NANOINDUSTRY RISK ASSESSMENT DURING GLOBAL ECONOMIC SLOWDOWN

ELENA LĂCĂTUȘ
POLITEHNICA University of Bucharest, Romania

Abstract: Each year Nanotechnology gains new potential uses becoming wider and wider; accordingly, the public awareness increases regardless lack of legislation, standardization or clear ethical limitations. Nourished till recently through Glocalization by numerous worldwide stakeholders, the nowadays Nanoindustry becomes in the actual Economic slowdown a real struggle for gaining customers and trading areas. Nanotechnology is already changing definitions not only on Materials' Science and technologies, but also on Politics, Economy and Industry. This paper presents some of these new approaches, their possible effects on selectively informed customers as well as the means for effectively addressing these emerging risks.

Keywords: Nanoindustry, nanomaterials, risk, nanosized included lifecycle,

1. INTRODUCTION

If it would be necessary to distinctly characterize nanoindustry, the key issues that will firstly enters on this complex equation would be, for the real part: interdisciplinary area; highly-top qualified personnel; pioneering technological solutions; intellectual property; unpredicted lifecycle evolution; potentially unknown risks; explosive growth; fiercely market competition going globally. As long as the imaginary part of the equation is already collecting peoples' dreams, curiously gathering: researchers, physicists, politicians, economists, engineers, doctors, educators, traders, scientists, entrepreneurs, etc.

This might be the main equation of tomorrow's life on Earth, given that from Far East Japan to Far West America and from Norway to Australia thousands of billions of different currencies are spent yearly on a competition of urgently reshaping our entire known world. At last, all that scientists only dreamed about for years, nowadays seems to become possible due to the coming nano-Industrial Era.

Academics are still searching proper terms to define the area or to recognize the authority on the already gained knowledge, meanwhile nanoengineered products are already on the market, and even more, manufacturers are educating their future customers. Through Internet NanoBIZ goes globally, and manufacturers and traders are making their own 'Nanoterms Pocket Dictionary' for their business use.

Presently, there are dozens of potential definitions for the same 'nano' issues, beginning with nanotechnology (NT) itself, and there are even more 'nanoindustry Road Maps', each and every one settling different priorities for the next ten to twenty years.

'*Nanotechnology is the engineering of machines on a molecular scale—the projected ability to manufacture components, devices and complete products "from the bottom up" using techniques and tools being developed today to place every atom and molecule in a desired place'*

API NAnotronics Group

Even this definition could be 'good enough' for the company's future costumers it is still confusing the educated reader with the sole 'bottom-up' approach, excluding a wide area of 'top-down' applications that are not foreseen by the manufacturer.

Today, nanotechnology is a reality, as scientists have succeeded in producing nanomaterials in a number of ways. The most popular technique remains "downsizing," or creating a nanomaterial from the 'top down' (for example, by etching a silicon microchip).

Conversely, an example of a 'bottom-up' approach is the synthesis of carbon nanotubes using techniques like Chemical Vapor Deposition, which is familiar to all chipmakers. Nanoparticles can also be manipulated individually by special tools, such as the Scanning Tunnel Microscope (STM) and the Atomic Force Microscope (AFM), and their improved versions. Yet another method is to harness the power of

DNA to create a self-assembling nanoscale transistor, the building block of electronics.

The absence of a universally accepted definition of Nanotechnology (NT) allowed the research emphasis to broaden, so, the first major characteristic of the activities grouped under this section is that the current R&D cuts across a wide range of industrial sectors.

A study extended across more than 30 countries, aiming to examine the distribution of the interest on Nanotechnology activities and plans, shows that the most active is the US, with roughly one-quarter of all publications in the area, followed by Japan, China, France, the UK and Russia.

So, Nanotechnology is primarily about making things. Thus, many of the materials that follow, involve either bulk production of conventional compounds that are much smaller (and hence exhibit different properties) or new nanomaterials, such as fullerenes and nanotubes.

The market's range of nanomaterials are considerable, being estimated that, aided by Nanotechnology, novel materials and processes can be expected to have a market impact of over US$340 billion within a decade, despite of the actual economic slowdown.

