

Roadmapping Stage 1 - Results

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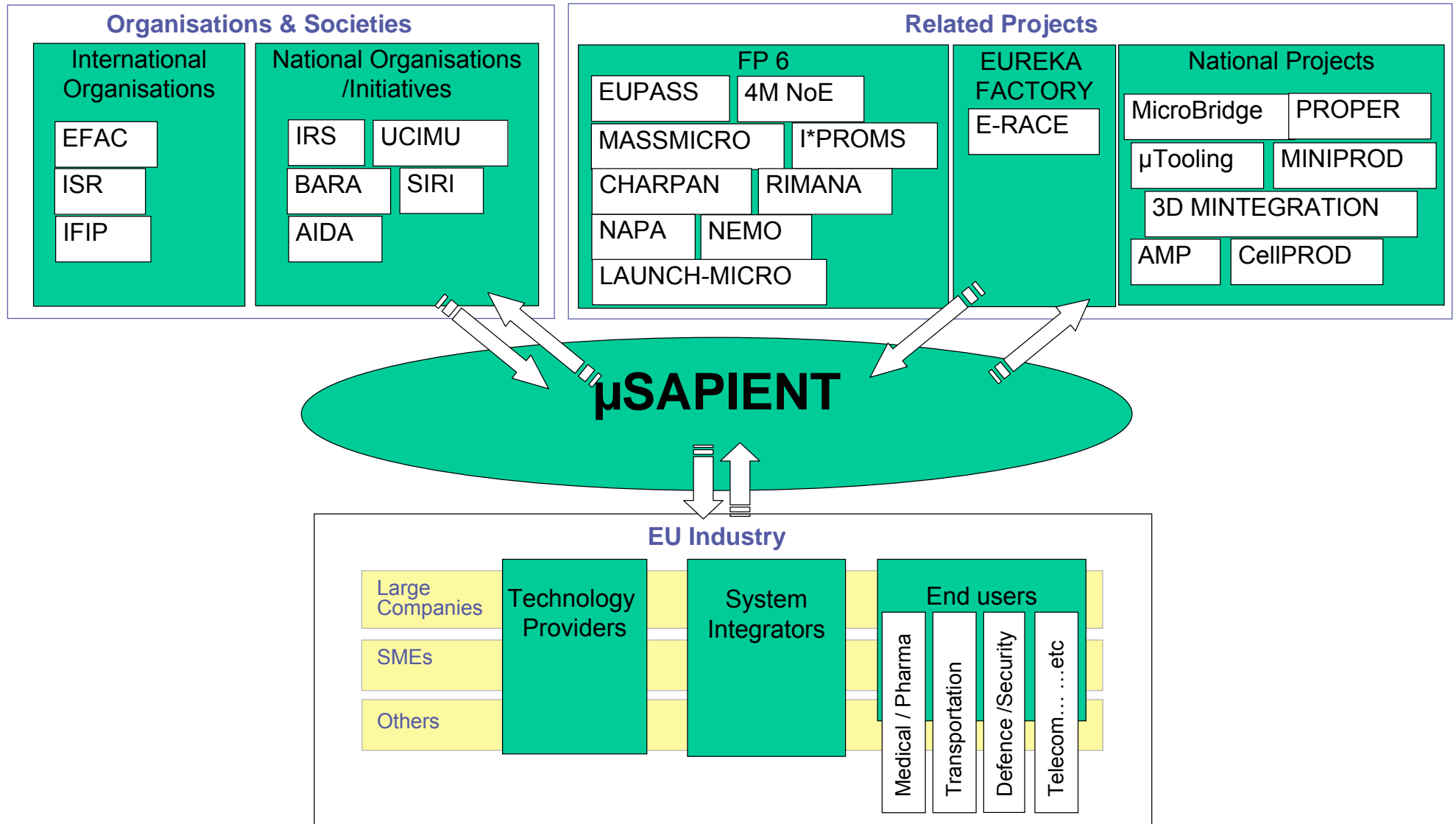


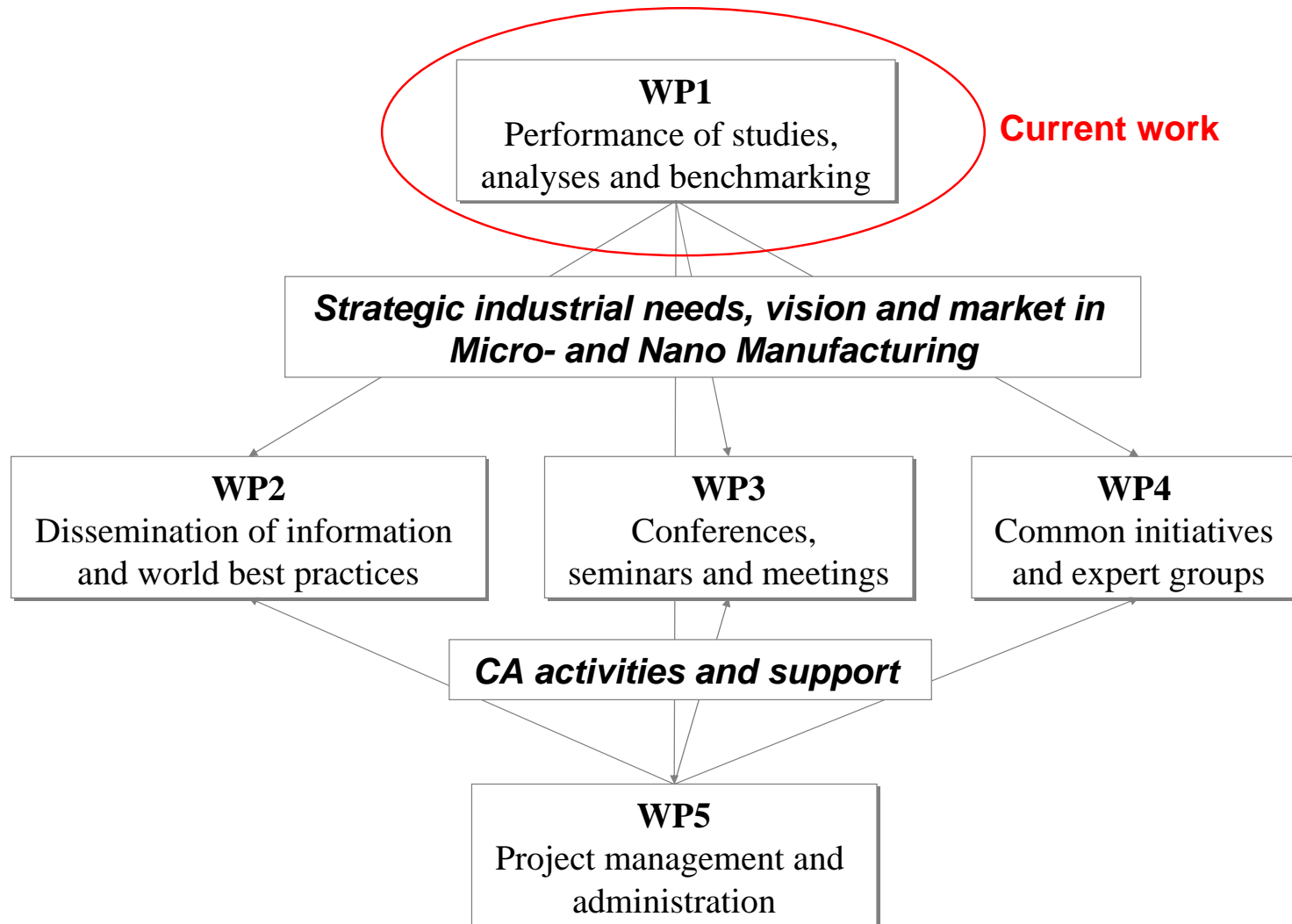
μ-SAPIENT aims to create a focused and sustainable European-wide infrastructure for the co-ordination of MNT research and dissemination activities, linking relevant national and international projects, organisations and initiatives to support critical EU market sectors by:

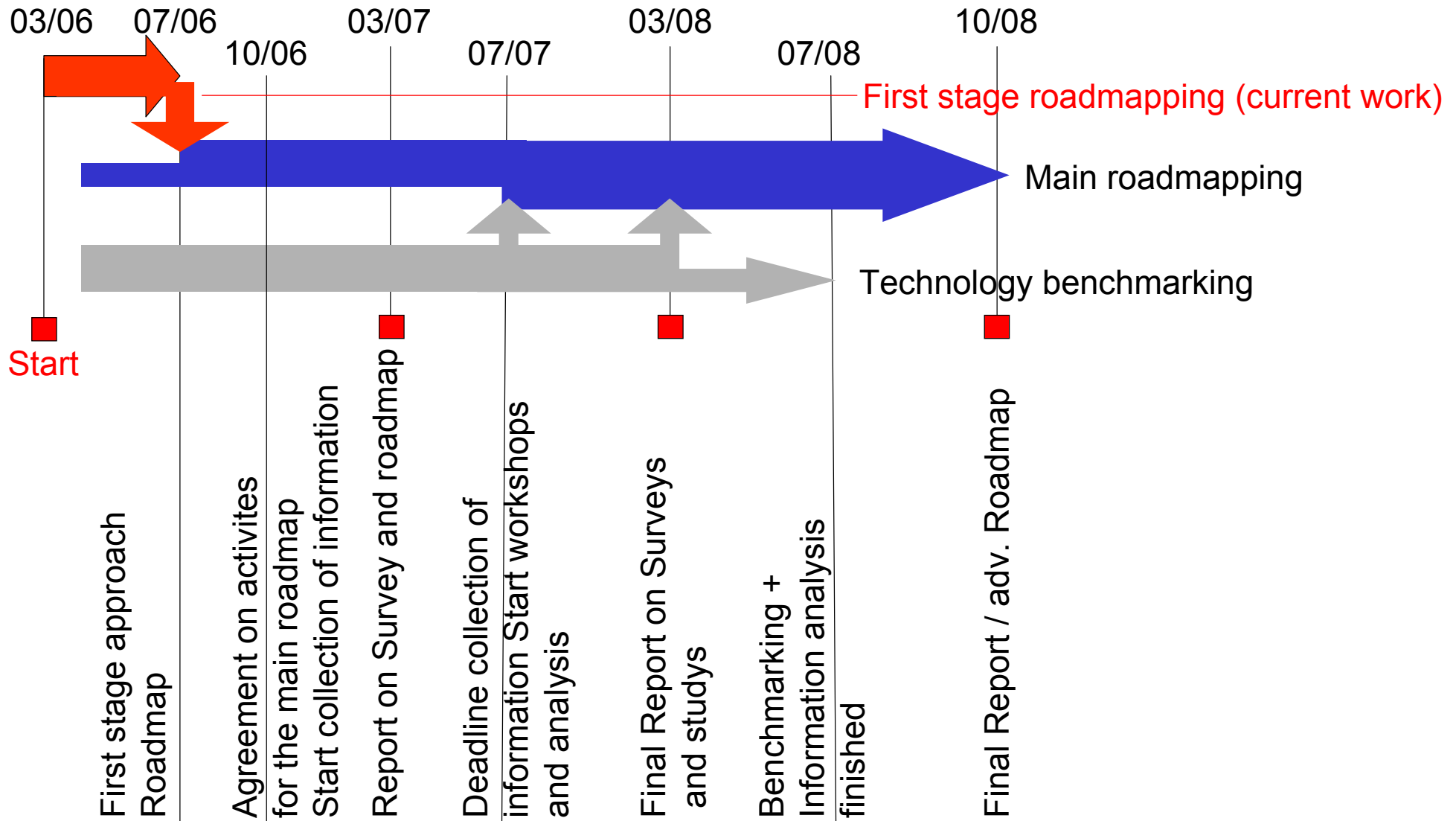
- Carrying out a critical analysis of emerging Micro and Nano Technologies (MNT) that result from many complementary EC, national and industrially funded Research and Development (R&D) projects.
- Identifying gaps in emerging MNT that prevent effective integration and up-scaling, thus assisting national and EC funding bodies in defining the priorities of their future R&D programmes.
- Creating a forum for co-ordinating the efforts of many complementary R&D projects in ERA and in this way to ensure that technology and application challenges are addressed concurrently.

A continuously updateable European MNT Roadmap - an MNT research and business plan for Europe - is a necessary underpinning feature of the project

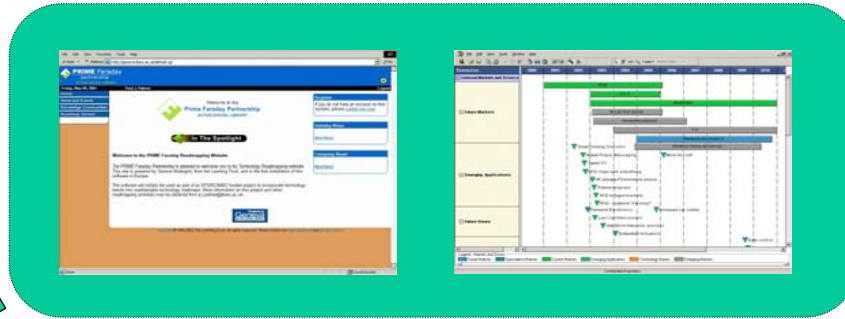
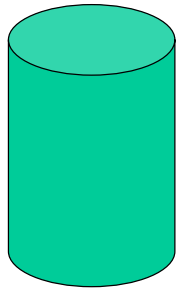
μ-SAPIENT – Coordination strategy



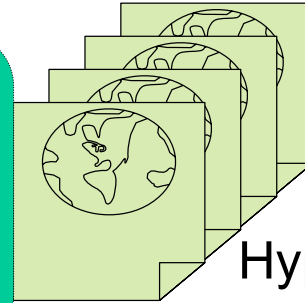




Knowledge database



Roadmap Presentation



Hyperlinks to external information



Roadmapping Process

Calculation

Viability Analysis

Review

The bottom section contains three main components:

- Summary:** A table with columns for Funding Scheme, Activity, and Date. It lists various funding schemes and their associated activities.
- Trend Analysis:** A line graph showing 'New Technology Capacity' over time, with multiple lines representing different scenarios or technologies.
- Technology Landscape:** A heatmap table with columns for Technology, Application, and Date. It uses a color scale (green, yellow, red) to indicate the level of technology readiness or application demand.

Summary

Trend Analysis

Technology Landscape

- We are aiming to construct a comprehensive picture from:
 - 1 A top-level view of how and when MNT will penetrate and impact market sectors important to the EU
 - 2 Predictions of product developments - enhancements or entirely new products - that may be enabled by MNT
 - 3 Suggestions regarding the production equipment that will require development to make the products of the future become a reality
 - 4 Forecasts of the design and manufacture process technologies that will need to be developed to underpin future products and markets
- The hierarchy 1-4 above will allow the examination of dependencies and thereby the planning and implementation priorities required for technological and economic success

Roadmapping Contributions 1st Stage

- UK
- Germany
- France
- Switzerland
- Spain
- Greece
- Austria
- Finland
- Sweden
- Festo
- Philips HTP
- Philips ATP
- Bosch
- TNO
- OCE
- IMS
- MA3 Solutions
- Lionix BV
- BE Semiconductor Industries N.V
- CSEM
- Microcoat
- Sensitec
- SNECMA
- ARCELOR
- TQC
- Battenfeld
- IDEKO
- Crown Biosystems
- Rolls Royce
- SMH
- Beckhoff
- Flexlink
- IEF Werner
- Feintool
- Lagniel
- Anter Ltd
- 2M engineering
- IVAM
- ACI-group

Roadmap structure

Market sectors

Military/Aerospace
Consumer/Entertainment
Automotive/Transportation
Medical/Pharmaceuticals
Pollution control
Communications
Clothing/Textiles
Construction
Food and Drink
Computers/Business
Energy/Water/Chemicals
Agriculture/Fisheries/Forestry
Security
Other

Products

Micro-electromechanical
Micro-optic
Bio/Genetic
Micro-fluidic
Micro-RF/microwave
Micro-magnetic
Nano-surfaces
Nano-particles
Nano-machines
Nano-patterns
Micro-electronic
Gas/chemical sensing
Micro-acoustic
Other

