scale materials. Focus on equipment\facilities for research should include the capability of making as well as testing\analysing.
- Investment and facilities in the area of Molecular Manufacturing and self assembly (which require a strong interdisciplinary approach).

Metrology

- Nanomeasurement devices
- Nanometrology and associated equipment companies
- Calorimeters
- Scientific, engineering and ethical standards and metrics
- Instrumentation on nano research and metrology.
- Controlling infrastructures, labs networking, calibration and validation of research protocol.

Risk assessment

- Nanotoxicology
- Health aspects of nanopowders
- Analysis of risks of nanoparticulates already in circulation; life cycle analysis of products with respect to nanoparticle release.
- Detection of nanomaterials for workplace and environmental safety. Deduction of standards and procedures thereof

For applications in **construction,** these comments were made on topics for European infrastructure:

- Cooperation of construction companies, material producers for construction and centres of investigation in materials should work together on the development of applications of nanomaterials
- Energy-saving coatings for building applications (large area applications with many long-term implications for the environment & society comfort) In order to address this, a strong consortium must be built with increased scientific work, faster exchange of relevant information.

Consumers

- Cosmetics,
- Foods,
- Paint and inks,
- Personal care products
- Sports
- Life style

Agro food:

Agro food was cited as an important sector in relation to societal problems like cost of healthcare and improving the standard of living for an increasing number of older people. Not very many research institutes address this field of application so there is still room to set up a strong infrastructure around a pole of excellence.

Optics

- Lighting
- Nano-optics

8 Human Resources

Clearly there is an urgent need for development of nanotechnology education and training. Almost one-half of the respondents foresee a shortage of qualified personnel needed to advance nanotechnology within 5 years, and another quarter in 5-10 years. Only 8% does not believe such a shortage of personnel will ever occur. One fifth did not know if and when there will be a shortage of personnel for nanotechnology. There are no significant differences between respondents from public research organisations and from commercial organisations.

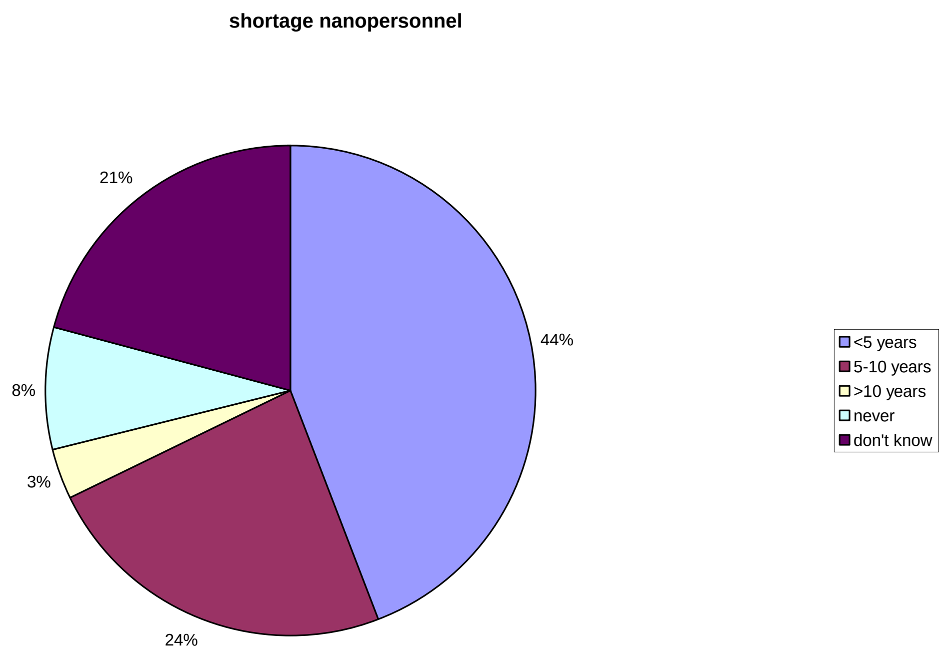

Figure 18: Expected occurrence of a shortage of personnel trained in nanotechnology.

The contents of this education should not be limited to natural sciences or engineering, but also cover practical skills. Five skills were given which might be considered important for the nanotechnology community and all were rated crucial or very important by more than half of all respondents (Figure 16). Interdisciplinarity is by far the most important, crucial according to almost two thirds, and crucial or very important by over 90%. Awareness of societal issues and communication/presentation skills came second and third, followed by entrepreneurial skills and interpersonal /management.

The above analysis was repeated with a segregation of the results according to the type of organisation in which the respondent is based. Those from commercial organisations ranked awareness of societal issues and entrepreneurial skills as almost equally important with around one fifth considering both as crucial and around half very important. Communication/presentation ranked fourth and interpersonal / management came last again. Apart from the small shift in position for entrepreneurial skills, the background of the respondent does not appear to have a significant influence on the responses.

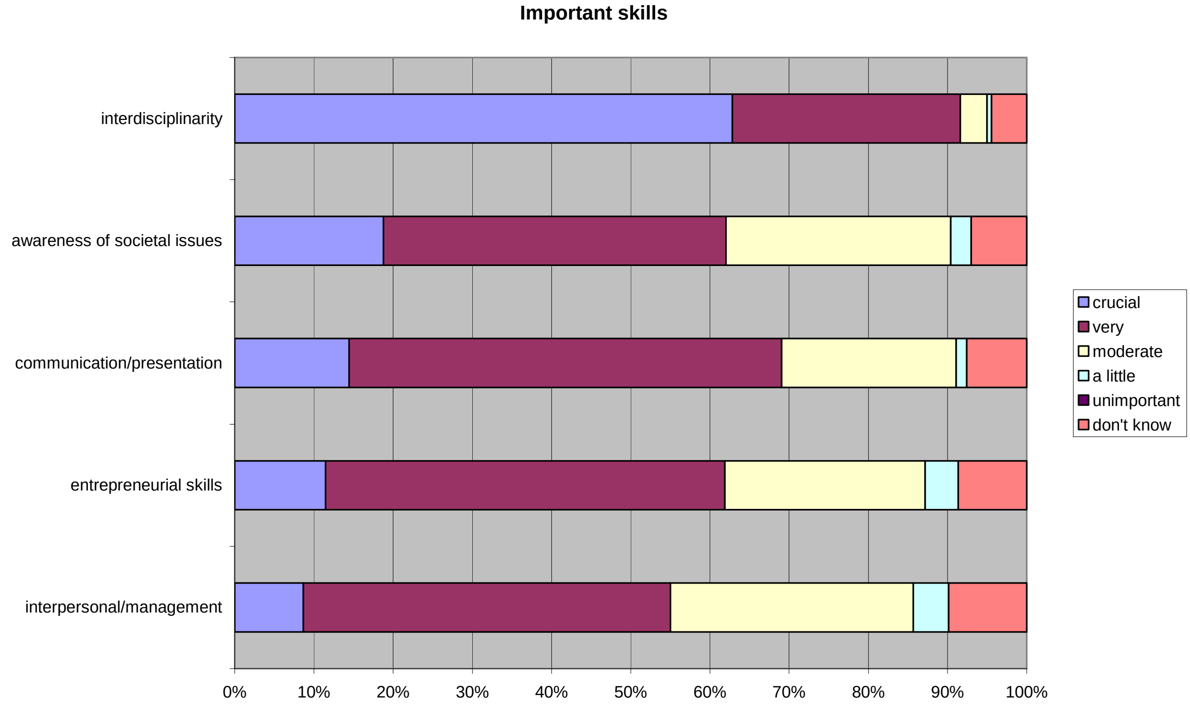

Figure 19: Ranking of important skills for nanotechnology personnel according to all respondents.

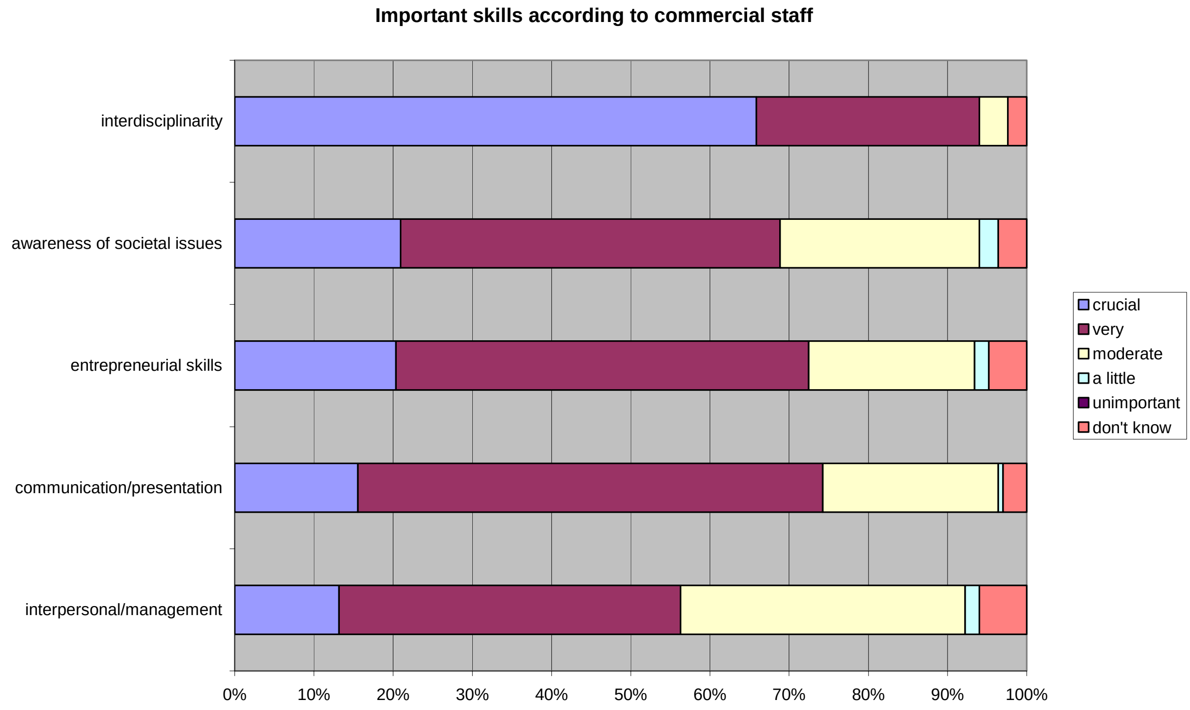

Figure 20: Ranking of important skills for nanotechnology personnel according to respondents working in a commercial organisation.

Together with funding research, the European Commission aims to achieve some science policy aims. In the context of human resources, these aims include equal opportunities for women, mobility for researchers, improving careers in research and further training opportunities for established researchers. In the survey, we found the following support for these three aims. It should be kept in mind that the majority of respondents are probably male (even though we did not ask about gender). All three aims were considered (very) important by more than 50% of respondents. Mobility of researchers is most popular, with over 80% finding it important including almost 40% very important. Further training opportunities follows close behind, with almost 80% important including about 36% very important. Equal opportunities for women scored about 55% important including 20% very important. None of the respondents found any aim unimportant.

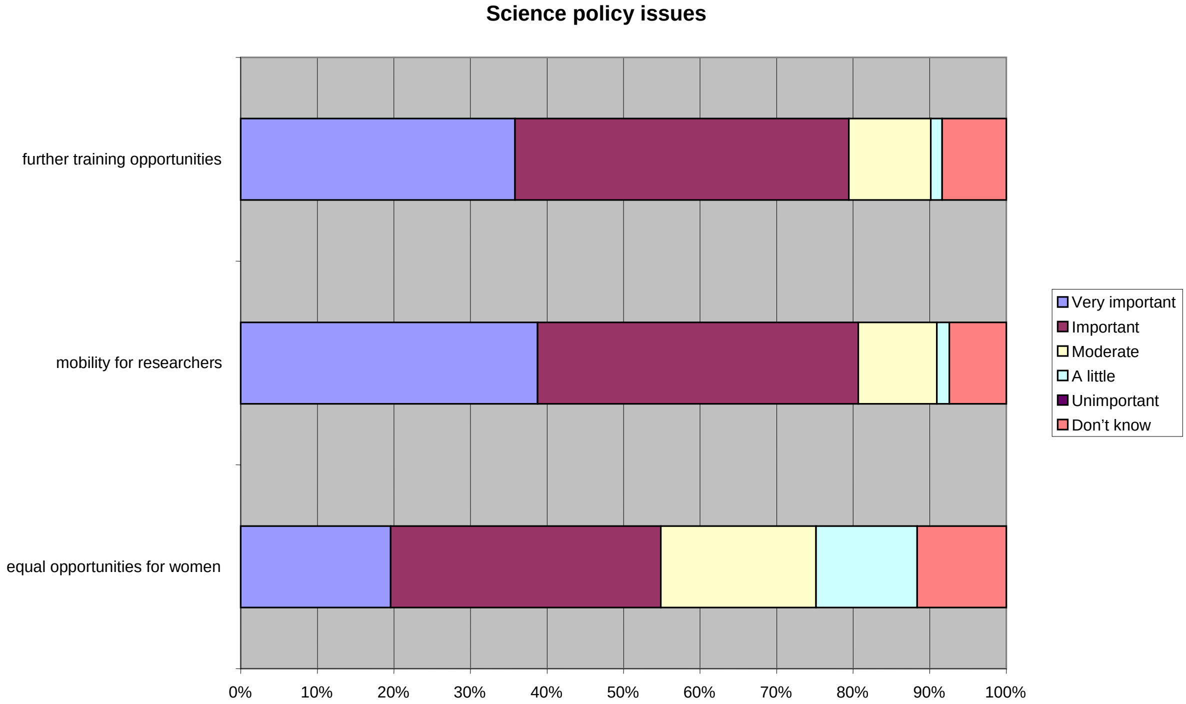

Figure 21: Opinions on the importance of some aims of the EU science policy.

To conclude the part of the questionnaire on education and training we asked: "What other actions do you think should be launched at European level to improve education and training in nanotechnology?" and received one or more suggestions from 318 respondents. Not all responses dealt directly with education or training. Respondents found the career perspective of scientists, mobility and integration of education in research projects and industry all important enabling factors for building up a good nanotechnology workforce.