Strategies on nanoindustry are settled by SMEs, as well as by stakeholders. As long as the US NNI published its Short Term - Strategic Plan (Fig.1) for nanomaterials and nanoproducts the Institute for Defense Analysis (US) anticipate *Long Term* evolution of Nanotechnology Deployment by sector (Fig.2)

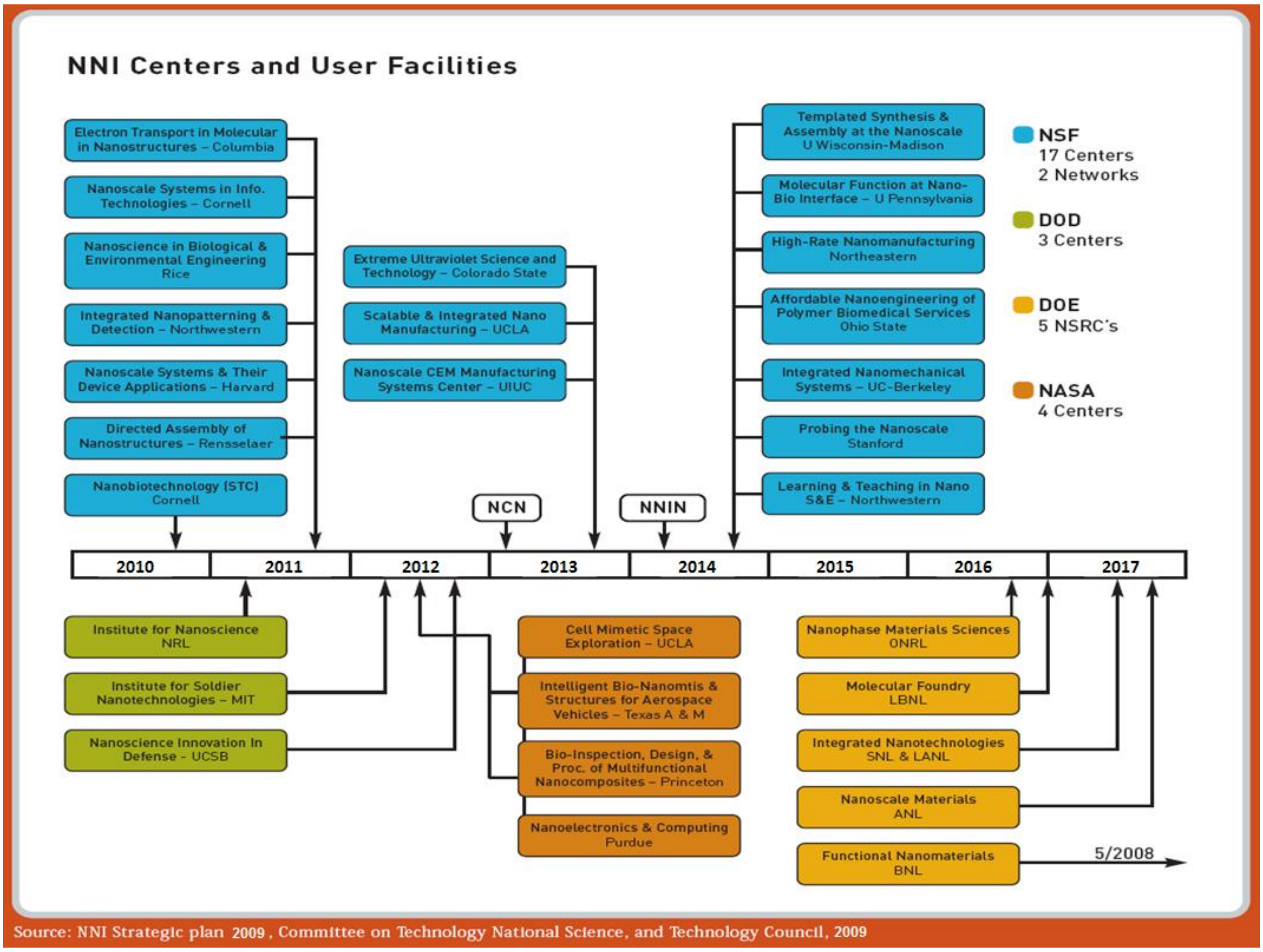


Fig.1 National Nano Initiative -Short Term Strategic Plan (USA)

Meanwhile, NASA R&D bodies settle their own Nanotechnology roadmap in the same geographic area. Very much alike are other documents that are settling EU Nanotechnology Roadmap up to 2020, Chinese, Russian, Australian, Japanese, and many others, scaling up to regional & international and scaling down to national level the NT's future.