Production Equipment

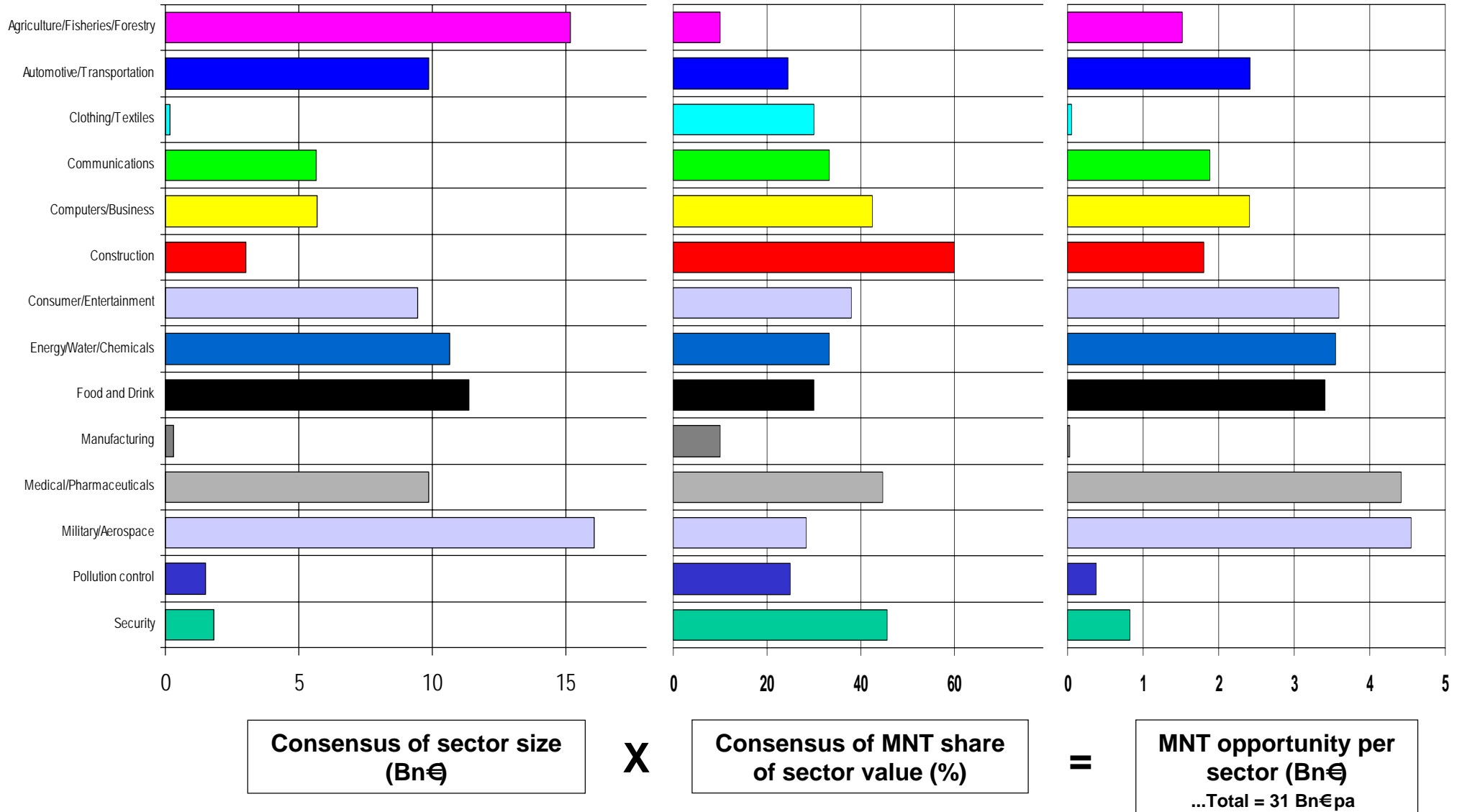
Actuators and drives
Moulds
Tooling
Fixtures, Grippers, Feeders
High precision linear stages
Sensors
High precision machine tools
Control and Vision
Cells
Micro factory
Imaging
Energy beams
Nanotooling
Nanosensors
Biorobotics
Nanorobotics
Nanofactory
System Integration
Design & Simulation
Test, inspection, characterisation
Other

Process Technology

Micromachining
Microfabrication
Microforming
Micro-growth
Micro-surface processing
Materials / Smart materials
Microjoining
Printing
Etching
Casting
Self-assembly
Lithography
Laser technology, additive
Laser technology, subtractive
Focused Ion Beam technologies
Metrology/Inspection
Packaging/Integration
Nanoindentation/nanostructuring
Nanoimprint
Nanocoating processes
Nano materials
Nanointegration
Other

- Contributors put forward 105 views regarding 14 Market sectors
- Questionnaires sought:
 - Summaries of the issues regarding the introduction and exploitation of MNT into different market sectors
 - Coarse estimates of the market value of EU production in each sector and the proportion of this value represented by MNT
 - Forecasts of the uptake of MNT in each sector over the period 2006 to 2016+
 - An estimation of the MNT technologies that will predominate in each sector