Detailed suggestions were received from 110 respondents including:

- Events (31)
- Mobility (USA, Japan or inside EU) (54)
- Industry hosts (4)
- Network / internet platform (21)

There were several concrete suggestions:

- European Level graduate schools and research exchange programs that enable skilled students to learn from the best people in the field. Programs could be established that allow students to "consult" world experts in their field to specific questions

- Virtual education (internet based) in special courses on certain topics (e.g. nanobased smart materials)
- Support mobility of individuals to study Nanotech at different institutes.
- Continue Marie Curie Research Training networks, but remove unnecessary restrictions on nationality and salary scales, do not prescribe the mix between pre- and post-doctoral researchers and have four year scholarships rather than three years
- Creation and inclusion in the program of training of students of universities of special rates on nanotechnology.
- European based fairs and technological research based conferences to exchange news and facilitate the entrance into this new technology.
- Euroconferences and summer schools are in my opinion the best and most cost-effective tools which also foster valuable informal international connections
- Organisation of further conferences with a Commission support and publication of proceedings in a reasonable time span after the conference

Some 95 reactions dealt with the contents of a nanotechnology **curriculum**:

- Basic natural sciences (16)
- Nano courses (40)
- Interdisciplinary (only natural sciences or including social sciences) (27)
- Enterprise skills (7)
- Applied research (1)
- Filtration (1)
- Integrate education and research (3)
- To emphasize on the interdisciplinary approach, starting from the pre-college level education to university and mostly post graduate level. Stronger Research Institution-Industry collaboration (via 'poles of excellence')
- Nanoscience requires interdisciplinarity and teamwork. It may be taught at a degree level but it is far more effective if scientists are taught one discipline first. They therefore have something to bring to the table. So nanoscience is best taught at a graduate level. Scientists would also benefit from certain enterprise skills
- 1. Residential practical courses (>1 week) on specific topics held at Centres of Excellence. 2. Briefing meetings on 'hot' nano topics for industry 3. Post-doctoral fellowships to encourage young researchers to move across discipline boundaries ('discipline hop')
- European dual diplomas should be encouraged by an increased funding of young scientists (PhD students and Post-docs)
- Awareness of the researcher of possibilities for utilisation, i.e. EU should provide framework to create this awareness of researcher and for full coaching about and easy access to IP issues
- Integrate training in ethical, legal and social implications of research into education of scientists and engineers.

Some 68 responses dealt with the issue of **public perception**:

- Science communication (34)
- Outreach to schools (27)
- Prizes/contests (5)
- Referendums (1)
- Stimulating scientific culture, diffusing science awareness in democratic participation

- Support of further publications of the type “Nanotechnology – innovation for tomorrow’s world” which I find extremely useful
- Public understanding of the subject, with new multi-media tools to assist this
- More communication like news letters, workshops, being more present in daily/weekly "good" newspapers
- A Nano -Mobile that drives trough Europe PR Campaigns
- Involve NGOs (2)
- Call a contest for the best schoolbook in nanotechnology
- Training camps for children demonstrating the principle methods in nanotechnology with basic large scale hands-on models may be mobile on a truck or so...
- Use European sporting events to promote science and technology. Get young people interested in science early on.
- Addition of a nanotech subject to the curriculum of all schools
- Improving the teaching of natural sciences at the elementary school level.
- Frequent referendums to update technological progress
- Educational program should include a fair and objective vision of hopes and hypes and driven by a multilevel body which should involve all stakeholders including advocacy group and NGOs

There were also 56 people concerned with how to **institutionalise nano-education**:

- EU institution (10)
- Networking R&D centres (5)
- Local clusters/poles (3)
- Centres of excellence (16)
- Network trainers (1)
- EU harmonization of education / best practice (19)
- Fund newcomers (2)
- EU Institutes for nanotechnology. The establishment of a European Nanotechnology Laboratory (comparable to the EMBL, of ESRF type, like CERN) Establish a European Centre for Analysis with the best possible equipment that money can buy and highly paid permanent staff to maintain and use the special equipment over long periods of time, should be run like ESRF or similar large scale European facility
- To set-up a physical (not virtual) centre of excellence with direct partnership of industry and apprenteships/4 year outplacements of leading universities.
- Better networking of R&D centres.
- Industrial emulation near universities/centres of excellence and reciprocally (clusters)
- Centres of competences, which do have links to universities
- Induce creation of 5-10 regional centers for nanotechnology with some overlap making use of existing skills, infrastructure, couleur locale etc.

Providing more funds for the establishment of individual research groups, managed by a senior researcher and containing 3-5 experienced international researchers. […] This funding scheme is similar to the "Marie-Curie Excellence Grants" but with more funds focused on nanotechnology.

- Establish a European Qualification for nanotechnology
- Harmonisation of educational levels across Europe - this will lower mobility barriers; general EU-guideline for the education programmes in the fields of nano-disciplines are missing

- Scientific advisory boards should be created on the European level with high ranked experts from R&D as well as universities. More competitiveness needs to be implemented. European ranking of universities and national research centres.
- European prizes for educational programmes.
- European master in nanotechnology managing by a virtual centre of excellence gathering key partners (universities and research centres / institutes)
- Since there is little competences for such teaching NoE should be used to organize training programs at European level
- Central body - equivalent to USA's NSF's NNI - with Government backing and support

It goes without saying that nothing works without funding. 42 people commented on **funding for education**:

- For undergraduates, PhDs, postdocs (25)
- General issues (15)
- Longer term funding (2)
- In the information age, nationals should not be forced to migrate to pursue their discipline of excellence. Young researchers need to get more stable positions in the country of their choice in order to maintain a continuous and vigorous strand of work.
- You won't achieve success on a very short time scale; I think the TMR and related schemes have been (largely) successful and should continue to be funded; again I believe you should support established excellence and particularly those networks that have world leading academic and industrial track records.
- A good follow up of projects already funded through efficient monitoring and strong involvement of organisation to get the best impacts of the efforts in EU.

Some 33 people were concerned about **bureaucratic issues** which hamper the development of education and of the permanence of a nanotechnology workforce:

- Brain drain (2)
- Cut red tape (8)
- Scientific culture (3)
- Scientific career (13)
- Women (2)
- Nanolaw (1)
- Risk dialogue (3)
- Definition (1)
- There is a huge lack of available professorship/tenure track positions in academia for young talented scientists all over Europe. As such, more funding, more possibilities, more academic positions should be made available to young scientists willing to pursue an academic carrier in nanotechnology.
- Key point is recognition of educated people. Today, it is difficult to find goods students interested in "hard sciences" because they know the possibilities for them will be larger if they follow "Business/Management" oriented studies.
- Many academic environments in Europe are closed structures and do not make it easy for individuals from different countries to establish careers in others. This does not encourage the sort of wide scale interdisciplinary work that is needed.
- Re-integration of female researchers that have quit because of family reasons.

Types of students/ education which are most needed were covered by 21 respondents:

- Industry staff (7)
- Vocational (3)
- Permanent education (3)
- Training (8)
- More courses could be encouraged at MSc level for training researchers but we also need more basic level courses 1-2 days courses to help industrialists realise what is going on
- Development of 'standard' teaching modules, specifically aimed at graduates already in employment, which can be validated and delivered by local Universities giving Masters level qualifications.

Academic-industry collaboration needs to be incorporated in nano-education according to 21 people, including for:

- SMEs (6)
- Industry-academic exchanges (15)
- Funding for learning by doing for start ups SME/industry spin offs in cooperation with university
- More flexibility for young and motivated researcher to combine academic research and product development.
- Combine scientific content with entrepreneurial education (if possible at all); provide means for young entrepreneurs to initiate business (access to facilities, free time of staff for start-ups etc.)
- Promote creation of consortia public-private with common technical and scientific facilities and agreement to share and exploit findings among different applications and commercial partners; activate university courses about nanotechnologies.

Education needs **new publications**, according to eight respondents:

- Journals (4)
- Catalogue of courses (2)
- Books (2)
- Re-establish a publishing medium that competes with the supremacy of US journals, e.g. by strongly supporting financially when European scientists publish in European journals
- To improve the understanding of nanotechnology among the students, good textbooks on this subject should be published.
- A European Journal of Nanotechnology would also be very good.

Finally, nine respondents saw **no need for specific nanotechnology education**:

- None. This is the province of the educational establishments in the member states and they should be taking on this role. The EC can provide useful educational documents such as 'Towards a European Strategy for Nanotechnology' which can be used to inform both the governments of member states, the general public and, especially, children.

- If the technology thrives into industry then training will follow. Existing R&D engineers will do the work the first years; they are qualified to adopt the technology, with their existing basis.
- No specific ones at all. All these issues are generic weaknesses of the EU innovation system.
- Nanotechnology does not have special requirements in these regards. All science needs flexible, mobile, interdisciplinary researchers. In most physical sciences, at least, recruitment of talented Europeans is challenging.
- Teach everyone what the truth is the only reason this unnecessary technology is being pursued is for corporate greed purely on a profit basis and is not needed at all!
- None, just make it clear that national nano-centres have enough possibilities to participate to European projects, training and education will self-organize
- Interdisciplinary approach to solve complex problems is needed - the sole re-naming of universities and their courses to encompass the word “nano”, does not adequately meet the requirements for education.

Finally some general comments:

- With regard to the question of inter-sectorial mobility, one respondent commented “In many European countries, university professors with experience from industry are seldom appointed nowadays. It is therefore not surprising that the gap between the private sector and the universities is increasing instead of getting smaller”.
- One respondent stated that “anticipating the possible pace and intensity of the emergence of “new jobs” today (defined as new combinations of competencies corresponding to new economic activity) is of primary importance for the development of specific educational programmes to accompany traditional teaching” citing business creation as an example of a specific programme.

9 Industrial innovation

This section assessed the perceived importance of a policy on nanotechnology for industrial innovation in Europe. About 85% agreed including over 40% strongly with the statement "An integrated strategy is needed so that Europe can maintain its competitiveness in relation to other countries." Over 70% agreed, including around 30% strongly, with the statement "Established European industries run the risk of not recognising the potential of nanotechnology early enough and losing competitiveness".

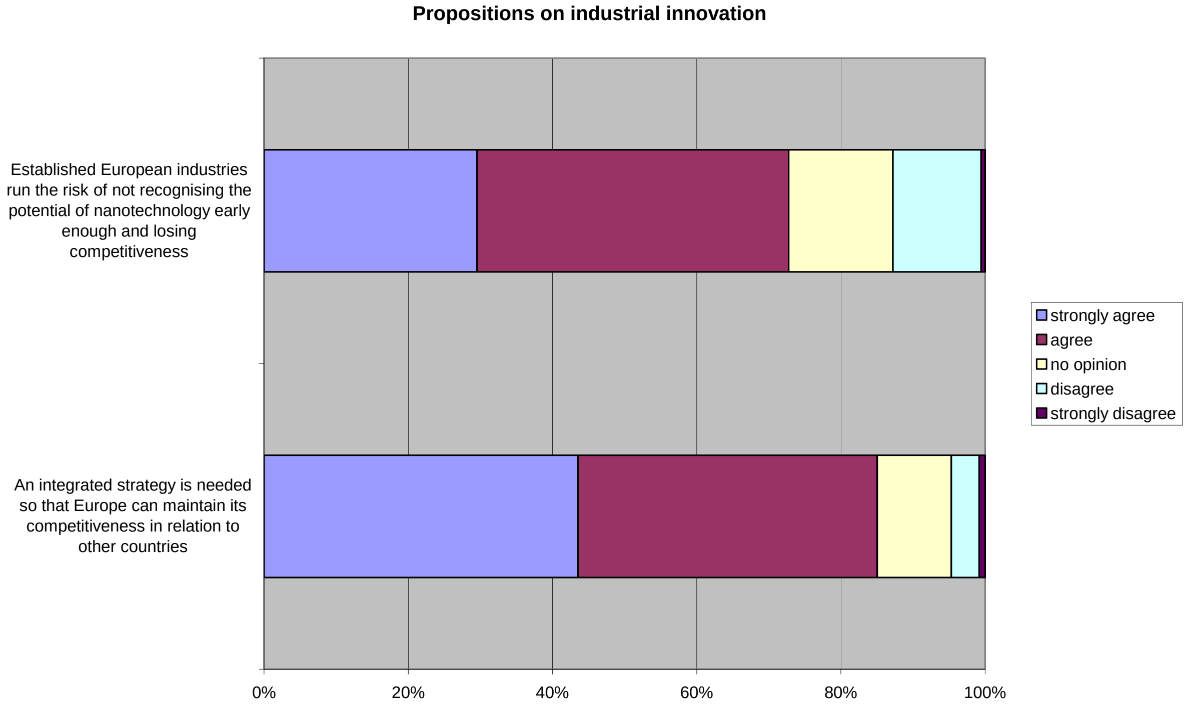

Figure 22: Responses to two statements on European innovation.

However, regulators cannot afford to sit on the fence either. "To ensure confidence from investors and consumers, regulation of nanotechnology is needed" within 5 years, said 46% and 25% believes this will occur in 5-10 years. Only 5% expects this need to emerge after 10 years and 8% never (Figure 23).