Table 1 Nanomaterials and their Envisaged Applications

Material	Properties	Applications	Time-scale (marketable/ years)
Clusters of atoms			
Quantum wells	Ultra-thin layers - few nanometres thick - of semiconductor material (the well) grown between barrier material by modern crystal growth technologies.	CD players have made use of quantum well lasers for several years. Next generation of low-cost telecom & optics nanodevices.	Current - 5 y
Quantum dots	Fluorescent nanoparticles those are invisible until 'lit up' by ultraviolet light. They can be made to exhibit a range of colors, depending on their composition.	Telecommunications, optics.	7–8
Polymers	Organic-based materials that emit light when an electric current is applied to them and vice versa.	Computing, energy conversion.	Yet unknown
Grains that are less than 100nm in size			
Nanocapsules	Buck minster fullerenes are the most well known example. Discovered in 1985, these C60 particles are 1nm in width.	Many applications envisaged, e.g. nanoparticulate dry lubricant for engineering.	Current - 2 y
Catalytic nanoparticles	In the range of 1–10 nm, such materials were in existence long before it was realized that they belonged to the realms of Nanotechnology.	Wide range of applications, including materials, fuel and food production, health and agriculture.	Current
Fibers that are less than 100nm in diameter			
Carbon nanotubes	Two types of nanotube exist: the single-wall carbon nanotubes, the so-called 'Buckytubes', and multilayer carbon nanotubes. Both consist of graphitic carbon and typically have an internal diameter of 5 nm and an external diameter of 10 nm.	Many applications are envisaged: space and aircraft manufacture, automobiles and construction. Multi-layered carbon nanotubes are already available in practical commercial quantities.	Current - 5 y
Films that are less than 100nm in thickness			
Self-assembling monolayers (SAMs)	Organic or inorganic substances spontaneously form a layer one molecule thick on a surface. Additional layers can be added, leading to laminates where each layer is just one molecule in depth.	A wide range of applications, based on properties ranging from being chemically active to being wear resistant.	2–5 y
Nano-particulate coatings.	Coating technology is now being strongly influenced by Nanotechnology. E.g. metallic stainless steel coatings sprayed using nanocrystalline powders have been shown to possess increased hardness when compared with conventional coatings.	Sensors, reaction beds, liquid crystal manufacturing, molecular wires, lubrication and protective layers, anti-corrosion coatings, tougher and harder cutting tools.	5–15 y
Nanostructured materials			
Nano-composites	Composites are combinations of metals, ceramics, polymers and biological materials that allow multi- functional behavior. When materials are introduced that exist at the nanolevel, nanocomposites are formed, and the material's properties - e.g. hardness, transparency, porosity - are altered.	A number of applications, particularly where purity and electrical conductivity characteristics are important, such as in microelectronics.	Current - 2 y
Textiles	Incorporation of nanoparticles and capsules into clothing leading to increased lightness and durability, and 'smart' fabrics.	Military, lifestyle.	3-5 y