Comparison of the MNT opportunity per sector



Sector characteristics

Sector () Number of contributions

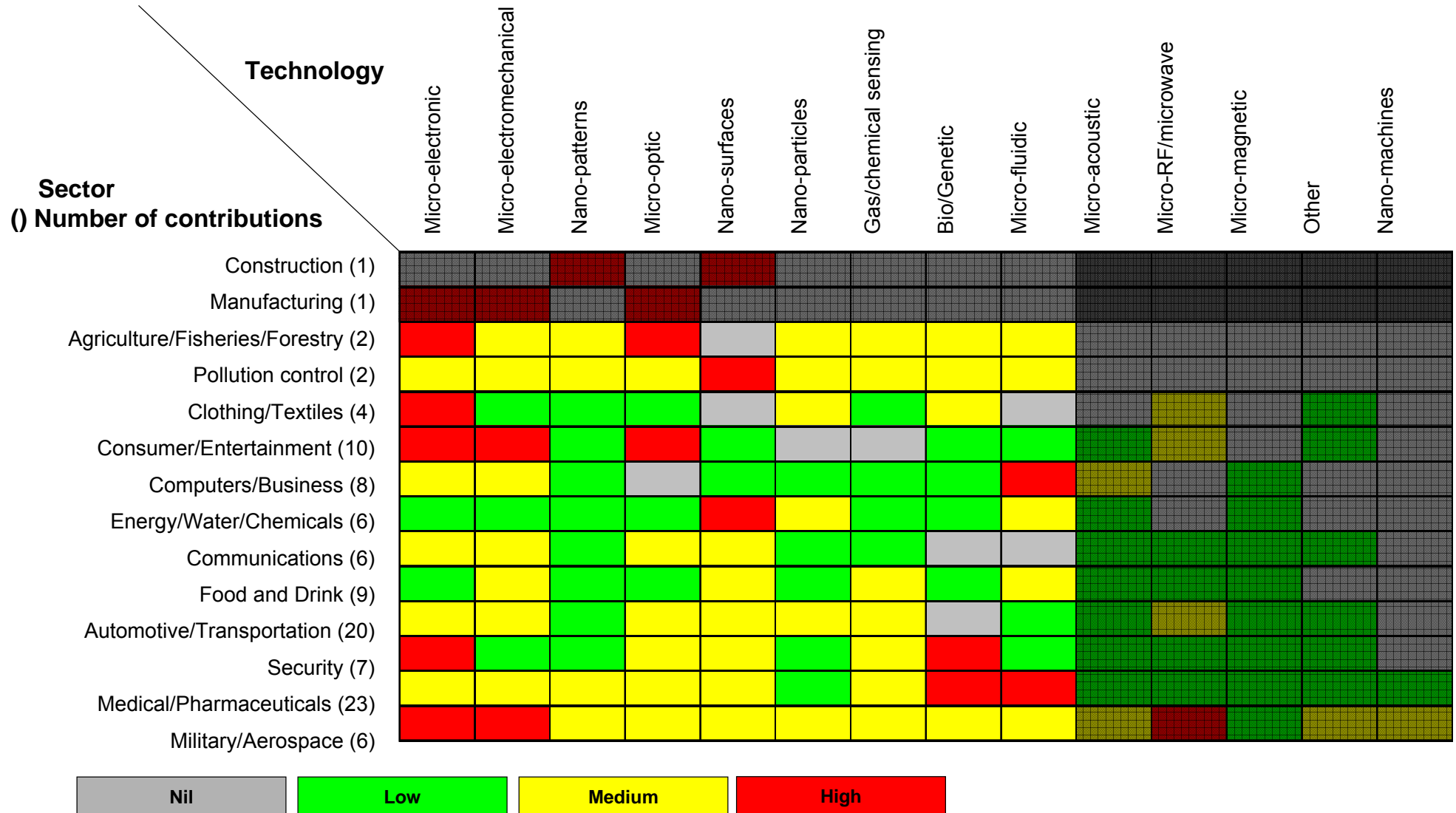


Market impact of MNT per sector

Sector () Number of contributions



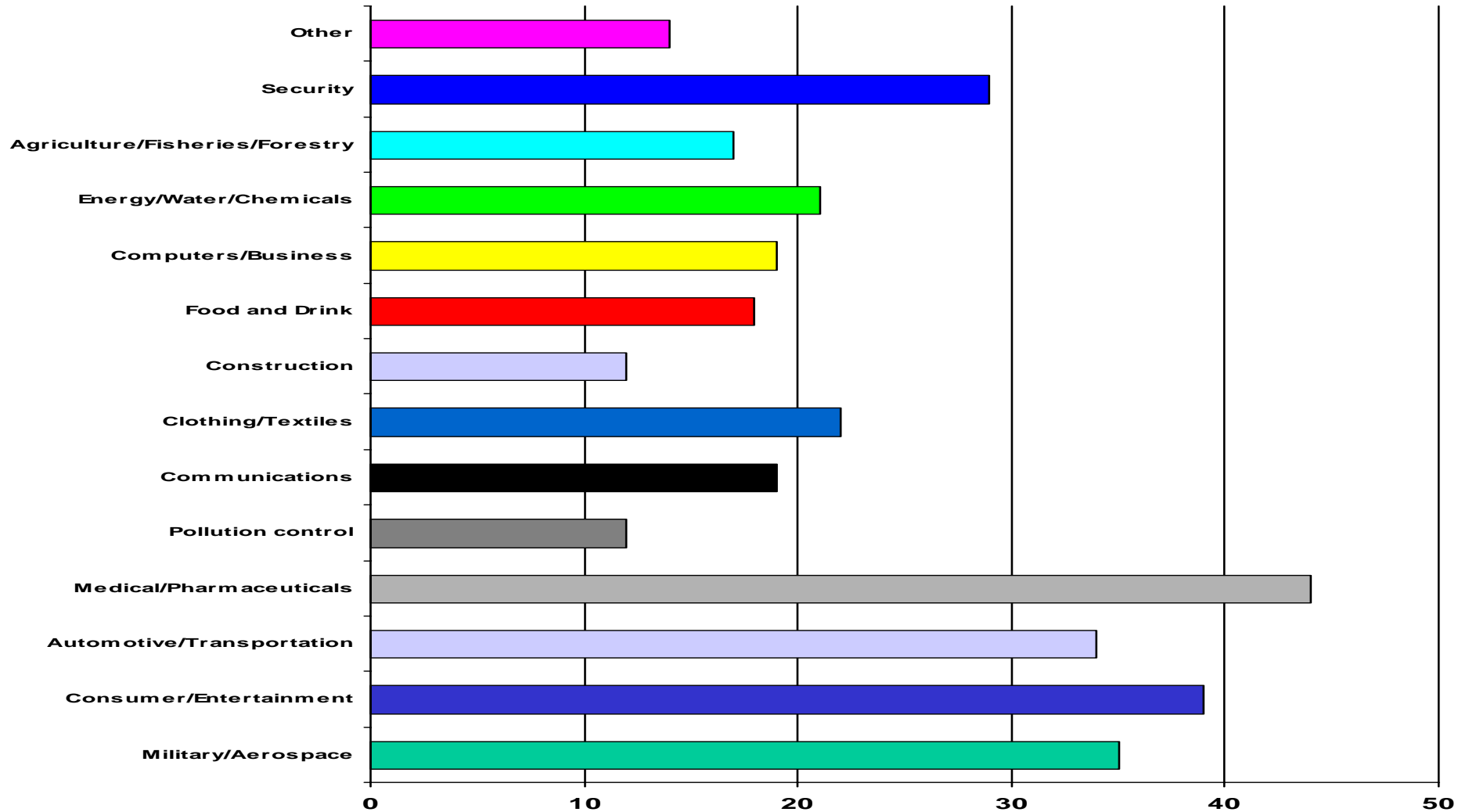
Projected use of MNT per sector (sorted)



Product forecasts

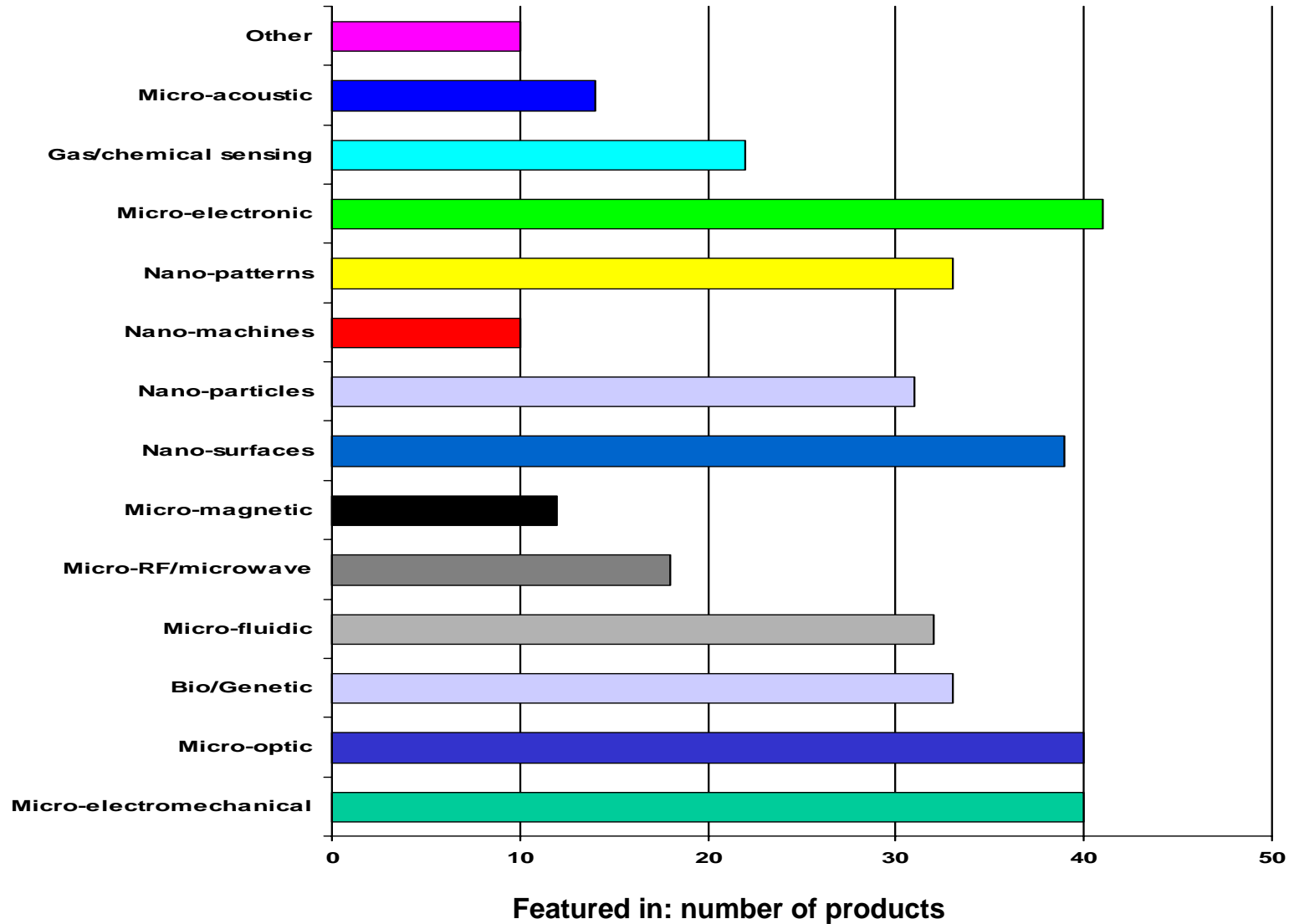
- Contributors put forward 86 views regarding potential products using MNT across 14 market sectors
- Questionnaires sought:
 - Suggestions for product developments - enhancements or entirely new products - that may be enabled by MNT
 - Coarse estimates of the market value of EU production for each product and the proportion of this value represented by MNT
 - Forecasts of the uptake of each product over the period 2006 to 2016+
 - A rough selection of the MNT technologies that will be used in the product
 - An idea of the market sector or sectors in which the product will be sold