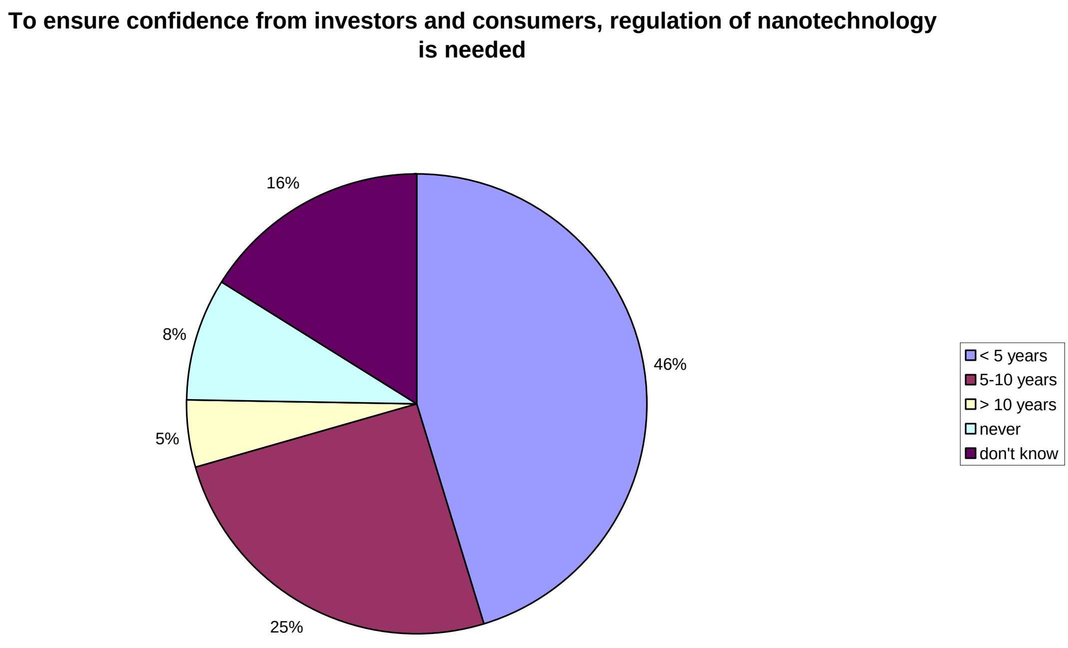

Figure 23: Attitude of all respondents to the source of regulation

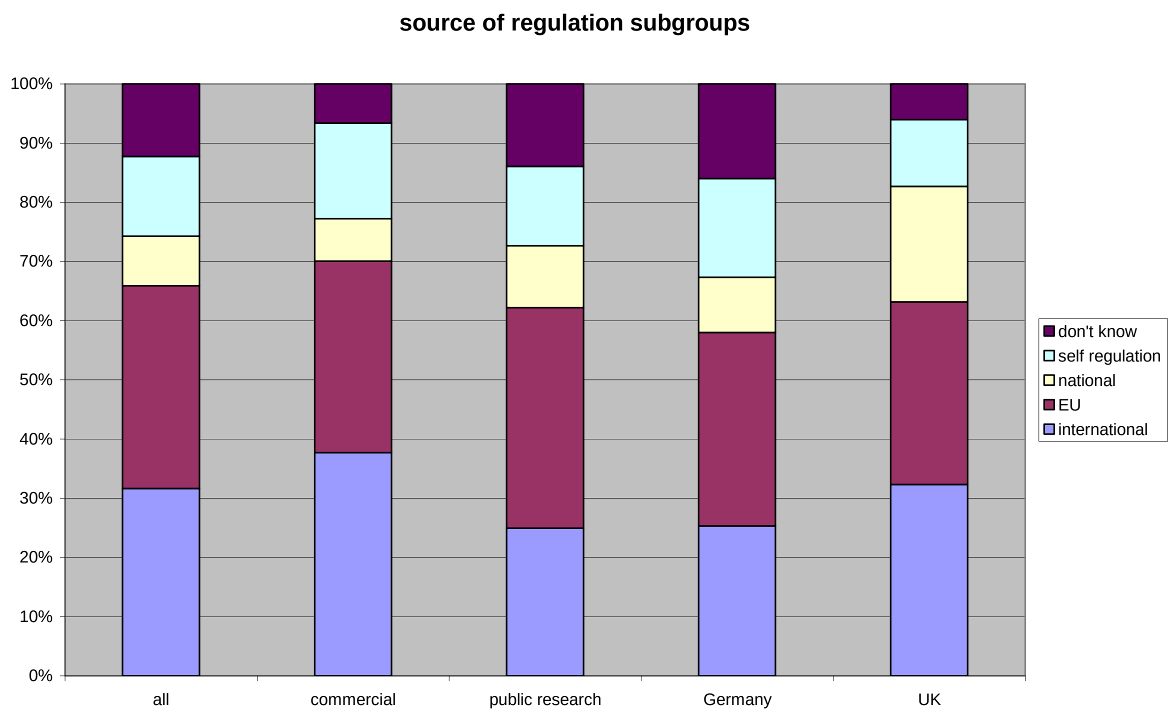

Figure 24: Attitude of different subgroups to the source of regulation

Around a third of respondents believe regulation of nanotechnology should come from the EU, and another third believes that international regulations are better. 13% believes self regulation by the market to be sufficient to deal with nanotechnology, 12% does not know who should regulate, and only 8% wants national governments to take the lead. There are significant differences between public researchers and people working in large or small companies. The academics have most confidence in the EU, whereas almost 40% of industry staff is in favour of international regulation. The latter are also slightly more confident in self regulation by the market than the academics. There are also national differences among the respondents. The two countries with significant numbers of respondents to allow statistical comparison, Germany and the UK, demonstrate clear differences in trust in international regulation and their national government (see figure 24).

Another set of questions dealt with the needs of SMEs and start-ups companies active in nanotechnology R&D. Respondents were asked to "Rate the importance of the main difficulties that are faced by SMEs and start-up companies active in nanotechnology R&D".
The lack of highly skilled personnel was given top priority, followed by cooperation with universities and research organisations. Access to public funding at EU/national level and private investment ranked third and fourth. Low cost knowledge protection and access to large industrial partners/clients were also considered crucial to important by over 60% of respondents. Management support, uncertainty about potential risks and public acceptance and lack of nanostandards were considered less important.

When answers from 109 SMEs and self employed individuals were considered on their own, these were found to differ from the general consensus. Highly skilled personnel also came first on their wish-list, but public funding clearly came second, followed by private investment and cooperation with academic institutions only fourth. Management support scored higher than nanostandards for these companies. The SMEs and self employed themselves were considerably more certain of their responses than other respondents. Whereas between 15 and 20% of all respondents answered "Don't know"; this was less than 8% for SMEs and self-employed.

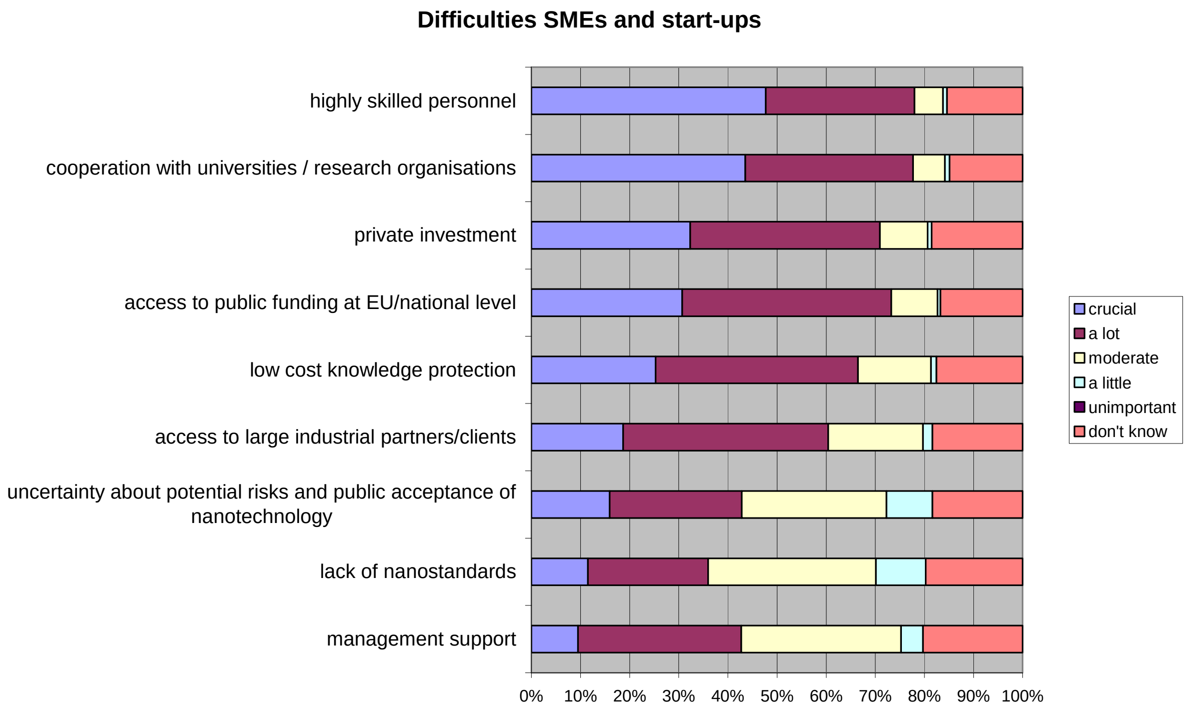

Figure 25: Rating the importance of the main difficulties that are faced by SMEs and start-up companies active in nanotechnology R&D.

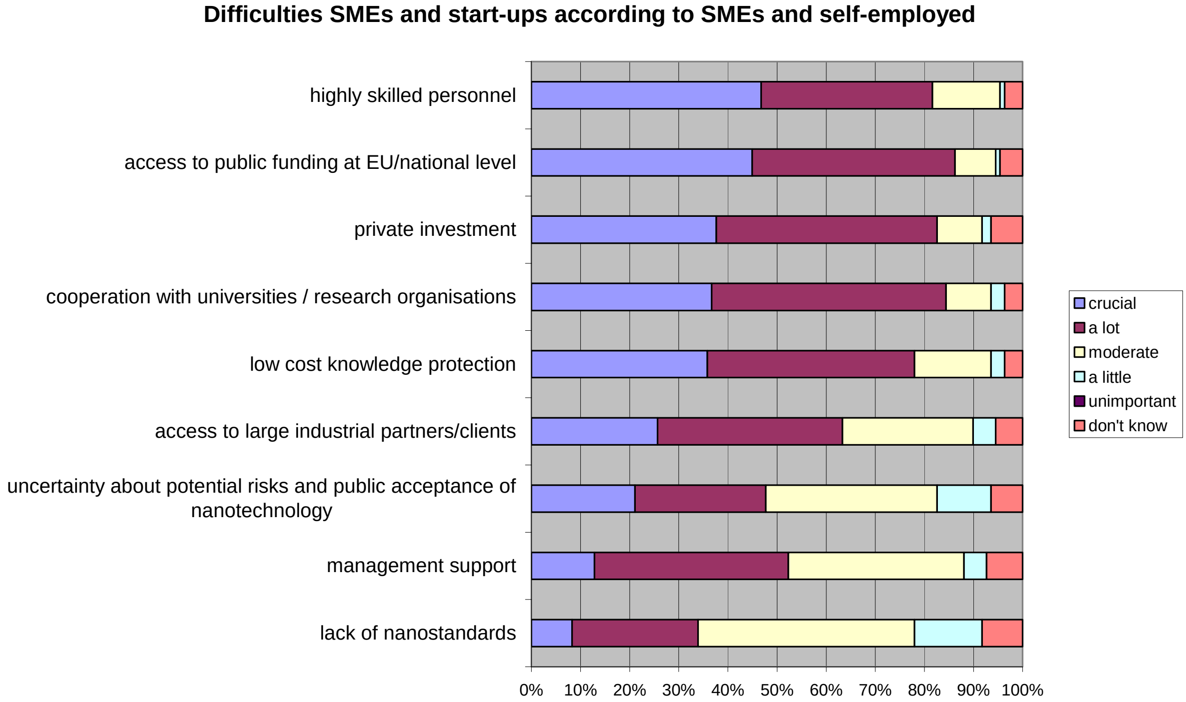

Figure 26: SMEs and start-up rating of the main difficulties that are faced by SMEs and start-up companies active in nanotechnology R&D.

Some 27 respondents suggested other main difficulties faced by SMEs and start-ups active in nanotechnology R&D. Three comments dealt with difficulties in collaboration, five considered the long time to market a barrier for investments, two complained about bureaucracy, five discussed public perception and risks, four were concerned about the academic culture, two saw costs as a bottleneck, three asked for more basic research, and one did not think there is anything specific for nanotechnology. One person did not understand the question.

Collaboration (3 respondents)

- Understanding the real costs of collaboration.
- Lack of trust.
- The organization of production chains with SMEs is the most complex activity to organize.
- Access of results obtained to improve impact in SME.

Time to market (5 respondents)

- Expectations of the return by investors are much too short term.
- The long time frame for NT to be significantly important for applications makes it difficult especially for SME to keep at it.
- Market acceptance (diffusion) of novel technologies.
- Few applications and long time between R&D and applications.
- Time scales/horizons of investors and politicians.

Bureaucracy (2 respondents)

- Crucial: low entry-barriers from administration point-of-view (national level, academic institute level if company is a spin-off) to start a nanotechnology-focused company.

Public perception (5 respondents)

- The perceived risks associated with nanotechnology are the same as those posed by chemistry (a significant part of nanotechnology) and the area is thus not a new frightening one but a natural development of a long established field.
- Availability of truth and realistic information - no hype.
- Education of public: from understanding to acceptance.
- Lack of understanding about the potential toxicity of nano-particles, and the impact on developing countries of appropriation of production methods by well-financed industrialised nations.

Culture (4 respondents)

- Entrepreneurial leadership at universities.
- Immobility, not moving fast enough.
- There are highly skilled persons in different disciplines, but too few who see the benefits of crossing disciplinary boundaries.
- Entrepreneurial spirit of the European scientist and subsequent mentality in public/private sector.

Costs (2 respondents)

- Cost of analysis.
- High investment in research is necessary comparable to the pharmacological market.

Basic research (3 respondents)

- Time is missing to go far into basic research.
- Must all research be couched in terms of its market value? A naive view, perhaps, but I become more and more frustrated by the increasingly prevalent view that scientific research is of no value unless a product is delivered to market...
- Nanotechnologies arise from high level scientific research. Such research level is only accessible to universities, academic start-up, and large companies.

Not new (1 respondent)

- So, the usual for any high-tech start-up.

Question unclear (1 respondent)

- Comment: the question is not clear; I mean with "less important", that it is less important as difficulty but important in itself.

295 responses were received to the question “What actions do you think should be launched at European level to encourage the industrial exploitation of nanotechnology?” Some of these covered several issues. Stimulating public private or other collaborations ranked by far the highest (71 times), followed by public funding and private investment (62), stimulating SMEs and spin-offs (47), public perceptions (35) and priority setting (33). Some more practical issues were also covered such as developing products and demonstrations (21); reduce bureaucracy (18), patenting and IPR issues (17), education and training (17), regulation (16), risk and safety (15), setting up centres of excellence (11). Some concrete suggestions included:

Cooperation (71) incl. Public private collaboration (64)

- Meetings between research organisations and enterprises to improve communication between them.