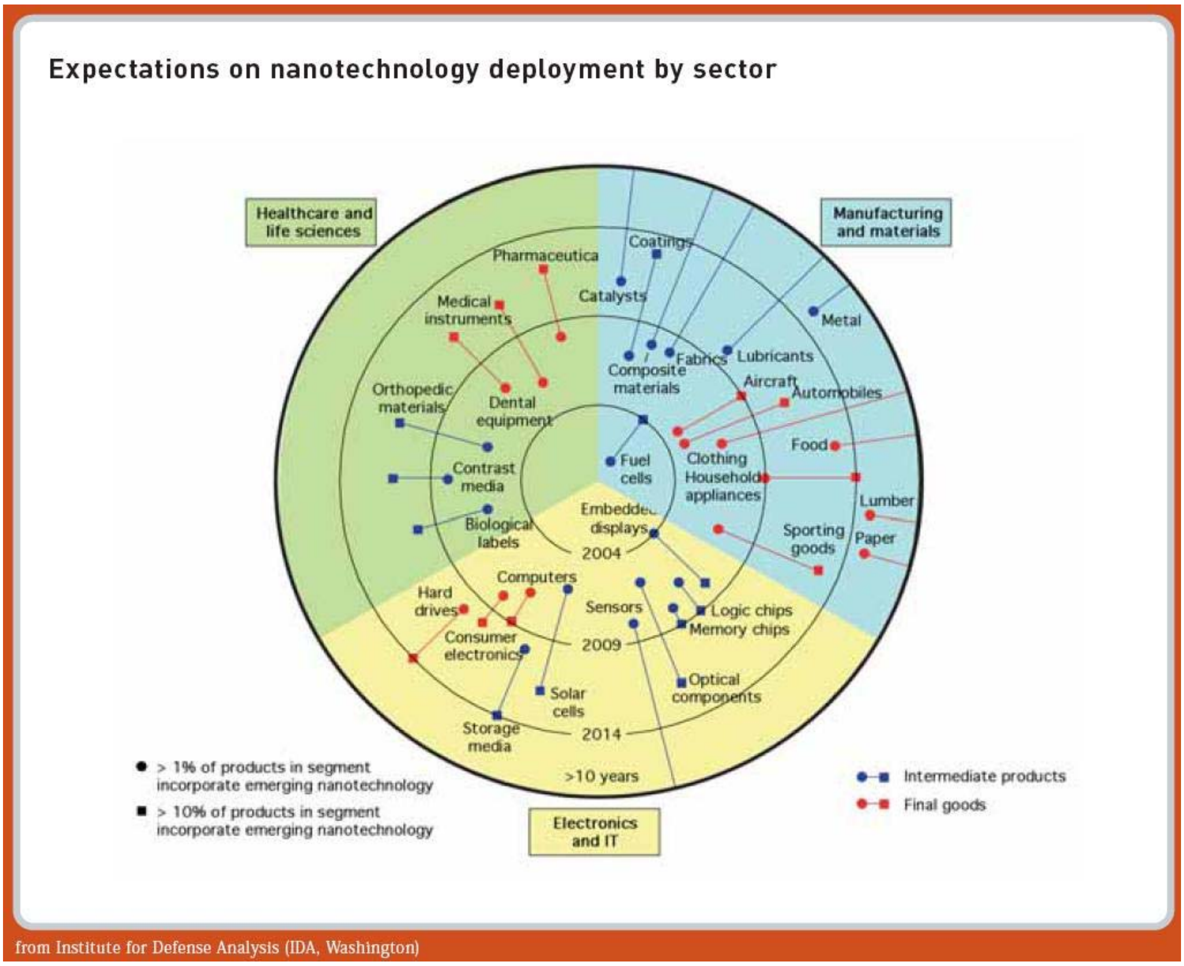


Fig.2 Long term evolution of Nanotechnology deployment by sector (Institute for Defense Analysis - USA)

2. NANO BUILT-IN PRODUCTS

Facing the constant time and cost cutting pressures, innovation remains the sole key to new products' success. So, in order to increase their sales growth and profitability, more companies are beginning to reassess their priorities, developing customers before products. That explains the extreme care about the costumers' thorough training on Nanotechnology, conducted by almost every manufacturer dealing with nanomaterials, or producing with nanotechnologies, advertising or selling on internet. So, the new realities the companies should take into account to be competitive are: Shortening Lifecycle's 'incubation period'; Globalization of world economies; Globalization of technologies; Shift on emphasis from manufacturing to knowledge-based economies. Global sourcing and lean[1] production have standardized this state of affairs, the result being products characterized by indefinite quality level.

The specific *nanoindustry* flourishes glocally[2] for several years while its basic nanoproducts properties are far from being characterized along their entire life cycle. The applications area wideness despite the obvious 'black holes' regarding the long time exposure effects upon humans or environment, possible toxicity of debris, effects of inhalation or ingestion of nanoparticles during successive layers applications or during prolonged contact with solvent (water).

Meanwhile, the first brief Dictionary of Terms for Nanotechnology appears only several months ago, as well as EPA Nanotechnology White Paper[3]. So, 'educated costumers' are informed mainly by nanoproducts' companies through specialized websites and blogs arising continuously and making nano-terms and nano-rules to be more and more difficult to be established each day passing.

3. IDENTIFICATION OF DECISION MAKERS

There is a specific format of a map of the decision-makers involved in planning and implementation of transportation (for example, fig.3) of hazardous goods. To effectively plan an organization to include proactive risk management, the actual, co-operative structure should be matched to the control requirements (production as well as safety) posed by the work space. A review of the criteria governing role allocation in an adaptive organization is therefore useful here, addressing nanoindustry hazards.