Product suggestions: Target markets



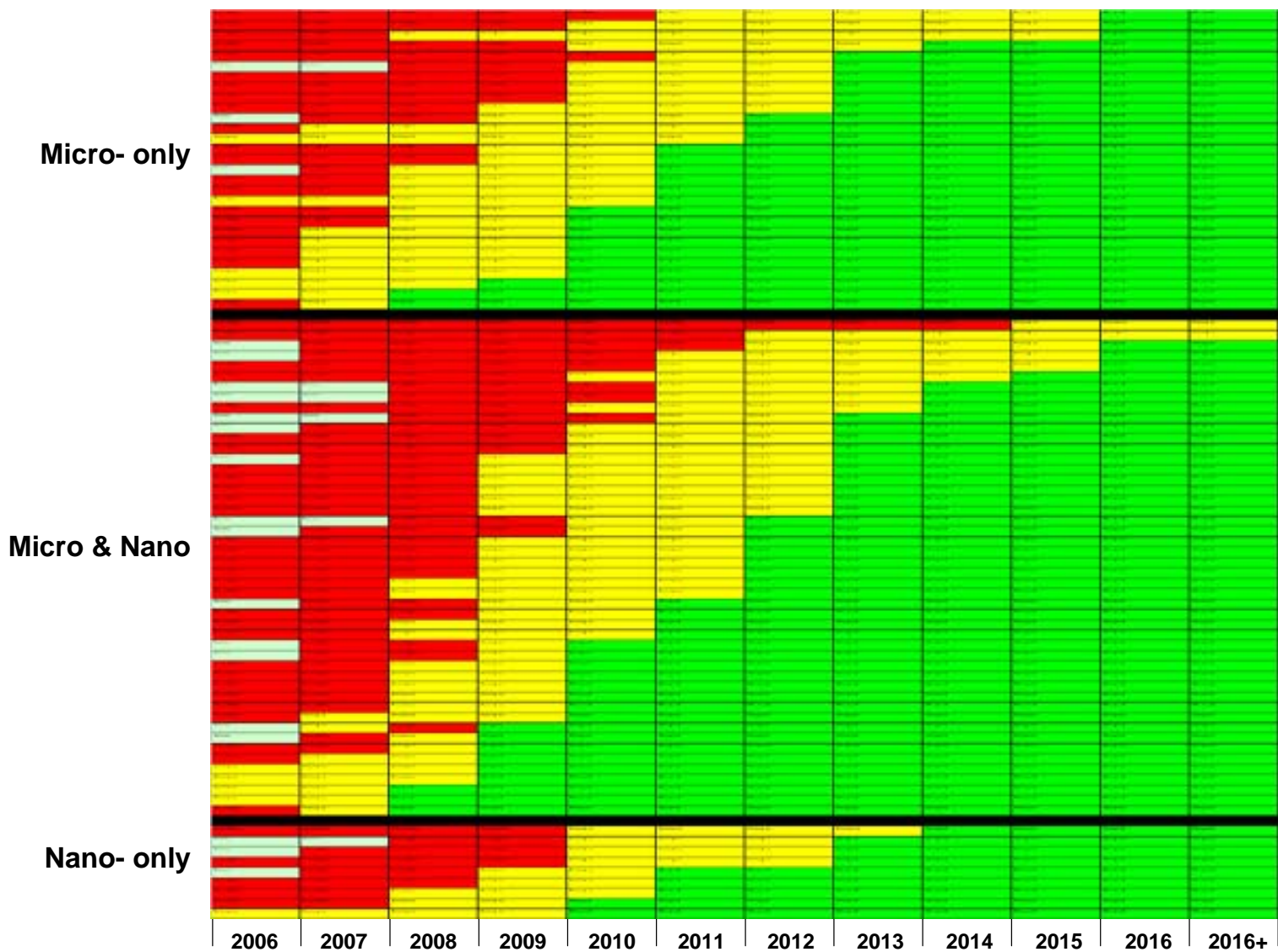
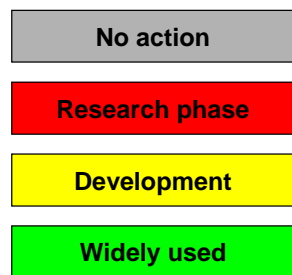
Number of suggested product developments
(Note: A single product may be sold across several markets)

Product suggestions: Technology content



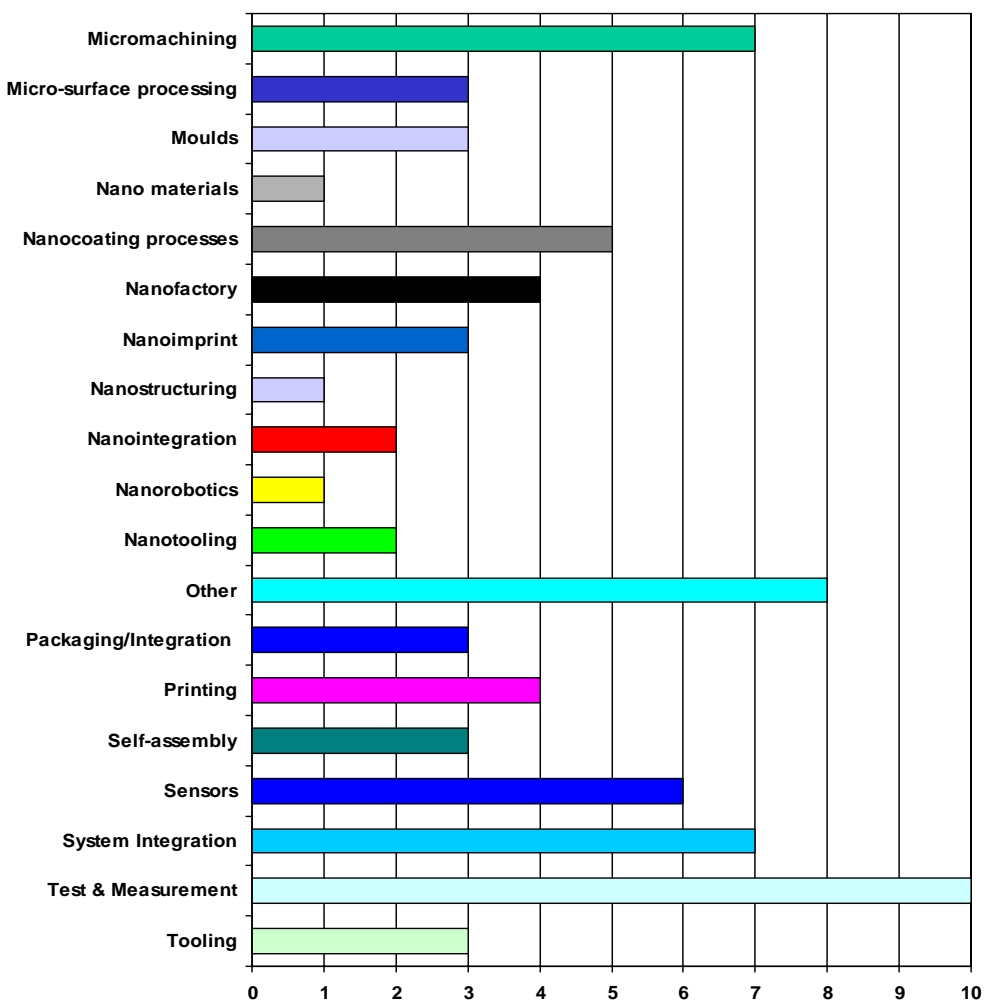
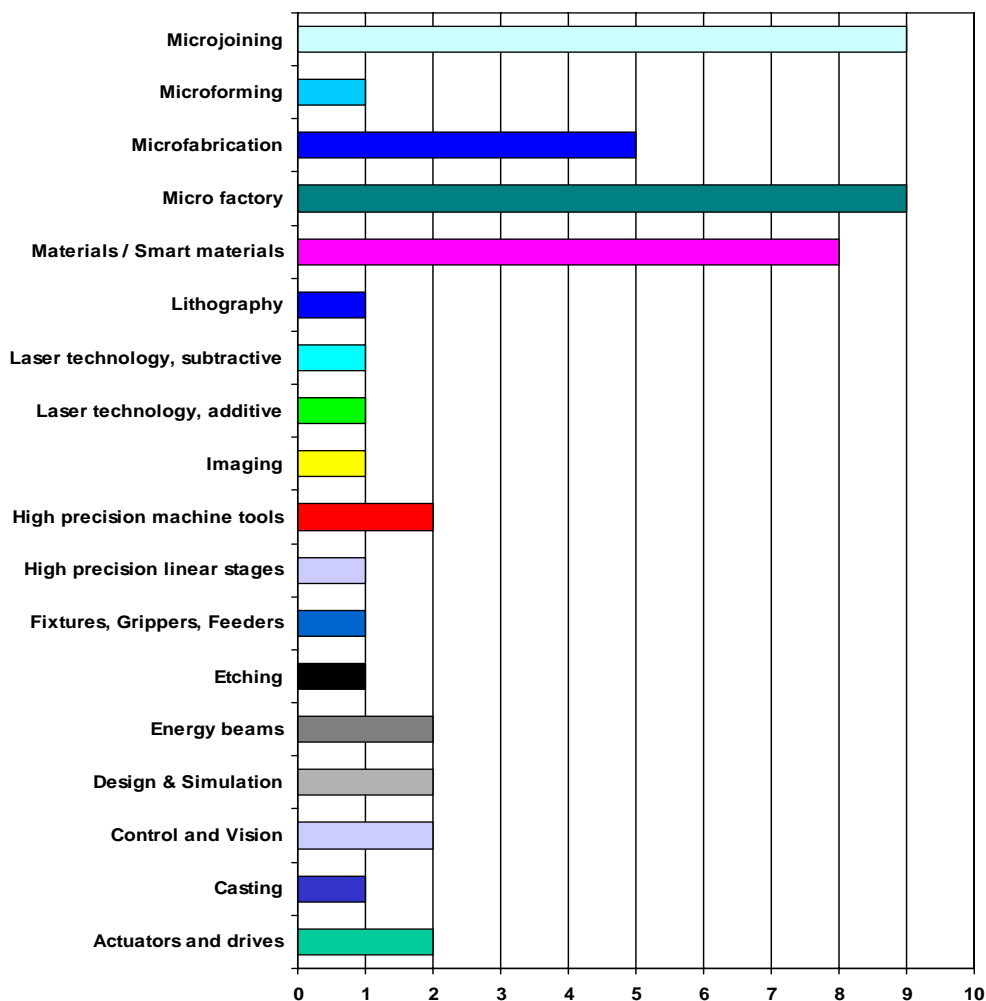
Projected introduction of new products using: Micro- only / Micro + Nano / Nano- only