- Efficient structures of technology transfer and technology licensing out.
- Industry-Institute partnership in evolving projects with defined objectives.
- Dissemination of knowledge (industry itself has to find the importance of nano).
- Encourage the exchange of personnel from industry to academia by payment of salaries for up to two years.
- Promote industrial participation in EU projects (e.g. by increased funding rate in high risk (concerning success)long-term research)
- Structuring of expert teams, experience of researchers that may be included in actual projects, funding structures.
- Provide funds for 'proof of principle' experiments. These grants can be held jointly by an academic and industrial partner. These would be small-scale projects at the outset and could explore 'blue skies' topics that some companies might initially be too conservative to fund.
- Engagement of all major companies, both manufacturers and suppliers since the potential disruptiveness of nanotechnology is pervasive.
- Coordinate member states activities and investment in nanotechnology. Develop a pan-European, industrially-driven, strategy on nanotechnology which then forms the basis of investment in this area. It is crucial to identify the markets that will benefit from nanotechnology before deciding on investment strategies in this area.
- Catalyse extended science and engineering (S&E) networks which bring different segments of the European academic and industrial community together through panel review, technology assessment, advisory committees and roundtable activities. These collaborations provide benchmarks, leadership and information on new frontiers and market needs for research, technology and education into nanotechnology.

Funding (62) incl. public (35), private investors (27):

- More funding of nanotechnology projects, at least at STREP level. More funding for mobility and combined industrial- university research. Support of starting enterprises.
- Ensure that the natural sciences (e.g. chemistry) and engineering (e.g. chemical engineering) are well funded in Europe. This in turn will ensure that highly-skilled personnel who are capable of working in interdisciplinary teams are readily available for deployment in industry.
- Government co-investment with venture capital ('risk sharing') 2. Support for universities/research institutes to collaborate with industry.
- Keep investors up to date in nanotechnology's possibilities and limitations.
- A low tax rate in case of investment’s in nanotechnology area.
- Support European and Swiss venture capital fund specialized in nanotechnology
- Encourage European Financial Institutions to invest in innovation, especially nanotechnology, and to allow easy access to such funds in order for industry to take calculated risks in the nano-sciences.
- Make the EIF easier to use for VC investments.
- Encourage investment of pension funds to nanotech

SME / spin-off (47)

- Defining Standards, Consulting and Information programmes for SME’s about the use of nanotechnology.
- Make funds readily available to SMEs who interact with leading research groups in a R&D project. Full funding up to product availability, but with an 'investment angle' to final profits.

- Similar schemes to the US SBIR in order to provide some funds for more speculative risky projects.
- More and non-bureaucratic assistance to SMEs, intensified information exchange.
- Make regional centres for nanotechnology open to SME's. Infrastructure is crucial for these companies.
- Fund STREPS at 100% for SMEs.
- Create some special fund for universities (in addition to already existing EU funds in this area) from which arise the start-up companies in nanotechnology, so it will be on the universities to support in fact their products and their students at the beginning (as in the U.S.)
- The organization of production chains with SMEs is the most complex activity to organize. The cooperation of design houses, developers, manufacturers, special consultants, and special lab services for nanomaterials has to be organized. Also special equipment has to be developed and produced. To realize this all is a complex organization. Activities should be directed at industrial exploitation under the restriction of avoiding potential risks.
- Involve specialised (even small) companies in R&D public/private consortia to look for fast exploitation of the results, with special granted license agreement (e.g. few years at discounted fees; supporting labs for quality-reliability-health verification; reduced submission costs for shared patents...)

Public perception (35)
- A campaign to make the general public understand the potential benefits versus the potential drawbacks/health risks & grants to encourage research in the area & the commercialisation of promising new technologies.
- A combined skills public perception institute that could also handle the regulation of nanotech so that there is a holistic approach.
- A series of popular lectures on principles and applications presented particularly on TV.

Priority setting (33) incl. Focus (20), Strategy development (13):
- Encourage clusters; identify best practices and special opportunities. Focus efforts on ruptures (technology push)
- Target research financing to a clear long term plan.
- General level: Knowledge generation on diffusion, adoption and implementation processes within general innovation processes regarding nanotechnology. 2. Operational level: stimulation of awareness of the business implications of nanotechnology (instruments: scenarios; business roadmaps)
- A critical market study for the next 5 and 5-10 years, respectively, with clear distinctions for small, medium, and large enterprises
- Launch of European Programs on specific themes from the basic research to the industrial applications (for example: European Program on hydrogen related R&D or European Program on Self Assembly Materials .....)
- Establishing of: incubator-groups / think tanks, public-private partnership programmes, monitoring groups (industry)
- An in-depth review of the business models employed in traditional industries as well as in high-tech sectors (such as biotechnology) could be used to determine which models best favour nanotechnology-based start-ups.

Products, demonstrations (21)

- More concentration on products than on basic research
- First users' action (high level of funding for small user company that uses nanotechnology for the first time.)
- Success stories. Coaching by experienced senior managers of big companies.
- Strengthening of research programmes which will likely lead to commercial prototypes.
- Demonstrations and show cases which tell about today's products and not science fiction.
- In general, researchers in the academia should be made aware of the current commercial demands on nanomaterials, nanoelectronics, nano-medicines. Industrial laboratories could help researches in academia to characterise properties of the novel materials and to help them to find applications.
- Stronger integration of nanotechnology R&D with "public works" projects - gearing technology R&D to implementable solutions of societal problems, thus integrating commercial viability and consumer demand from the start.

Bureaucracy (18)

- Helping break down barriers to gaining access to individual countries research to make it available across the whole of the EU.
- Make the application for funds and receipt of funds happen faster. Perhaps money could be allocated at national and regional levels, for enactment - i.e.: one body for all sources.
- SMEs still have big problems to participate in FP (very difficult situation with bank guarantee!!)

Patenting/IPR issues (17)

- Realise a strong, affordable and harmonised IPR regime throughout Europe. This can be done by introducing the Community Patent and/or strengthening the European Patent System. The costs of applying for and maintaining a patent must be made cheaper in Europe compared to the US and Japan.
- Easier negotiation of IP, one of the biggest problems is often the negotiation of consortium agreements. There also often problems with multinational companies which have a strong presence in Europe but are based in USA. These are sometimes classed at non EU and therefore are not eligible for funding and so drop out of European research projects.
- Have an EU level body concerned with patents - ideally (for me!) researchers could contact them, provide the material, they could handle all the patenting issues, and could be partly or fully self-funded by taking a small percentage of income from the resultant patents.
- Change the patent laws to be in line with those of the US. I.e. you can publish and still protect IP retrospectively. Current UK patent laws make IP exploitation extremely difficult in start ups/SMEs compared with the US.
- Some kind of academia-industry 'IP and know-how transfer fair or web-site' could be helpful, if connections made at that place are followed up with some kind of EU exploitation support scheme.

Education and training (17)

- Operational level: integration of the phenomenon nanotechnology in current educational programs (bachelor / master) on technology and business.

- Marie Curie type actions, but where the mobile personnel are taken from industry and placed in a University for a certain period.
- Education of companies which are potential uses of nanotechnology products. Support for new companies should be mid term.
- During education mix for some classes engineers and scientists. - put on a same site science and industrial facilities.
- European standards for education and training (ECTS/VET)

Regulation (16)

- Review existing regulation to take into account the impact of nanotechnology rather than develop new regulation in this area. It is also vital that a common international (not just European) approach is adopted to ensure a level global playing field.
- Early indication on which areas of nanotechnology will be regulated at all and if so, how.
- Regulation & classification of the nanoparticles (considering the nanoparticles as a new substance with new properties)

Risks and safety (15)

- Demonstration that they are safe for the workers of this sectors
- Ensure that nanotechnology is safe
- Clearly determine its possible impact on health to prevent rejection from people (c.f. problems with genetically modified plants now).
- Studies about potential risks and safety of nanotechnology (nanoparticles and nanotubes).
- Standards Group for HS&E
- Suitable strategy to evaluate risks, as industry is concerned about liability issues which may follow unforeseen negative effects of the new materials

Centres of Excellence, infrastructure (11)

- Organise local centres of excellence with scientists of all European countries
- Nanofabrication R&D centers

Negative (11)

- None - more basic research is needed
- 'Actions' as such are not needed. More articles in the public press, more high visibility demonstrator projects, more accurate assessments of the technology (and the time frames involved) are what are needed.
- Redistribution of most of funding to local levels in the EU.
- Nanotechnology is already exploited by industry. The industry will not jump on any "nano" development unless it will bring substantial product improvement/new markets and economic gain. No specific actions are needed just let the market work efficiently.

Applied research (8)

- Establishment of special instruments which promote applied research and transfer into products
- Needs more applied research to bridge the gap between the potential advantages offered by nanomaterials and new applications/products.

Basic research (7)

- By the time an area is identified and funding agreed, innovation has moved on. So no actions targeted towards industry, The EU should foster the science on a long-term basis.
- Industrial exploitation will appear by itself when the R&D community will present facts which will attract the investors. The present nanotechnology hype is not convincing investors and commercial partners because the field is still in the beginning.

Events (7)

- Conferences focusing on the exchange between academia and industries, including special symposia, closed meeting (access after signing a confidentiality agreement).
- Special workshops liked to special markets

Standardisation (6)

- Enhanced support for pre-normative research and standardisation
- Development of nanotechnology definitions and standards
- Standardisation R&D cannot be effectively undertaken within larger non-standards related projects, such as Integrated Projects. It was pointed out that “with dedicated normalisation actions, as with the former SMT programme of FP5, projects could and should have a direct connection to the relevant standards body”. It was their opinion that “the absence of such a programme could seriously frustrate European industrial development”. Another participant noted that motivators were needed to ensure ‘necessary confidence’ in metrology for the safety and ecosafety of nanotechnology applications.
- Respondents stressed the importance of measuring at the nano-scale, nanometrology, and standardisation. The Commission can propose mandates to CEN, CENELEC and ETSI with the objective of establishing international references in the framework of the ISO (International Standards Organisation). The urgent need for nomenclature as a common reference vocabulary for nanotechnology was stated.

Manufacturing (5)

- No industry will radically discard their present production methods to turn to "nanotechnology". The manufacturing of nanotechnological products should thus merge or being compatible with the present facilities.
- As stated before, it is in the transition from lab-scale to development scale, especially for materials where the problem lies.

Career (3)

- Secondments. Career prospect improvement for PhDs
- Help more young researchers get stable positions in the country of their choice in order to maintain a continuous and vigorous strand of work.

Competitiveness (2)

- Industries exploit if given the opportunity. It is important that healthy competition and accountability is established through governance by independent non-partisan bodies so that quality and integrity of product and information is maintained.
- Reduction of labour cost, discourage moving to China.

Literature database (1)

- Start a public (scientific public) accessible literature database.

10 Integrating the societal dimension

Recent studies have shown that the awareness of nanotechnology among the general public is not very widespread but it features in an increasing number of science fiction movies. In the wake of controversies surrounding new technologies, most recently genetic modification, there is the possibility that nanotechnology will receive a similar public reception. While the political debate about the societal aspects of nanotechnology has started, one may ask if this debate is considered to be important by people with an interest in nanotechnology. If so, who should take the lead in public awareness rising of nanotechnology?

To the statement “Europe needs to take account of the potential risks and societal impacts associated with nanotechnology at an early stage”, over 75% agreed including almost 30% strongly. Only a small minority of respondents, less than 10% disagreed with this statement. There appears to be a broad consensus that potential risks and societal impacts must be taken seriously. Most of the respondents also find communication and dialogue important. To the statement “Without a serious communication effort and dialogue with the public, nanotechnology will face a negative public reception”, almost 70% agreed including around 28% strongly. At the same time, more people disagreed: almost 20%.

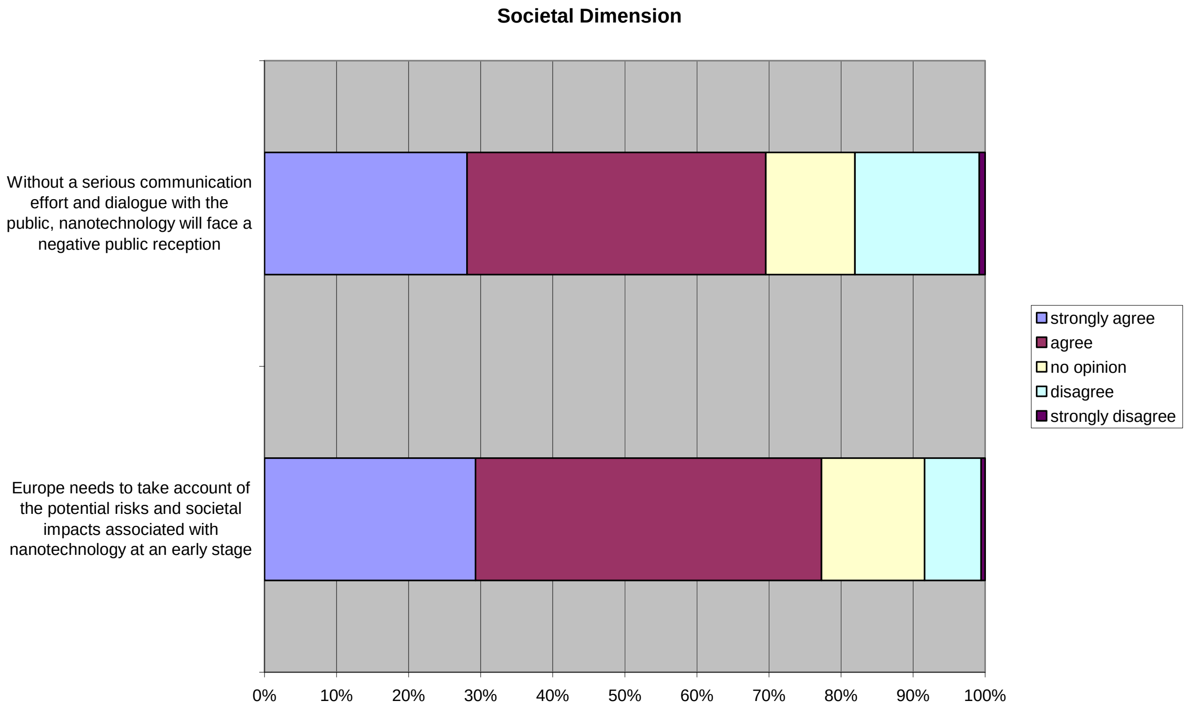

Figure 27: Importance of integrating the societal dimension.

Respondents were asked "Who should be more active in providing information on nanotechnology to the general public?" Most people thought that research organisations should take the greatest responsibility in providing information on nanotechnology (22%). Academic researchers were slightly more in favour of this than industrial respondents. However, they agree to share this responsibility with national /regional governments and the media (both 21%), and with the European Commission (19%). Industry has a responsibility according to 14% (17% of industrial respondents) and 3% want others to get involved. National differences may be important, as demonstrated by the results of German and British respondents. The Germans see information more as a task of governments; whereas more British respondents think industry and research organisations should take the lead.