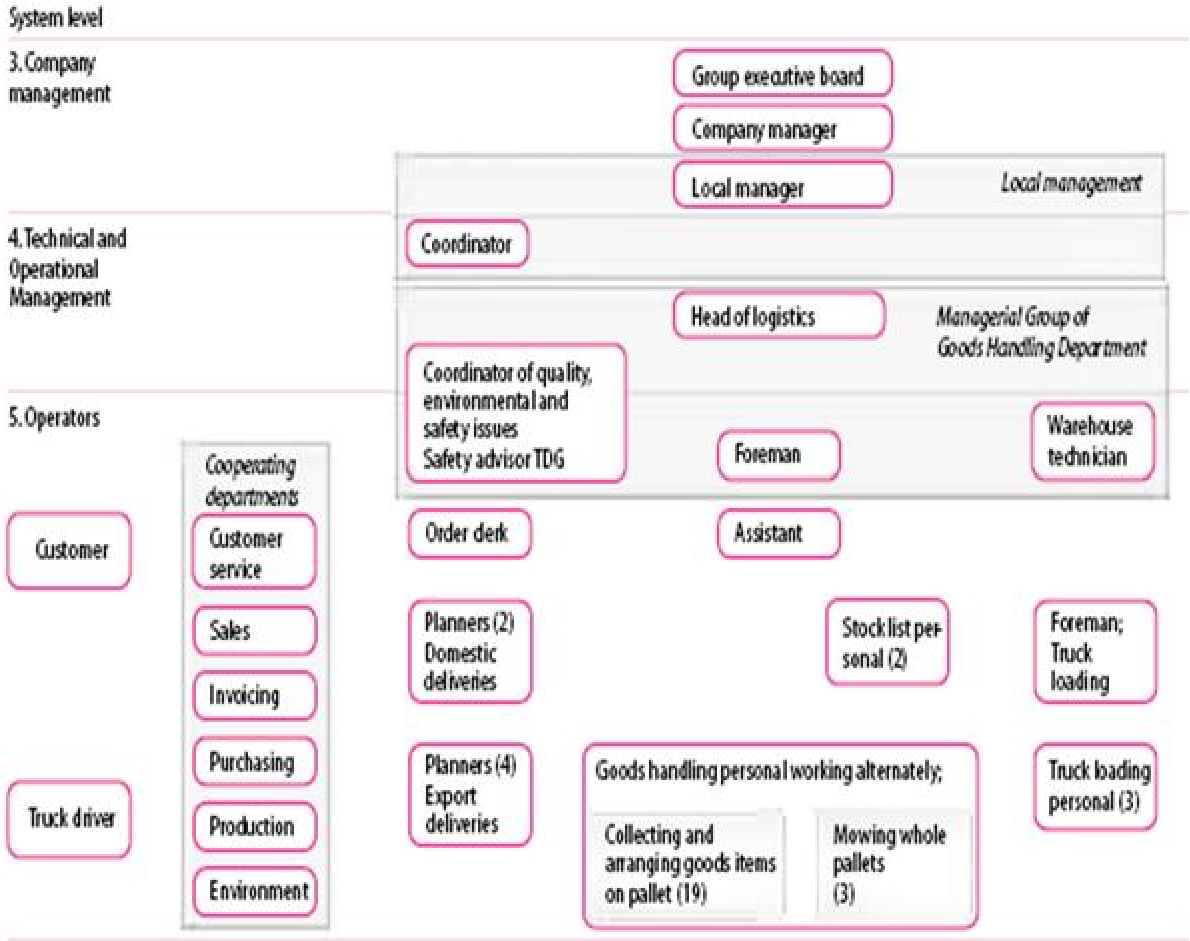


Fig.3 Sample map on planning transportation of hazardous nanosubstances (proactive risk management)

3. IDENTIFICATION OF CONTROL SPACE: ROLE ALLOCATION

A work place typically involves many loosely coupled activities and, therefore, requires co-ordination by an integrated control function in order to perform in a concerted way. Information processing involved in decision-making in an organization serves this purpose, even more for those organizations dealing with nanomaterials. Acceptance of this systems point of view implies that the functions of decision-making and the structure of the involved organization cannot be modeled or planned without considering the basic system function (process plant properties, manufacturing processes, security issues, etc.) which the decision making is intended to control.