Contributions in each category ranked by timescales



- Contributors put forward 126 project proposals, 62 regarding research into MNT equipment and 64 concerning research into MNT process technologies
- Questionnaires sought:
 - Suggestions for projects to develop MNT production assembly and test equipment
 - The drivers, difficulties and resulting capabilities that characterise the research, and whether it builds upon, depends upon and/or enables other projects
 - The technologies that will be applied as a result of the research and the market sectors that will be supported
 - An idea of the budget required for the topic, and the research phasing over the period 2006 to 2016+
 - Whether each suggested research project is “necessary”, “enabling” or “speculative”, whether it is short, medium or long term, and to gauge the level of its market impact

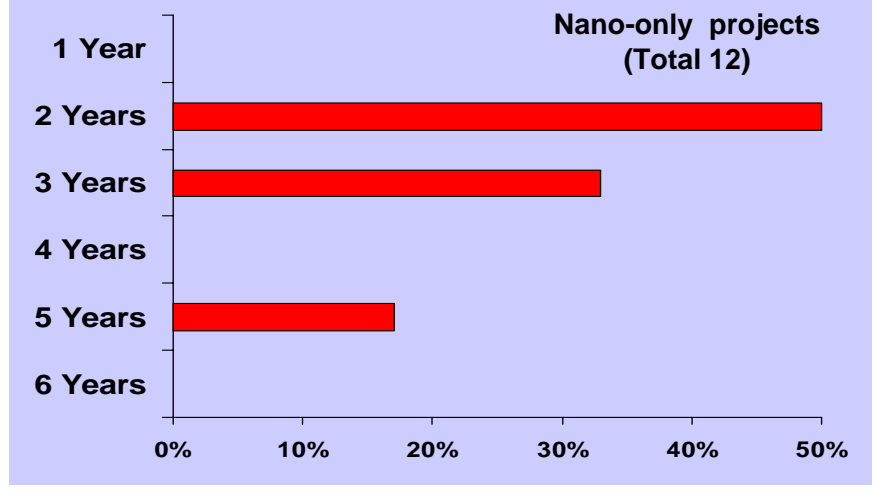
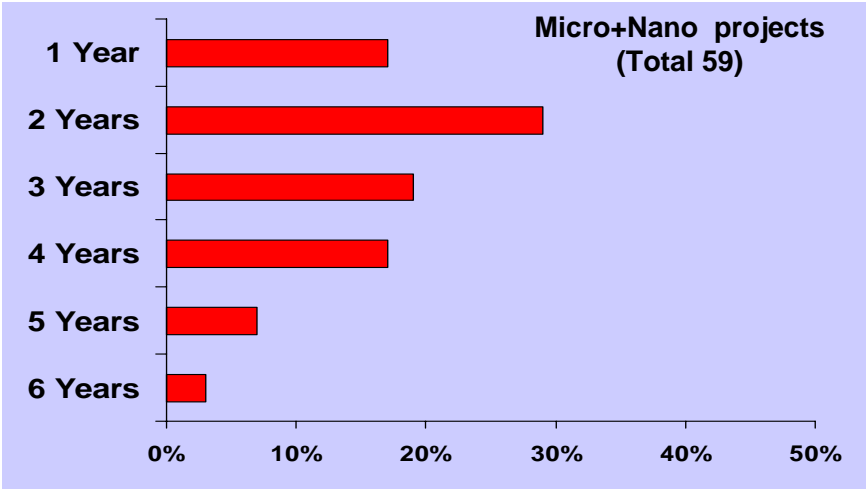
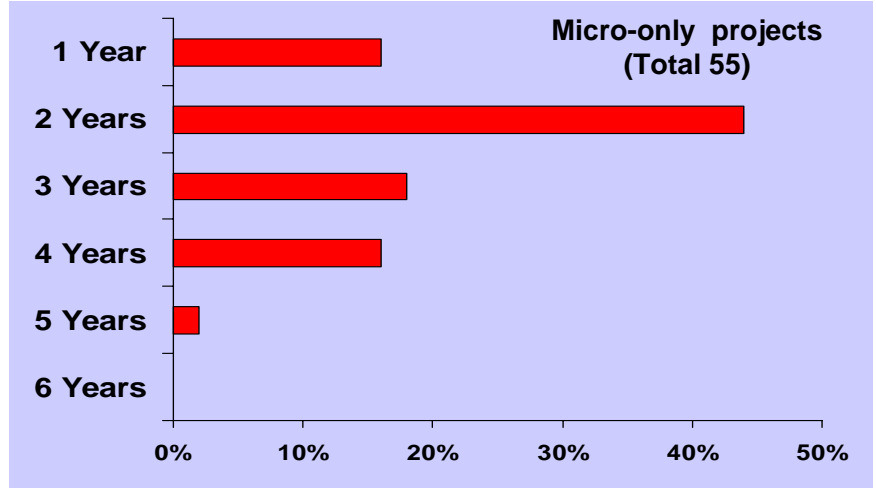
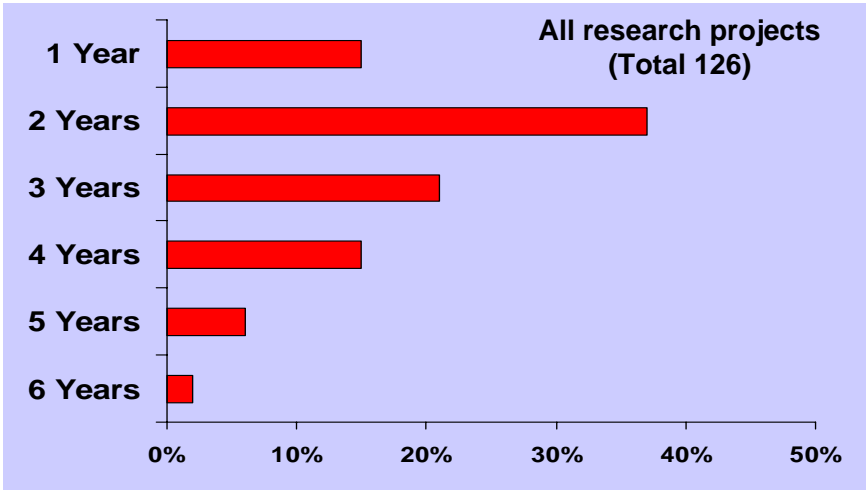
Sample research projects: Frequency of primary topics from 126 suggested projects