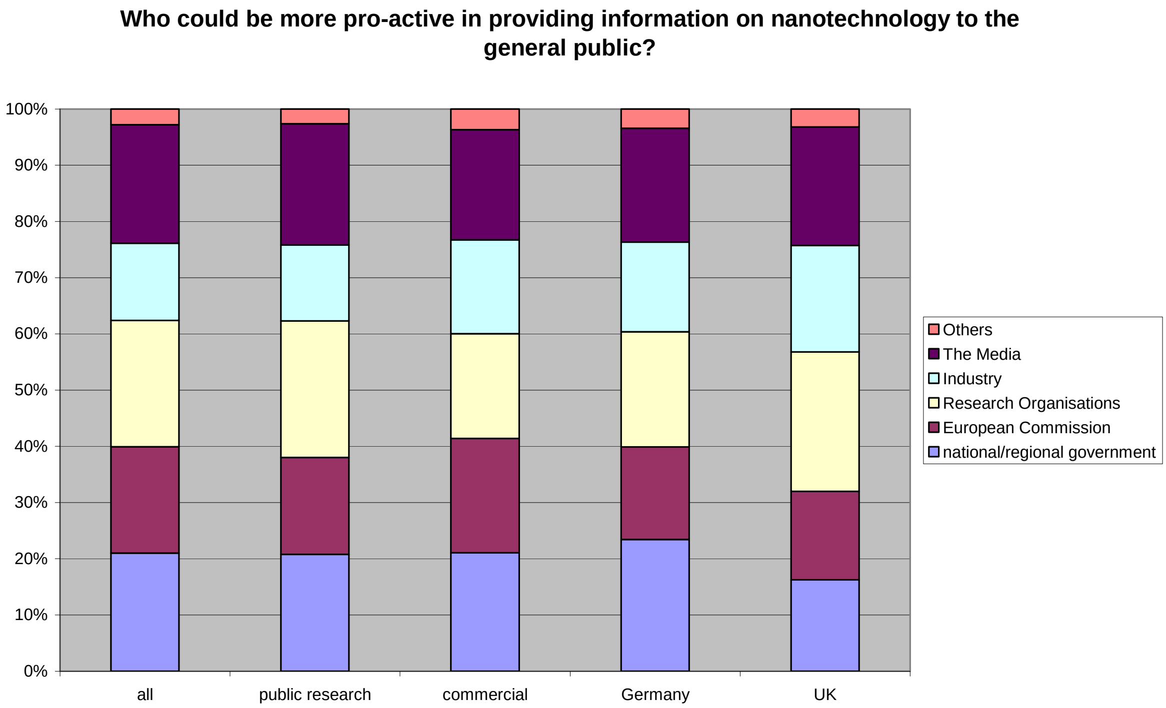

Figure 28: Responsibility for informing the public about nanotechnology.

Of the 68 respondents who mentioned other participants that should play an active role in communication and debate (i.e. those not included on the predefined list of options), by far the most popular were individual researchers, universities, networks or learned societies (22). Other organisations included NGOs, educational institutions or schools, and professional science communicators were also mentioned, as well as government bodies, social scientists, the media, SME's and health organisations.

Researchers, universities, networks or societies (22)
NGOs (9)
All (8)
Education / schools (7)
Independent organisation(s) (6)
Science communicators (5)
Governments (4)
Nobody (3)

Social scientists (2)
Media (1)
SMEs (1)
Health organisation (1)

Some general comments on the social dimension were provided:

Two participants welcomed the recognition in the Communication of the need to involve the public and the intention to enter into dialogue as a means of taking their views into account for decisions concerning R&D policy. On the other hand, the same respondents note that there appears to be limited integration of this concept in, for example, discussing R&D priorities and funding in terms of investment and economic growth. One respondent highlighted the importance of collecting information about nanotechnology which is understandable for the public.

Three respondents supported improving raising awareness of the nanotechnology among the public e.g. “the public be better and thoroughly informed about all aspects of nanotechnology!” One respondent went on to say that “public funding will only be given to nanoresearch and development that looks for solutions to today’s problems, which have to be defined in the first place, with the participation of the public”. One participant stressed, however, that a more deliberative process of public dialogue and engagement is better since “the Communication seems to suggest that wider public concern may be simply managed by the more effective communication of nanotechnology”. In this context, two participants highlight the importance of learning the lessons from the experience with genetic modification.

One respondent noted that “an innovation is by definition, the disruption of an existing concept. Therefore, the disruptive nature of nanotechnology may be relatively fierce and may have the ability to cause unpredictable social and economic diversities, contradictions and tensions on a regional, national and worldwide scale”. One participant urged, in the context of potential military applications, the “determined decision to interrupt the future nanotechnology applied in neural implants”.

On the subject of realising the potential benefits of nanotechnology, one respondent highlighted that “in the absence of mechanisms to distinguish between ‘good developments’ and ‘bad developments’ with reference to societal objectives fosters the impression that so long as nanotech develops its commercial potential then it is all good news”.

11 Public health, safety, environmental and consumer protection

In the Commission's Communication, emphasis was placed upon ensuring that applications of nanotechnology adhere to the highest standards of public health, safety, environmental and consumer protection. With the statement "Investigation and assessment of health or environmental risks associated with nanotechnology should be integrated into the R&D process at the earliest possible stage, 76% agreed including 30% strongly. Only 11% disagreed. Research into environmental and health risks of nanotechnology clearly has a high priority according to the vast majority of respondents.

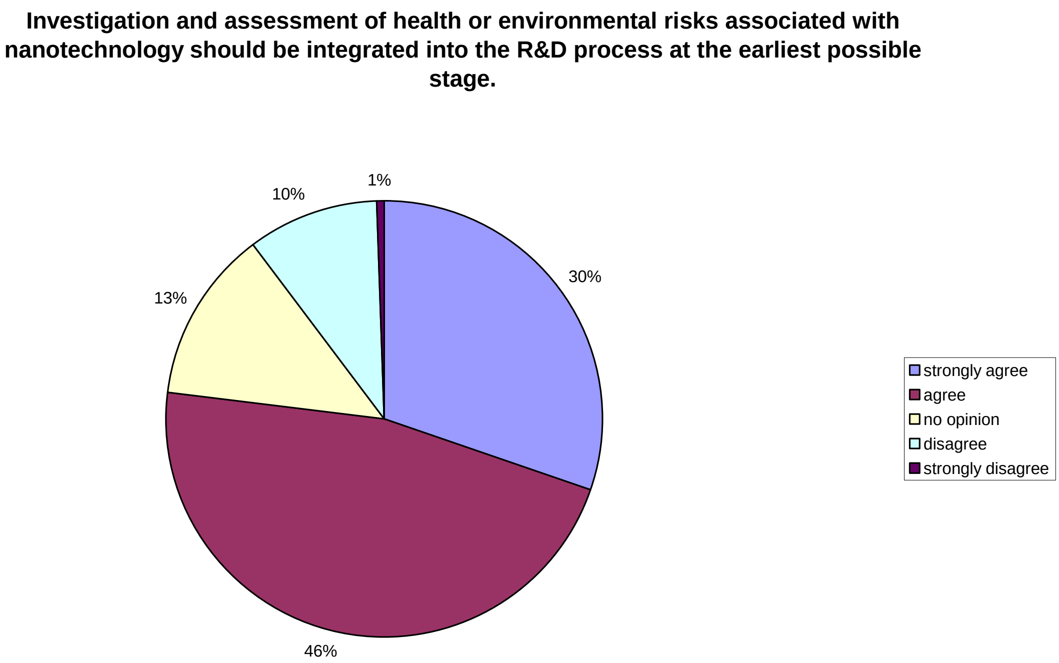

Figure 29: Opinions on integrating risk assessment in nanotechnology R&D.

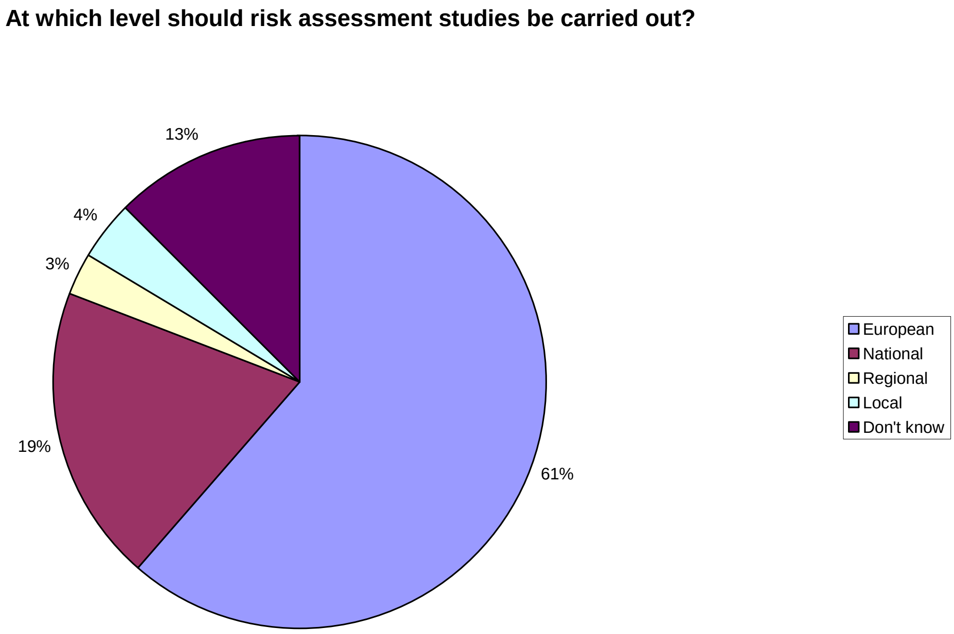

Figure 30: Opinions on the level for carrying out risk assessment studies.

Respondents were subsequently asked the question "At which level should risk assessment studies be carried out?" 61% of respondents answered European, 19% national, 4% local and 3% regional. 13% did not know. Most participants seem to agree that risk assessment studies need to be conducted at European level.

Scientific priorities for risk assessments were evaluated by posing the question: "What are the more urgent hazards of nanotechnology for which scientific investigation and risk assessment are needed". Several pre-defined options for responses were provided along with the allowing a free text response. The risks of free nanoparticles or nanostructures are considered to be most important. 72% of respondents thought "Human exposure to free nanoparticles or other nanostructures" need research and risk assessment, and 56% "Environmental release of free nanoparticles or other nanostructures".

With regard to materials or devices containing immobile nanoparticles there was less concern on the part of the respondents. The "life cycle of materials / devices containing immobile nanoparticles or other nanostructures" must be investigated according to 39% and "human exposure to materials/devices containing immobile nanoparticles or other nanostructures" is only considered important according to 23% of respondents. Only 7% did not think any hazard needs investigation and 5% indicated other hazards worth looking into.

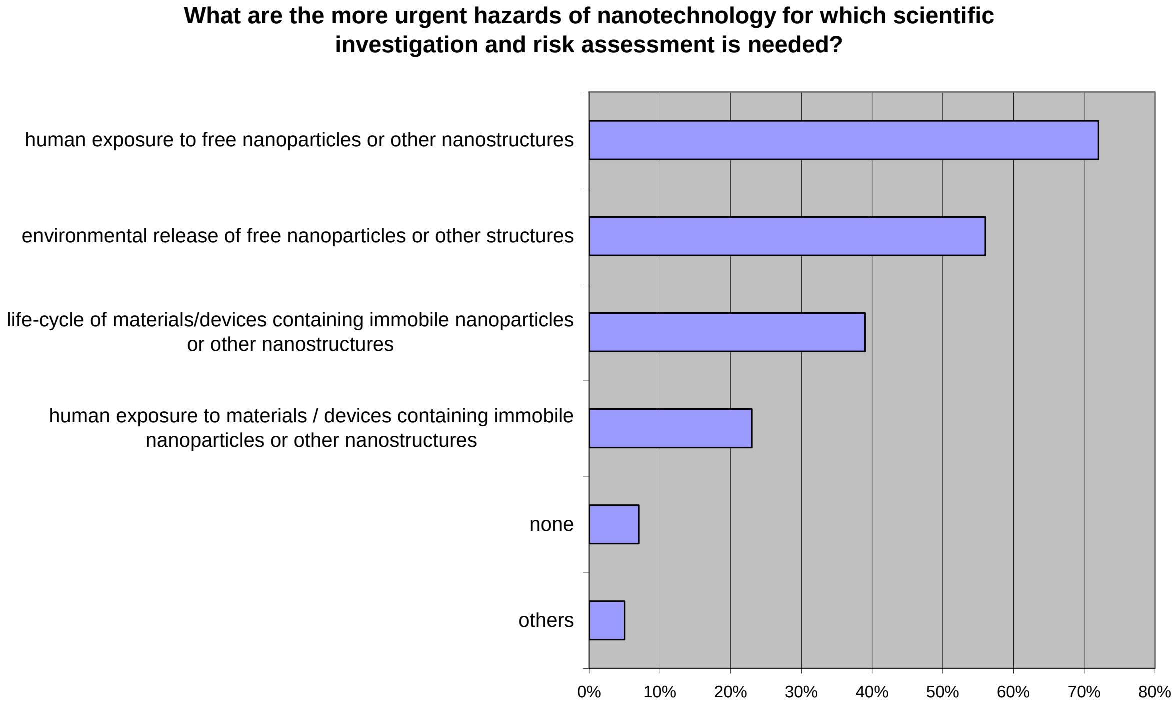

Figure 31: Opinions on the topics for risk assessment.

We received 101 free-text comments to this question, of which, almost half of these were related to distinct types of nanomaterials, of which free nanoparticles scored highest. Most respondents pointed out that diesel exhaust gases and other existing airborne ultra fine particles were the most pressing issue at the moment. Comments from 25 participants dealt with research needs, and 16 with ethical, legal and social issues. Below, we list relevant comments, avoiding duplication.

Distinct types of nanomaterials (49):

- Free nanoparticles (33)
- Immobilised nanoparticles (4)
- Replicators (4)
- Other (8)
- Specific high temperature industrial processes (especially in the sectors of mechanics) already release submicron particles.
- At present we are already exposed to the extremely potentially hazardous nanoparticulates: diesel fumes and cigarette smoke.
- Interaction of free nanoparticles with existing materials and their chemical interactions and fire and explosion characteristics.
- Increased risks of explosions due to the increased reactivity - based on a higher surface to volume ratio especially of nanoparticulate dusts.
- This discussion should be redefined: hazards of ultra fine particles (>100 nm) in general (including, but not focussing on nanoparticles).
- Need to think more about how the nanoparticles change surface etc over years. The surface is key to its hazard, and is far from stable over long periods.... Reacts, restructures etc.
- Non-spherical nanoparticles should be examined carefully, especially fibre-like ones

- One should never be complacent about these issues, but human exposure to immobilised nanoparticles is of lowest importance.
- Differentiation according to the chemical / physical nature of nanoparticles is very important!
- Should investigate reaction to biomaterials that are composite. Need to fully understand the lifespan of materials.