Consequently, there are organizational aspects to be addressed from two different points of view (Fig.4):

1. The *functional work organization* required to co-ordinate activities will be determined by the control requirements of the work domain (using appropriate taxonomy of the materials and technologies). This functional organization will determine the

allocation of roles to the individual actors and the contents of the communication required for coordination.

2. On the other hand, *the social role configuration* chosen by or imposed upon the individuals and/or teams depends on the management style which, in turn, influences the form chosen for the communication and social interaction within the functional team or organization (the real risk-reaction speed and system effectiveness assessment)

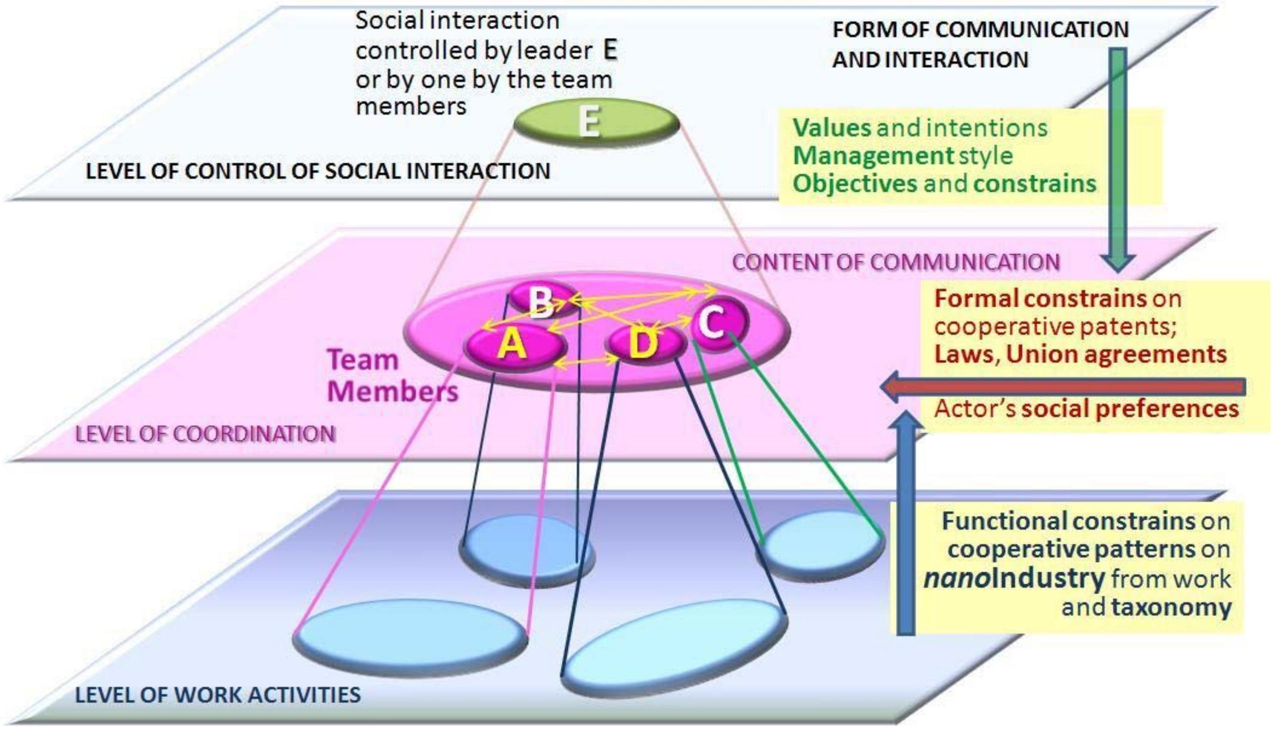


Fig.4 Integrated control for organizations dealing with nanomaterials

4. CONCLUSION

The *functional work organization* in this very specific area of *nanoindustry* is emerging from the interaction between the bottom-up propagating control of the work-space and the top-down propagation of requirements social practice (settled elsewhere) and management style. There are four agents or decision-makers (Fig.4) each allocated particular, but overlapping 'activity windows' overall work domain.