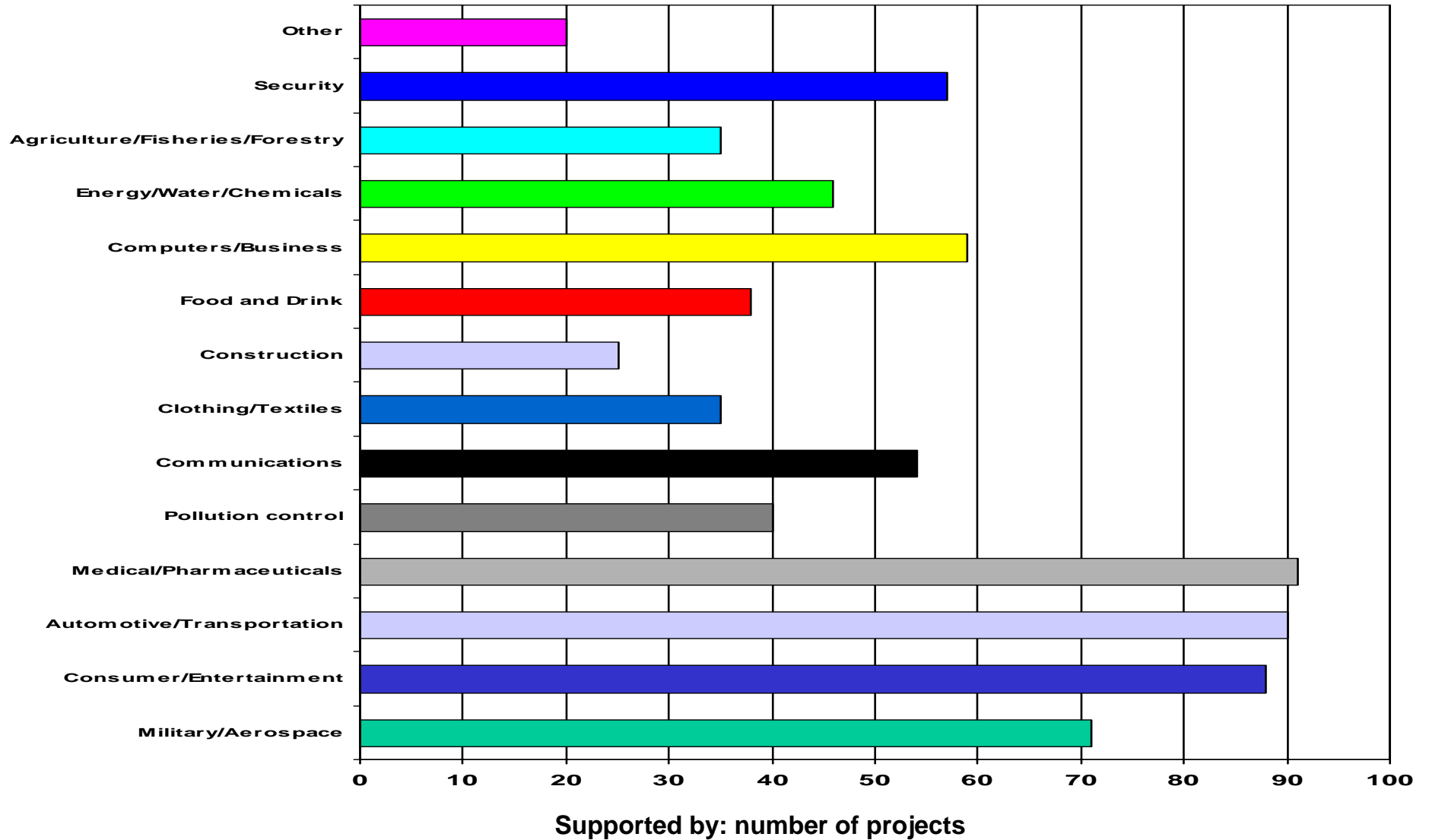
■ Except for the widely-defined topics, primary interests are spread very evenly



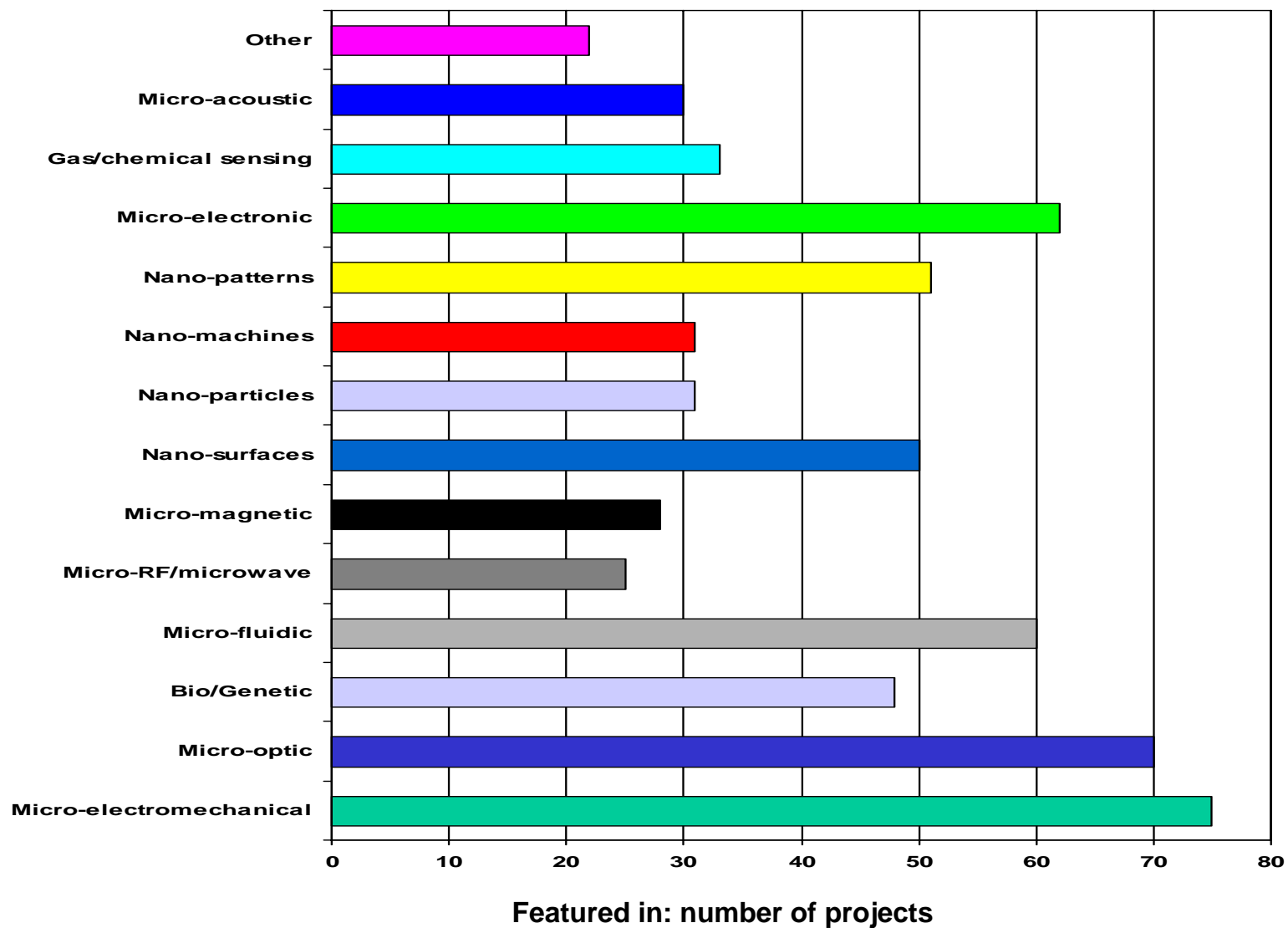
Research projects: Distribution of estimated duration



Research projects: Market sectors supported



Research projects: Technology Content



- A comparison of the number of projects suggested in each Primary Category of research against estimated Cost reveals an underlying opinion of which are the major research themes
- This is not to say that categories which attracted few suggested projects should not be supported, but rather that there were fewer research opportunities seen in those areas by the workshop contributors

Major research themes (1)

Primary Category	<1m€	<10m€	<100m€	>100m€
Microjoining	Improved micro joining techniques Micro joining of small parts	Interconnections Micro / nano dispensing Adhesive application technology Lead free micro/nano soldering Micro assembly snap-in	Micro/Nano Fusion as applied to assembly / joining	
Sensors	Optical laser control system	Sensors monitoring functional modes Electric fluidic die to substrate bonder	Low cost sensor	
Nanocoating processes		Structured Coatings Coating technology	High added value coating Hybrid process system (plasma / wet process) Roll to roll surface treatment.	
Materials / Smart materials	Chip to Substrate connection Optical plastic surviving soldering process	Smart Cap Smart Textiles Aspheric glass moulds surviving 800K to 1M shots Smart Materials for Self Heating PZT Deposition		
Self-assembly	Cheap Operators and maintenance	Design for replication		

- Large and small projects were suggested within these categories of research

Major research themes (2)

Primary Category	<1m€	<10m€	<100m€	>100m€
Micromachining	Drug Capsule Smart razor "wet"	Surface Machining Cheap handle wafer removal process Mult process micro machining factory Micro texturing	Micro and Nano assembly	
Micro factory	Desktop factory	Manufacturing Automation Wafer Batch Bonder Flexible fast micro assembly Microfactory	Micro nano soldering cleaning dispensing assembly. Replicator Nano Reactor Disassembler	
Moulds	Micro mould drug capsule	High precision replicator with low cost	3 x injection moulding.	
Test, inspection, characterisation	Measurement of optical properties relative to mechanical features.	Magnetic Imaging for The inspection of IC defects Test Equipment Standards for MNT related equipment High precision measurement system	Characterisation of nanostructures Laser process technology for MNT production Handling and logistics platform for MNT Micro fluidic channeling tools	

- Generally smaller projects were suggested within these categories of research

Secondary research themes

Primary Category	<1m€	<10m€	<100m€	>100m€
Micro-surface processing		New cleaning technologies for surfaces	Develop an MNT Diagnostic Instrument Simulation for Interface Chemistry	
Nanoimprint		Nano Imprint lithography for Quantum dots Nanostructures on large areas	Micro fluidics in Printing	
Nanotooling		Modularisation of automation	Nano plasma texturing surface equipment	
Packaging/Integration		Very high integration density electrical connections Assembling	Assembly and packaging of highly miniaturised sensor systems.	
Tooling		Ultra short pulse laser Dispensing systems for small volumes	Wafer independent shaping and assembly	
Printing	Electronics Printing on ceramics	High Accuracy printing for Reel to Reel production Submicron Printing High precision printing		
Control and Vision	Nano Assembly	Quality control of particle contamination.		