Research (25):

- Life Cycle Assessment (7)
- R&D programmes (11)
- production process (3)
- Other (4)
- We need to anticipate another asbestosis/lead scenario where a useful material turns out eventually to have adverse health effects.
- Mechanisms of nanoparticle effects (brain, liver, blood).
- Life-cycle of free nanoparticles and of eroding nanoparticles which initially were immobilized.
- Tissue engineering is needed to test effects of nanoparticles.
- Human exposure and environmental release of gasses and liquid waste related to nanotechnological and related processes.
- Inhalative exposure at the workplace represents the area with the greatest need for toxicological research and generation of data for risk assessment.
- Effect of free nanoparticles and other nanostructures on the food chain.
- Effects on all sorts of animals, plants, contamination of water, possible interaction of nanoparticles, effects of accumulation, possibility of unforeseen reactions.
- A good set of measurement method for toxicity, health aggression (allergy, asbestos, etc.) have to be urgently planned and decided.
- It was clearly recognized recently that mobility of nanoparticles poses a threat to health and environment. The "Mapping out Nano Risks" workshop (convened by the Health and Consumer Protection Directorate General of the European Commission in Brussels on 1–2 March 2004) in particular pointed out the need to distinguish between free and fixed nanoparticles (NPs), the latter being much less likely to raise concerns because of their immobilization. Free nanoparticles can enter the human body, move in it, and bio accumulate in some target organs or disperse in the environment and "fixed nanoparticles" are embedded in a matrix and cannot move. The nanotechnology industry is faced with a considerable body of peer reviewed scientific literature, which indicates that particles of less than 100 nm tend to be highly mobile, both within the body and in the environment. There are also strong indications that, for insoluble particles, decreasing particle size is associated with increasing toxicity. Matter organized in nanosized structures can show properties that differ substantially from those of matter in bulk or organized in larger particles as well as from those of single molecules. Scientific investigations of mobility of nanoparticles at different conditions and their interaction with different media are urgently needed.
- Questions of recycling of compound material with several and quit different materials has to be considered if these are used in large quantities.
- Could be incorporated into existing tests, i.e. expand them down to the nano scale.

- Industrial Programs should be supported by EU and National funding agencies
- Specialist R&D programmes should be established to look at these; they should NOT be forced into every R&D programme being undertaken - this is specialist work.

- Industry will look at most hazards associated with particles they are working on / marketing. Universities should look at the risks associated with their research. The risks are very low provided moderate containment is used. Info will come out in time in the health care area when these types of materials are put into animals.
- I believe we are already on track to assess the risks of nanotechnology through national and EU funded research programs e.g. NanoSAFE.
- See Chapter 9 of "Nanoscience and Nanotechnologies: Opportunities and Uncertainties", www.royalsoc.ac.uk - I am fully in agreement with the results of this study. Note that there are many areas of nanoscience which do not pose new health or safety risks. It is extremely important that the risks associated with *specific* applications are investigated when considering regulatory procedures. It is not enough to impose, in a 'broad-brush' fashion, regulatory procedures spanning all of nanoscience.
- Ethnographic research on scientific practice.

Ethical legal and social issues (16):

- science communication (9)
- legislation (3)
- GMO example (2)
- Employment (1)
- Developing countries (1)
- Influential members of society (e.g. the British Royal family) should be educated by the industry & by EU etc. to give a balanced view re the potential benefits/dangers. If this is not done, the public opinion could be adversely affected.
- Of course the health risks should be addressed as needed. But a proactive "health panic" could destroy the opportunities of this science.
- Legislation is needed. The Precautionary Principle has to be applied now.
- As a regulator of GM I would like to see some learning from that debate transferred to nanotechnology and an approach that is inclusive being developed.
- Regarding regulation of nano, I strongly support the recommendations of the Royal Society report in the UK that nanotechnology does not require separate legislation but that instead new nano-products should be treated as distinct "new chemicals" even if their macro-counterpart already has full safety clearance. This should be coupled with continued research into health and safety effects of nanoscale particles. Separate nano-legislation would be counterproductive and unwieldy. In response to this question another area of nano-hazard study should be current levels of nanoparticles in our environment, notably from diesel, smoking, industrial chimney output, etc - not enough attention is paid to this.
- A whole communication explaining that not all nanotechnologies are alike should be made. People should understand that only a small part of nanotechnologies are hazardous and should not hinder development of all nanotechnologies.
- Existing work place health and safety acts should be adequate - we do not need more bureaucracy, but we do need to make sure risks are assessed and appropriate precautions taken.
- More urgent questions: will nanotechnology create or reduce employment and wealth? Can/should there be nanotechnology at the nanoscale or only nanotech components of mesoscale objects? etc.
- Impact of technologies on developing country economies, especially those from Least Developed Countries. Impact of technologies on human health and nutrition.

Applications (15):
- Healthcare (2)
- Defence (5)
- Human manipulation (4)
- Sun cream (2)
- Other (2)
- Dangers in the application of nanotechnology. I think of the differences in the properties that come with nanotechnology. It is crucial that the applications are assessed and not only the particles.
- Military applications, especially self-replicating in natural environments (several decades from now).
- The worst impact of nanotechnology will be its ability to make better weapons for military use.
- Nanotechnology applications that are directly opposed to human interests, such as urban sensor-nets, weaponry applications and nano-genetics.
- Physical-medical human interference without seeing.
- It is no good making a sun tan lotion with nanoparticles if they are going to enter the body through the skin and cause problems. What is the point of protecting humans from the sun by exposing them to another danger?
- The cosmetic industry has a very urgent need to assess the risks of UV-Protections particles in sun creams together with neutral organisations.
- Application of nanotechnology in new products Role of nanotechnology to change industrial processes and economic structures.
- Nanotechnology in itself may be a great step towards environment protection - if applied appropriately.

Nothing new (6)
- In my opinion the existing regulative standards and assessment strategies are absolutely sufficient! "Nano" in itself is nothing new.
- The vast majority of nanotechnology work will not be risky and already takes place under other names (e.g. Biochemistry). This work is already controlled and should not suddenly become subject to additional and unnecessary safety legislation.
- This should not bog down the real work. Matter at the nanoscale has existed and been produced without us being conscious of it for ages. Until there is any evidence, fear is not of any use. Environmental, Health, Safety and Society concerns are already directly integrated in all parts of public or industrial research nowadays in the EU. Reinforcing this aspect is slowing down outcomes and decreasing competitiveness.

All (4)
- All are relevant. We know too little to rule out any of the above.
- It is always wise to look at all aspects from the beginning for a comprehensive understanding before any damage is done. That should be evaluated by non-partisan bodies and not by corporations or vested interests of any sort.

Some comments of a general nature were submitted as follows:

One respondent welcomed the Communication in terms of the “recognition that there could be new risks in relation to nanoparticles that need attention”. Another respondent supports the actions in this part of the Communication and agrees that “risk issues should be addressed upfront as an integral part of the nanotech development.” In the context of regulation they went on to say that “a relationship map of nanoproducts and nanomaterials needs to be agreed at Community level so that the applicability of new and existing legislation can be defined more clearly for divergent categories (such as nanoparticles, nanomachines and composite materials).”

Two respondents noted that “nanotechnologies can be safe but it is necessary that everybody knows the possible mechanisms of interaction with the human body […..] I think it is necessary to use the results of European research in order to optimise the use of nanoparticles.” “R&D is needed to understand the level (in terms of nanoparticle size and concentration) at which new and additional (distinctively nanoscale) health and biological hazards emerge.

One respondent stated “the Communication is welcome in that it agrees with the need for further research [into the potential health and environmental risks of nanomaterials] but says very little about protective measures in the meantime”. One respondent goes further by requesting “regulations [….] be immediately introduced for nanoscience, nanotechnology, nanoparticles, nanomaterials and nanoproducts. Every intended scientific research, product development research, and marketing of a nanoproduct has to be notified at EU level with a thorough description and risk assessment.”

12 International cooperation

In this section we wanted to establish the interest and motivation of the respondents for international collaboration with other parts of the world. There is a great consensus on collaboration with high tech countries. To the statement: "International cooperation in nanotechnology R&D is needed with other high technology countries to advance basic knowledge and industrial take up in Europe," almost 50% agreed strongly and another 40% agreed. Less than 5% disagreed or disagreed strongly.

To the statement "An international "code of good conduct" (or similar) would help to secure global agreement on the principles for the responsible development of nanotechnologies," over 60% agreed including over 20% strongly. Almost 30% had no opinion and about 10% disagreed. So, there is a firm majority in favour of such a code as proposed by the Commission.

International collaboration with less developed countries is less popular, but a majority believes it is needed, more to help these nations than to ensure European access to emerging markets. To the statement: "International collaboration in nanotechnology is needed with less developed countries to ensure that there is equitable transfer of knowledge", almost 60% agreed, including over 15% strongly. About 15% disagreed and the rest had no opinion. To the statement: "International cooperation in nanotechnology R&D is needed with less developed countries to ensure access to emerging markets", just over 50% agreed, including just over 10% strongly. About 15% disagreed, and about 35% had no opinion.

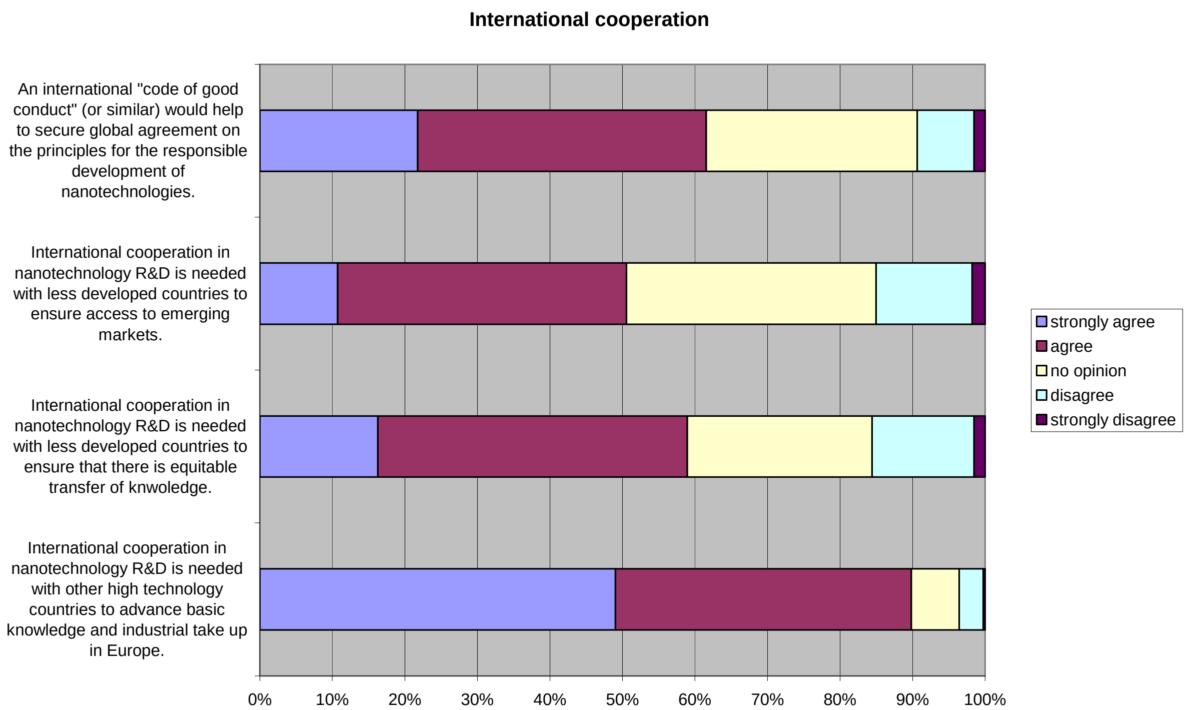

Figure 32: Opinions on international collaboration between the EU and other parts of the world.

Providing the option of a free-text response, we asked: "What other actions do you think should be launched at international level?" and received 117 reactions. Several people included more than one comment. 43 people suggested undertaking activities, 33 wanted partnering to be stimulated, 33 asked for regulation, 12 had interpreted international to mean the EU Framework programme for R&D, and 8 were against international actions.

Activities (43):

- events (7)
- Social science or dialogue (18)
- Education (8)
- Market studies (1)
- Share information (9)
- Regular symposia where industry and researchers exchange progresses, which could also be used for public awareness campaigns.
- Mitigating any views of nanotechnology displacing traditional industries and trades, especially in underdeveloped countries or countries that are not as technically advanced.
- Policy groups to focus on utilising the technology for the benefit of the world e.g. sustainable fresh water supplies; drug delivery; soil reclamation; less use of the world's resources; re-cycling of nano-devices etc.
- Open and free sharing of information on health and related issues. Improved free internet access to published scientific articles for developing countries.
- Test and criteria of/for necessity: e.g. I don't think we need self-cleaning windows; we can live with dirty windows. Test and criteria of/for global beneficence: e.g. in medicine: to lessen unbearable pain is beneficial, to develop more ways to prolong life not necessarily.
- Unify the conference scene. At present there is a hotch pot of conferences. It would be nice to have a Semicon Nano type event
- Educational programmes should also be offered to less developed countries.
- On line university courses
- Access to developing countries to research infrastructure and services as done in 'Galileo'.

Partnering (33):

- in general (11)
- international organisation(s) (8)
- with less developed countries (7)
- USA/Japan etc (6)
- EU-Mediterranean (1)
- International agreement and alliances between major research organizations: Fraunhofer Society, Max Planck, CNRS, CEA, ENEA etc…
- Flexible actions to exchange information/research results, using this page for instance organize a list/scheme/diagram of research topics in nanotechnology an people working on these topics to facilitate the mentioned exchange of information/results in a record time
- The European Union should promote the creation of a system of individual and network fellowships (akin to Marie Curie fellowships and TMR networks) operating on the global, rather than European, scale. The system should be funded by the rich nations and administered by an international organisation such as UNESCO, and treat developing countries in a similar fashion to "disfavoured regions" in the European programmes. This would vastly accelerate progress in nanotechnology and other cutting-edge fields.

- Let the OECD take a first bite on the subject to underpin the economic relevance and develop indicators
- Setting up a non-partisan organisation that has the best interest of life and the environment of the world community at large. / UN body
- As above, international commission to screen new technologies for their potential social and ecological impacts. Led by civil society and resulting in international treaties equivalent to the NPA and CTBT on nuclear weapons.
- International cooperation with less developed countries to stimulate research on the societal and economic implications of nanotechnology for less developed countries.
- Funding for researchers from developing nations to work in Europe. Workshops in developing nations.
- Permanent interaction of highly developed countries for mutual inspiration and development of qualitatively new approaches.

Regulation (33):
- safety regulations / code of conduct (18)
- definitions / standards / best practice (13)
- Patents (2)
- Ensure safety regulation to avoid hazardous work being undertaken in countries that care less about safety.
- DDT is mostly spread in third world countries; please let that not happen with nanoparticles!
- Consideration of possible Health & Safety and Environmental Issues.
- Development of an international legislation related to responsible development of nanotechnologies, rather than a code of good conduct.
- Such an international code of good conduct should not be restricted to nanotechnologies.
- An international convention and a review of toxicology of molecule at nanoscale level
- Sharing of best practices and integrating into existing environmental respect programmes, like the Kyoto Agreement.
- One participant supported “an international treaty, comparable to the Kyoto protocol that lays down a global code of conduct in respect of nanosciences and nanotechnology.”
- Avoid that trade regulations can suffocate the R&D in not-leading edges countries or prevent the formation of international consortia and partnerships; but still supervision about the exploitation and impact of nanotechnologies in the human life and environment; set basic agreements to harmonise national legislation (mainly between USA-EU-Far East) and prevent fundamental litigation at commercial level but still offer a good competitive market and stimulus of the R&D activities in the different countries.
- International cooperation in nanotechnology R&D, including the responsible use of nanotechnology, is needed with less developed countries to ensure that there is equitable transfer of knowledge and benefit from this technology. However, this needs to be balanced with assurances over ownership issues and robust protection measures for IPR to ensure that any intellectual capital and know-how developed by chemical companies in Europe is not stolen by business and individuals in less developed nations. Overall, international cooperation in nanotechnology is vital and a positive development provided a level playing field especially on regulation (HSE, IP) is developed throughout the world.
- An agreed system of nomenclature.

- Nanometrology
- Characterisation and Regulation of NT-based materials and products
- The normalisation efforts in Europe have to be developed in the global world especially through CEN (Europe) to ISO (World wide) and a voluntary policy ought to be addressed.
- Change patent law.

EU framework programme (12):
- bureaucracy (8)
- funding (4)
- International cooperation is important and should be supported by EC. However, the cooperation should be spontaneous. At present some large NoE or IP seem to be artificially large.
- Establishing a European wide network of monitoring groups on safety, risks and regulation of nanotechnology as we did it in Switzerland (Swiss core group safety and risks of nanotechnology). The goal of the interconnected groups should be knowledge transfer, awareness raising, launching of common research projects (intern.) Initiating of international coordinated projects (science, industry, Government).
- For EU Commission: think step by step. Don't try to organize all activities and aspects at once. Let the application of nanotechnology grow in "normal way". It is impossible to control all aspects in one time.
- Increased funding to allow further mobility of researchers between international centres

No
- Above items pretty much cover the frame of the start up
- Global competition is the best action
- None, there are already too many talking shops. You should put your money into useful actions, rather than supporting airlines.

13 Concluding Comments

In the last section of the questionnaire, we asked: “Finally, please provide any further comments on the proposed European strategy or any other issues that have not been addressed above.” We received 112 comments, including nine “no (or incomprehensible) comments”. Some comments dealt with several issues. 35 comments covered stimulating research, 26 public perception or policy, 24 innovation, 17 the research scope and 11 the questionnaire itself.

Research stimulation (35)

- EU Framework programme (23)
- Internationalisation (6)
- All European (3)
- National level (3)
- Nanotechnology will only benefit the EU if it is managed under a coherent programme of appropriate and suitable regulation, public acceptance and easily accessible funding for R&D and industrial organisations alike.
- In my opinion nanotechnology and biotechnology should become a top priority in Europe! Much more funding should be available for nanotechnology and biotechnology research projects!
- The approaches and processes you are using to collect information are excellent. The mechanisms generally of EU R&D, their focus, and contact with the issues have improved enormously recently. Some programs still seem a bit in trouble, mainly the NoE's, and possibly some of the IP's possibly due to their size (?) and more or less random way of forming....But overall things moving in right direction.
- Integration of science across Europe doesn't really happen. This is in part due to the competitive nature of Framework bids. It would be better to encourage the 'best groups' to work together by encouraging better integration as the top five groups are identified in any specific call. This might mean forcing new consortium to form if they are to get the funding for a project.
- The policy to stimulate co-operation by requesting increasingly large consortia in IP's and NoE's is counter productive to the necessity to create focus. Focus is essential to success in nanotechnology.
- Much less IP funding if any. The Japanese-like research conducting - industry and research institutes as a big "family" - will not be accepted in Europe. Much more money for STREPs, which are more effective for research purposes than IPs.
- A specific programme to develop large-scale production capabilities for bulk nanopatterned material is required. Future focus is autopoietic aspects of such system: self-amplification and programmed fabrication in small packages.
- Only the very, very large infrastructures should be supported, but infrastructure at lower level must also be available at national level; studies on health and environment also on international level.
- Mobility within Europe for researchers is still not sufficiently integrated and this has a knock-on effect on nanotechnology research along with others. Although researchers are encouraged to move country there are still many penalties to doing so, such as no integration of pension schemes, etc etc.

- I think most important issues have been addressed. For 6th FP the lack of funding is critical. Another very critical point is the quality of evaluation procedure and quality of evaluators.
- Informal flexible networks of local and focussed centres of excellence spread across Europe are in my opinion much more effective than unmanageable NoEs. Support business plan competitions and easy transfer of IP from research organisations to start-ups. Drastically reduce bureaucracy and formal requirements.
- A lot of time is spent for proposal preparation; and it is not a big difference between the "very good" project funded and "good" project non-founded. I propose to collect all these proposals and publish them; maybe there are some organisations interested to invest money in science.
- An effort to reach individuals involved in nanoscience management, in more direct way. The information available in CORDIS is overwhelming and I cannot get what I want and need in an efficient way.

- EU should work with non-EU member countries in Europe and continue there collaboration with Canada and the US
- Very helpful if it could be seen as broader than Europe to avoid duplication of effort, enable consistency and effectiveness.
- There is a strong need of systematic support of the cooperation between EU and USA in the nanoscience and nanotechnology.

- European strategy ought to be really "European" and to provide framework for including interested researchers from all Europe (not only Member and Associate Member) countries.
- In order to well reach all the most interest partners (scientists and industrialist) a better common/joint approach and the development of synergies between Framework programme with other frameworks in Europe such as COST (28 Actions i.e. 2000/3000 researcher), Eureka, European Science Foundation but as well some European societies such as AllChemE, European Colloid and Interface Society (ECIS), Dechema in Germany etc.
- Similarly to USA and Japan (see COMMUNICATION FROM THE COMMISSION Towards a European strategy for nanotechnology, p.8) EU nanotechnology should be much more centralized, coordinated and focused. The possibility to establish European Nanotechnology Agency (similarly to European Space Agency, International Atomic Energy Agency, and European Environment Agency) could be considered and estimated.
- There is need for reinforcement of European coordination of national research policies in acceding countries and in countries with low level of public funding. The resources of small countries are not high enough to ensure excellence and to provide critical mass at local level
- Joint actions organized by Directorate General for Enlargement and Directorate General for Research could improve situation with nanotechnology and nanoscience in New Member States by prevention of fragmentation and duplication, removal constraints of the past and stimulation of scientific excellence. As a first step a special workshop funded by EU for acceding and small countries devoted to the integration to ERA, identification of main needs and gaps and mobilization of resources could be organized jointly by both DGs.
- Small research projects and scientific meeting should be supported in less developed countries, like Turkey.

- I would prefer most of this to be addressed nationally, but a unified EU response is going to be useful.

Public debate/policy (26)

- Public perception or dialogue (15)
- Risk assessment /control (8)
- foresight (2)
- definitions (1)
- I find the document „Towards the European strategy for nanotechnology" very good and stimulating.
- Strong information campaign in media (radio, TV) plus innovative forms of reaching young people (the generation which will profit mostly from nanotechnology)
- More publications and information about Nanotechnology.
- Knowledge-society needs cognitive efforts and cultural change. This is particularly true for nanosciences (and biosciences). Both for public and scientist awareness.
- The strategy must emphasis the importance of public acceptance by having a policy of openness and making information freely available, particularly on potentially the generation of new toxic materials in the form of nanoparticles.
- Focus on "today's products" and not science fiction/hype products and technologies, is very important to avoid the fear within the general public and to trigger the industrial involvement.
- Doubling the budget is not enough. Politicians must understand and support the vital role of nanotechnology for the future of humankind.
- Forum, open to the civil society to question open issues.
- Integrate independent experts (scientists) in the societal discussion at an early stage, so that they and not environmental activists can set the stage.
- The unproven 'theory' of evolution is behind many aspects of 'convergence' thinking and nano-bio research. There are great dangers here for public trust in science when genetics research finally quashes macro-evolutionary thinking.
- It is important to launch one control organ of nanotechnology on the world.
- When particles with the same order of magnitude of a "prionic protein" are constructed, it is necessary to convince the public opinion about their safety by media, newspapers, magazines etc.
- Please be aware that R&D projects, even integrated projects can not satisfactorily perform risk assessment, but they should be used as source for technological information.
- With regard to exploitation ensure that the widely communicated applications (usual suspects like sensors etc.) are critically reviewed.
- Marketing/industrial involvement should be available only after the risk assessment.
- It should be avoided that research on safety topics is "over funded" at the expense of funding other projects.
- The peoples of Europe does not need what the Commission envisages, a "serious communication effort and dialogue with the public". Instead it is required that potential problems and risks with nanotechnology are treated as serious stumbling stones, and not only something which drains resources and time from the saviour of modern industrial technology.
- Definitions: everyone knows what it means and the wrong usage can be avoided. Then e.g. the EU funding is going to real nanotechnology projects.

Innovation (24)

- SMEs / start-ups (11)
- Competitiveness (10)
- Academic/ industrial contacts (3)
- Less bureaucratic systems in European research funding. A program comparable to the US program named SBIR program is urgent necessary in Europe
- EU program (IP, CRAFT and STREP) are too time consuming to set-up for an SME. They are not a way to help SMEs in the present FP6. In addition, the Commission don't have positive approach of the financial help to SMES: no advance, payment after the work to be done when the large companies having more financial capabilities are paid in advance!
- Perhaps there should be a means of funding small projects to enable greater participation of SMEs who may not require the large sums typical of the current instruments. This could entail the funding of projects involving two or three SMEs and much simpler proposal preparation.
- The biggest problem that European R&D faces compared to say America is the reluctance of people to set up companies and the preference for people to stay on their assigned career path. The European attitude to bankruptcy is generally quite negative, whereas it seems to be more of a badge of honour in America. If we are going to foster and encourage riskier ventures then we must learn to accept failure.
- Put SME in focus, universities and Research Institutes will follow. Have such a call depending on SME's; they can make use of universities and institutes as required.
- SME industries are the motor of the European economy and especially in the high technology, for that is essential high participation of SME in all of the decision in this field.
- It will be important to take account of other world economic blocs that are investing large amounts in specific areas (e.g. Korea) and making a determination of whether the EU strategy should be to compete, stay in the game in niche areas or exit completely. It will also be important to build on the key skills and centres of excellence we already have so that we maintain the advantage already gained.
- Benchmarking!
- There is a major opportunity for Europe but there must be a great deal of co-ordinated action delivered over a short time-scale. The utilisation of experts in policy should be considered with secondments being an appropriate model.
- I am afraid the EU is well behind US and should speed-up the activities on nano-initiatives to close the gap.
- Europe has made good progress under FP6 in initiating larger networks like NoE and larger projects like IPs, to get a critical mass in some specific topics. But the similar investments in the USA (NNI) or in Japan or Korea are much bigger and will decrease the potential market for European companies in the future.
- EU proceeds too slowly, go to China and have a look!
- It is important to have worry on EU competitiveness - however we should not build protectionist barriers for importing technology or research from outside EU, but let market economy work. Internal competition between EU countries is an important competitive advantage for EU, which differentiates us from USA. EC has very important role as coordinator, and it should incubate national and regional competition within EU.
- More industrial / academic contact is needed as half research effort is now wasted on areas which will not have applications. There is no network in this area yet involving industry.

- It would be very helpful to establish Internet forums of researches and practitioners and www search engine on these forums.

Research scope (17)

- Basic research / ERC (8)
- Education (6)
- Applied research (3)
- More research in fundamentals of Nanotechnology is needed. We should not rush into applications of these materials before we understand clearly their nature, mechanisms of their formation, and until we have a coherent theory allowing prediction of new nanostructures and their functional and exploitable properties.
- A true European Science Foundation or equivalent structure with considerable budget is needed. Scientists should have the opportunity to compete for funding of fundamental nanoscience at European level. Administration load and constrains should be reduced to a minimum.
- To a large extent nanotechnology represents the current directions of many individual traditional sciences. As such it has relatively few issues, whether educational, ethical or environmental which are truly specific to it. They are the same issues relevant to all of science and its exploitation.
- I wished it would be much more cautious, and wouldn't see economy and competitiveness as the main reasons to adopt nanotechnology.
- Promote educational systems as a means to inform both students and industry about nano technology.
- Develop scientific education with interdisciplinarity to support possible crossed fertilization between the different scientific domains
- Nanotechnology must stop to be a fashion, scapegoat or the solution to everything and must take its proper position in the European strategy for the future. The emphasis should be on the applications of nanotechnology which can bring into the market improved products and for this more funding should be devoted on the development of integrated nanoparticle processes especially based on aerosol technologies.
- The most pressing question is: how to make nanoscale systems compatible with the everyday macroscopic world through compatibilization with macroscopic material matrices (liquids, solids, surfaces) whilst conserving nanoscale based phenomena (optical, electronical, mechanical, etc.) and at the same time translating these into high value applications for the European economy.