- There were no very large projects suggested within these categories of research, and fewer proposed research ideas in each category

- Actuators and drives
- Control and Vision
- Etching
- High precision linear stages
- High precision machine tools
- Imaging
- Lithography
- Microfabrication
- Microforming
- Micromachining
- Moulds
- Nanofactory
- Nanorobotics
- Nanotooling
- Sensors
- System Integration
- Test, inspection, characterisation
- Tooling

- Casting
- Design & Simulation
- Energy beams
- Fixtures, Grippers, Feeders
- Laser technology, additive
- Laser technology, subtractive
- Materials / Smart materials
- Micro factory
- Microjoining
- Micro-surface processing
- Nano materials
- Nanocoating processes
- Nanoimprint
- Nanoindentation/nanostructuring
- Nanointegration
- Packaging/Integration
- Printing
- Self-assembly

- Justifying an investment - plant, people, a research project, or even a whole research programme - should rest heavily upon a plan which puts forward a compelling economic argument and the wider context which will make the investment an attractive and successful proposition
- The roadmapping work within μ -SAPIENT makes this justification by:
 - Summarising the issues and timescales regarding the introduction and exploitation of MNT into different, quantified, market sectors
 - Testing these issues through the suggesting of products benefiting or enabled by MNT, with estimates of their sales values and timing for introduction
 - Assessing the MNT technologies that will predominate in each sector
 - Identifying the research that must be done to underpin economic development through MNT, with an estimate of timescales, costs and emphasis
- This is truly an MNT business plan for Europe

Manufacturing NanoMaterials

Nanophased particles production & functionalisation

Bulk integration

Nanophased particles production & functionalisation bulk integration

Manufacturing NanoSurfaces

Nanostructuring and coating of surfaces

Surface functionalisation and nanolayering

Manufacturing Micro-Components

Technologies for (micro/nano) components and devices

Volume production processes

Assembly and integration processes

Micro- and Nano Manufacturing Systems and Platforms

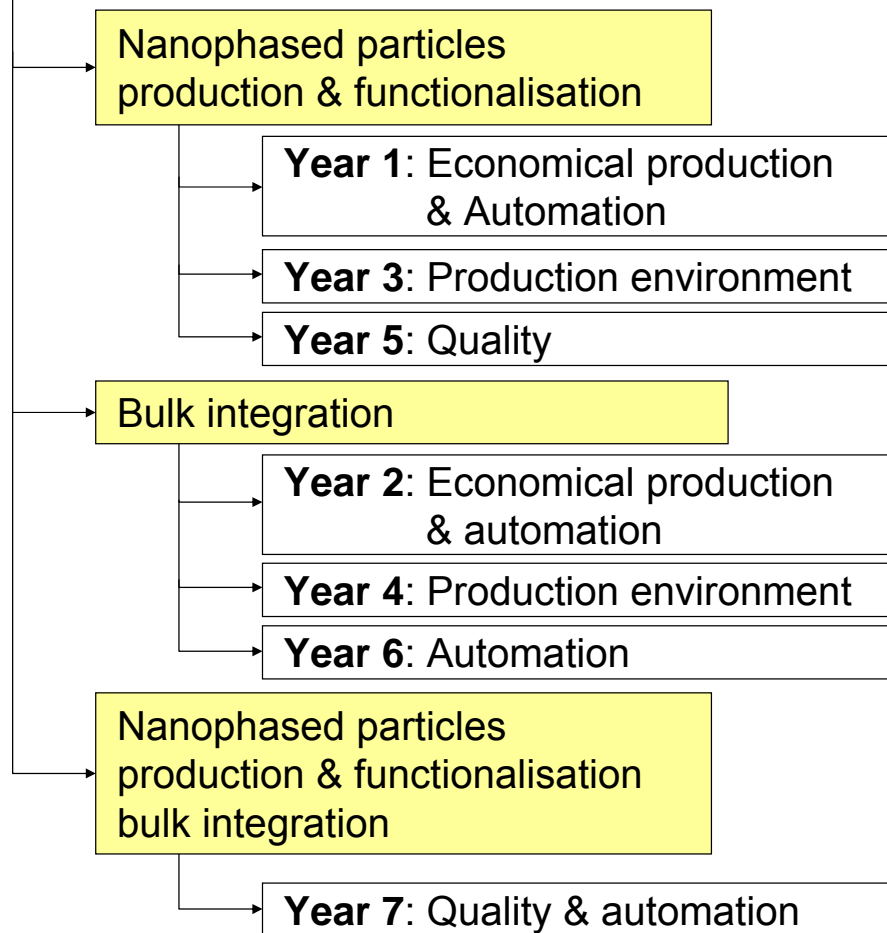
Knowledge based fabrication

Development and implementation of scalable, intelligent and modular meso-, micro- and nano- manufacturing systems

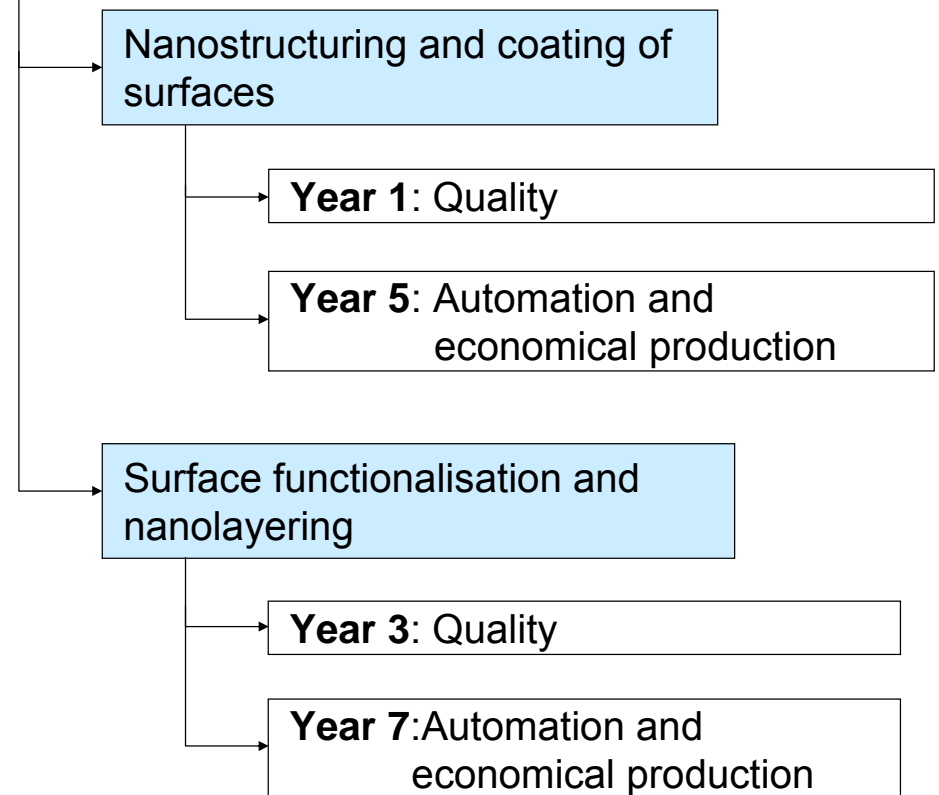
Integrated platforms

... to production lines

Manufacturing NanoMaterials



Manufacturing NanoSurfaces



Micro- and Nano Manufacturing Systems and Platforms

Manufacturing Micro-Components

Technologies for (micro/nano) components and devices

Year 1/4: multi-material meso/micro components and devices with micro and nano scale functional features

Volume production processes

Year 2/5: enabling volume production process chains for development of high throughput micro-manufacturing platforms

Assembly and integration processes

Year 3/6: Micro-assembly processes for multi-functional multi-material meso-micro devices

Knowledge based fabrication

Year 1: Design, modelling and simulation of specific knowledge of the micro- and nano domain

Year 4: Fabrication environment under clean and safe conditions

Development and implementation of scalable, intelligent and modular meso-, micro- and nano- manufacturing systems

Year 2: Intelligent, scalable, adaptable manufacturing systems and platforms

Year 3: Flexible, modular and knowledge based manufacturing system architectures

Year 6: Integrated solutions for reliability, quality, safety, standardization

Integrated platforms

Year 3 and 7: Integration in specific and cross-domain sectors

Year 5: Collaboration (esp. SME production networks)