Questionnaire (11)

- Very limited and narrow-minded, restricted to too specific fields.
- Are you sure the people setting together this questionnaire have any ideas about nanotechnology?
- All these questions are a little bit problematic since it is not clear which technology or science the participants of the survey count to NT and which not. This is especially problematic if you would like to assess the societal and economic impact of NT as it was ask in one of the first questions.
- It is great to see this consultation process taking place, also to see the Nanoforum taking a pro-active role!
- Should I really expect you to take on board any of this? Your questions indicate that you already have your minds made up. This consultation is of little more than PR value, a facade of participation while the decisions continue to be made at a great distance from citizens and under the influence of corporate interests.

- One respondent noted that the questions posed in the online survey were biased and assumed a positive attitude to nanotechnology. Similarly, another respondent noted that the Commission gave “the impressions that all nanotechnology developments are to be considered as good”.
- One respondent noted that “the Communication contains statements, which are excellent and therefore deserve the full support of the scientific community”.

Annex I: Names of the organisations of respondents

Of the 107 people who filled in the questionnaire on behalf of their organisation, the representatives of the following 86 organisations did not want to keep their reply confidential:

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Of the 107 people who filled in the questionnaire on behalf of their organisation, the representatives of the following 86 organisations did not want to keep their reply confidential:

1005 tekstproducties
4M2C PATRIC SALOMON GmbH
ABB
air liquide
AIRI/Nanotec IT
ALTANA Chemie AG
Asociacion de la Industria Navarra
BASF Aktiengesellschaft
Basic Research - High Educational Centre
British Nuclear Fuels plc
BUZIL-WERK Wagner GmbH& Co KG
Case Scientific
Center for Computational Materials Science
Center for Micro- and Nanotechnologies
Center for NanoBiotechnology
CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS / CHEMICAL PROCESS ENGINEERING RESEARCH INSTITUTE
Centre of Excellence for Magnetic and Molecular Materials for Future Electronics at the Institute of Molecular Physics, Polish Academy of Sciences
Centro Sviluppo Materiali
CIDETEC
Città della Scienza- Fondazione IDIS
Commission de la santé et de la sécurité au travail
COPA/COGECA
Danish Technological
DeA-associazione Donne e Ambiente
Degussa
DGTec
Donaldson europe
EMF Ireland
ESL Europe
Forschungszentrum Karlsruhe GmbH in der Helmholtz-Gemeinschaft
Fraunhofer IKTS
Fraunhofer Institute for applied optics und precision engineering
Fraunhofer Society
FutureCarbon GmbH
G & H associates Ltd
GAIA-ASOCIACIÓN DE INDUSTRIAS DE LAS TECNOLOGÍAS ELECTRÓNICAS Y DE LA INFORMACIÓN DEL PAÍS VASCO
Gebze Institute of Technology (GIT)
Grupo ACITURRI
Harran University
Institute for Environment, Philosophy and Public Policy
Laser Zentrum Hannover e.V.
LioniX BV

M4 Technologies Ltd
Micro Materials
microTEC Gesell.fuer Mikrotechnologie mbH
nanobionet ev
NanoDimension AG
NanoMagnetics Ltd.
Nanosolutions GmbH
Nascatec GmbH
NECSO Entrecanales Cubiertas, S.A.
Neue Materialien Würzburg GmbH
Oy Keskuslaboratorio - Centrallaboratorium Ab (KCL)
Philips
Philips Electronics
Saarland University, Department Powder Technology
Seconda Università di Napoli
SIOS Meßtechnik GmbH
Spinverse Consulting
SusTech GmbH & Co. KG
Swedish National Testing and Research Institute - SP
Technology Centre AS CR
The Food Commission UK
Thomas Swan & Co. Ltd.
Thuringian Institute for Plastics and Textile Research
TNO TPD
TWD Gmbh, Deggendorf, Germany, www.twd.de
Universidad Politécnica de Cartagena
University College Cork
Viking Advanced Materials GmbH
Wellman International
Cavan Leitrim Environmental Awareness Network, IRL;
DEMOS, UK
European Committee for Standardisation (CEN);
European Materials Research Society
Frauenhofer Institute for Systems and Innovation Research, DE;
Greenpeace, UK;
Helmholtz Association, DE;
Kinnsys, BE.
Max-Planck-Gesselschaft, DE;
Swiss Physical Society, CH;
The Hungarian Academy of Sciences, HU;
The Irish Council for Science Technology and Innovation, IRL;
The Royal Society, UK;
The UK Government Chemist, UK;
Unilever

The 431 individual respondents who did not want to keep their response confidential came from these organisations:

A.V.Shubnikov Institute of Crystallography
Aarhus University
Åbo Akademi
Academy of Finland
ACCESS Materials&Processes
ADIT, Biofutur, Cité des Sciences et de l'Industrie, Process Alimentaire,...
Air Force Office of Scientific Research
ALCIMED
AMPS Ltd
AREVA T&D
Aristotle University of Thessaloniki
Armstrong Optical Ltd
ASC-Consulting
Asim Kocabiyik MYO, Kocaeli University
Aston University
ATOFINA
austriamicrosystems AG
AUT
AVANZARE Innovacion Tecnologica
AWE Plc
Baku State University
BASF
Bayer MaeterialScience
Bergische Universitaet Wuppertal
BIA - BG institute for occupational safety
Bilkent University
bioanalytik-muenster
bitfaction
Borealis GmbH
BTU Cottbus
Bundesanstalt für Materialforschung und -prüfung
Burgundy Gold Ltd
C&C CONSULT Umwelt+Nanotechnik
Cambridge University
Cardiff University
Cardiff University, MEC
CEA
CEA LETI / Alliance
CEA/Minatec
CEIS
Center for NanoScience, Ludwig-Maximilians-Universitaet Muenchen
centre de recherche public henri tudor
Centre for Metrology and Accreditation (MIKES)
Centre for Multidisciplinary Research
Centre for process Innovation
Centre for Technology, Innovation and Culture - Univerisy of Oslo
Centre National de recherche scientifique

Centre Suisse d'Electronique et de Microtechnique (CSEM) SA
CERTH/CPERI, APT Laboratory
Chalmers University of Technology
Charles University in Prague
City of Vienna
CNR - ISTM
CNR-ITAE, Istituto di Tecnologie Avanzate per L'Energia "Nicola Giordano"
CNRS
Consejo Superior de Investigaciones Científicas (CSIC)
Consiglio Nazionale delle Ricerche
COPROIN SL
Council of the European Union
Cranfield University
Czech Technical University
Czech Technical University in Prague
Darmstadt Technical University
Defence Research Agency
Department of Materials, Oxford University
Department of Medicine B, WWU
Development Center for Biotechnology
Dicle University
DipartimentoScienzeChimiche
DIRECTION GENERALE de la SANTE
Dow Europe GmbH
Dpt. of Sociology and Social Research, MILAN-BICOCCA
Durham University
Ecole Nationale des Ponts et Chaussées / LATTS
Ecole Polytechnique
eindhoven university of technology
EMPA
EnablingM3
Enterprise Ireland/Irish Nanotechnology Association
Environmental Agency (Umweltbundesamt)
EPSRC
erinstitut Mittelsachsen e.V.
EuroScience.Net
Ford otomotiv sanayii a.þ.
Forschungszentrum Jülich
Forschungszentrum Karlsruhe
Forschungszentrum Rossendorf
FORTH
Fraunhofer Gesellschaft
Fraunhofer-IGB, Stuttgart
Fraunhofer-Institut für Silicatforschung
Freiburg Materials Research Center
Fundacion ASCAMM
Fundacion Inasmet
FUTUREtec Gesellschaft für angewandte Informatik mbH
Fyzikalni ustav AVCR
Garlock France

Gdansk University of Technology
Health and Safety Executive
Helsinki University of Technology, Center of New Materials
Helsinki University of Technology
Heriot Watt University
I.N.F.N.
ICBAS-University of Porto and Hospital Santo António - Porto (Portugal)
ICFO-Institut de Ciències Fotòniques
ICMAB-CISC
IEF -CNRS - Université Paris Sud
IMC - University
IMEC
Imerys Minerals Ltd.
Imperial College of Science, Technology & Medicine
Imprenta Digital de Sevilla SL
IMS Nanofabrication GmbH
INASMET Foundation
InfoChem GmbH
Ingenieurbuero für Arbeitsschutz
Inst of Semiconductor Physics
institut curie
INstitut des Matériaux Jean Rouxel
Institut National de la Recherche Agronomique
Institut National Polytechnique de Grenoble (INPG)
Institute for Physical High Technology
Institute for Prospective and Technological Studies
Institute of inorganic chemistry of SB RAS
Institute of macromolecular chemistry, Academy of sciences of the Czech Republic
Institute of Materials Science
Institute of Nanotechnology
Institute of Physical Chemistry, University of Tuebingen
Institute of Physics SAS
Institute of Problems of Microelectronics Technology RAS
Institute of Semiconductor Physics
Institute of Solid State Physics
Institute of System and Control Theory
Instytut Wlokiennictwa (Textile Research Institute)
International Society Doctors for the Environment
International Society for Molecular Electronics and BioComputing (ISMEBC)
International University Bremen
Intertek ASG
IOM
Ionbond Ltd
IPC Irish Productivity Centre
IPCF-CNR
ITAS, Forschungszentrum Karlsruhe, Germany
J. Heyrovský Inst. Phys. Chem., ACAd. Sci.
J.W. Goethe-Universität Frankfurt am Main
Johann Wolfgang Goethe-Universität Frankfurt
Johannes Gutenberg-University, Mainz

Karl-Franzens-University Graz
Katholieke Universiteit Leuven
Kavli Institute of Nanoscience Delft
King's College London
Kodak Ltd
Kodak Ltd R&D
Kompetenzzentrum Neue Materialien Nordbayern GmbH
KSV Instruments Ltd
Lancaster University
Leibniz Institute of Polymer Research
Leibniz-Institut für Oberflächenmodifizierung
LGEB
LIOF
LMU
Loughborough University, UK
Lund University
Marmara Research Center
Max Planck Society
Max-Planck-Institut für Metallforschung
MEL Chemicals
Mickiewicz University in Poznan
Middle East Technical University
ministry of industry
Morris Consulting
MR ENSCM/CNRS/UM1 5618
NANOLEDGE S.A.
NanoScape AG
Nanostart AG
nanosys gmbh
Nanotechnology Reseachers Network Center of Japan
National Institute for Lasers, Plasma and Radiation Physics
National Institute for Materials physics
National Institute for R&D in Microtechnologies
National University of Singapore
nawor research
NCSR "DEMOKRITOS"
NEMOPTIC
NV Bekaert
Oce-Technologies
Omicron NanoTechnology
Optimus
Oxford university
Oxford University Begbroke Science Park
P.J.Safarik University, Kosice
Philips Research
Physikalisch-Technische Bundesanstalt
Politecnico di Milano
Polymer Institute
Portland State University
Queen's University Belfast

Ravenshill consulting
r&d national institute for microtechnology, bucharest, romania
Regional Goverment of Emilia-Romagna
Research Center Jülich/Germany
Research Institute for Microtechnologies
Riga Technical University
ROBOTIKER
Rockwell Diamonds
Royal Institute of Technology
RWTH Aachen
RWTH Aachen University, Germany
SAATIPRINT
Scan Drill KB
School of Electronic Engineering
Semiconductors manufacturer + Design/Reliability/Testing
SKU Management
Solvay S.A.
SoundEra
SRI - BAS
Star-Oddi
STMicroelectronics
Stockholms Universitet ITM/L
STW
Swiss Office for Science and Education
SWR Public Radio & TV
Syntens
T. Universität Darmstadt
Tallinn University of Technology
Technical University Hamburg-Harburg
Technical University of Lodz
Technion-Israel Institute of Technology
Technology for Industry
Technology Management Consultants
Technopreneur Ltd.
Tekes
Teknomedia AS
Tetronics Ltd
The Carpet Foundation
The Institute of Nanotechnology
The Research Council of Norway
The UK Transhumanist Association
The University of Sheffield
The Weizmann Institute of Science
TNO
Tomsk State University
Trinity College
Trinity College Dublin
TU Wien
TUBITAK-UEKAE
TUTTU PICCOLO S.A.

Uludag University
UMIST
UniKasselTransfer
Unilever
Univ. Zuerich
Univeristy of South Carolina
Universidad Autonoma de Madrid
Universidad Barcelona-Institut Catala de Nanotecnologia
Universidad de Castilla-La Mancha
Universidad de Granada
Universidad de Valladolid
universidad del pais vasco
Universidad Politécnica de Cartagena
Università degli Studi di Roma "La Sapienza"
Universita' di Messina
Universita' di Milano
Universität Duisburg-Essen
Universität Kassel
Universität Münster
Universitat Politecnica de Catalunya
Universität Stuttgart / 4. Physikalisches Institut
Universität Zürich
Université Claude Bernard Lyon 1
Universite de haute Alsace
Université de Montpellier
Université Joseph Fourier
Université Libre de Bruxelles
Universite Paris Sud
Universiteit Antwerpen
Universitry of Glasgow
University College Cork
University College Dublin
University of Aarhus
University of Bangor
University of Barcelona
University of Bath
University of Birmingham
University of California at Santa Barbara
University of Catania
University of Crete
University of Edinburgh
University of Edinburgh/Scottish Microelectonics Centre
University of Glasgow
University of Goettingen
University of Grenoble France
University of Kocaeli
University of Kuopio, Finland
University of Leeds
University of Leoben
University of Limerick

University of Liverpool
University of Modena & ReggioEmilia
University of Newcastle upon Tyne
University of Nottingham
University of Oldenburg
University of Oulu
University of Portsmouth
University of Santiago
University of Sheffield
University of Sofia "St Kliment Ohridsky"
UNIVERSITY OF SOUTHAMPTON
University of St.Gallen
University of Surrey
University of Sussex
University of Trieste, Italy
University of Ulm, Experimental Physics
University of Valencia
University of Vienna
University of Warwick
Universoty of Oxford
Universté de Sherbrooke
UPC-CD6
Uppsala Universitet
VDI Center of Technology
VDI Technologiezentrum GmbH
VDI/VDE-IT
Veen Bosch & Keuning
Vienna University of Technology
VITO
VNO-NCW/STT
Vrije Universiteit Brussel
Wageningen UR
Wageningen UR - Agrotechnology & Food innovations bv (A&F)
Washington State University
Wroclaw Technical University, Wroclaw, Poland
WTC
Yildiz technical university
Zuyd University