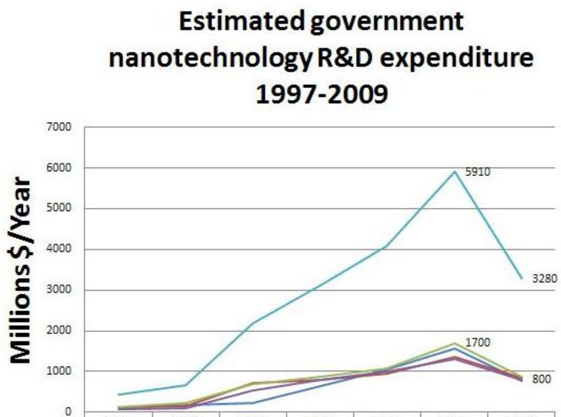
The structure of the communication net and content of the communication and, therefore, the actual work organization is determined by the control requirements of the work domain that urgently must be settled to address *the nanoindustry* specificity.

The social organization, in contrast, is determined by the conventions chosen for the form of the communication, which depends on the 'management style' or 'culture' particularities.

The control requirements of a work domain change over time as will the functional work organization, mostly in a booming area as NT. A particular division of activities and, consequently, a functional work organization will evolve for each situation depending on the competencies of the actors, the 'technology' of the work domain and on the external environment of the organization.

Studies show that, even in traditionally tightly controlled organizations such as the military and high hazard process plants, the actual co-operative structure changes dynamically to match the actual circumstances and therefore a framework for modelling must be able to capture this adaptive feature. In the actual work situation, ways to allocate work roles to the individual actors will depend on several criteria: Norms and Practice; Load-sharing; Functional de-coupling. Competency. Information access. Safety and reliability- for work in a domain posing a hazard to the staff, the investment, or the environment, safety criteria, such as

functional redundancy, are governing role allocation.
These criteria are often competing and their influence change with time governed by the control requirement of the work-space that must be enrolled for all *nanosized* particles' applications, from research laboratories to already ongoing *nanoindustry*.



	1997	1999	2001	2003	2005	2007	2009
EU+	126	179	225	650	1050	1560	780
Japan	120	157	720	800	950	1350	840
US	116	225	697	862	1081	1700	860
Others	70	96	550	800	1000	1300	800
Total	432	657	2192	3112	4081	5910	3280

Fig.5 Economic slowdown impact upon nanoindustry

In terms of investment, has to be noted that 'firms are facing dilemmas of where to invest, asking what the winning technologies are, and having problems with identifying them'. It appears that traditional cost-benefit analyses are complicated because of the apparently unique challenges facing the field and the difficulties associated with measuring the benefits against the risks.
The prime concern among investors has been to decide between their investment being a risk or opportunity. The central issue largely has been the inability to derive a framework that would establish a strong workable relationship between the three disparate aspects of technology-innovation, socio-ethico-regulatory concerns and financial decision making, largely because these factors are considered immeasurable.
Access to capital is considered the main constraint on commercialisation of nanotechnology and on the impact of nanoindustry and funding was considered the primary constraint on R&D activity. Worldwide, government incentives to industry are crucial to stimulating innovation, along with joint ventures and international co-operation.

REFERENCES

[1] GOLDMAN, L., NAGEL, R.L. and PREISS, K.: Agile Competitors and Virtual Organizations - Strategies for Enriching the Customer, Van Nostrand Reinhold, 2008.
[2] ROBERTSON, F. : ‚Nanomaterials: Promise or Peril?, Science Now, Daily News,17 August 2009
[3] **** International Council on Nanotechnology, University of California, Santa Barbara, Nanotech Survey, Full Report Phase Two Report: Survey Of Current Practices In The Nanotechnology Workplace Workers (Report 06/06/2009)

---

1 *Lean Manufacturing*- A philosophy of production that emphasizes the minimization of the amount of all the resources (including time) used in the various activities of the enterprise. It contains a set of principles and practices to reduce cost through the relentless removal of waste and through the simplification of all manufacturing and support processes.
2 *Glocalization*- as a term, though originating in the 1980s from within Japanese business practices was first used for the scale interactions from local-regional-global (or micro-meso-macro scale).
3 *EPA* - U.S. Environmental Protection Agency; EPA believes it is very important to develop sound risk assessment concerning nanomaterials before moving to the next step. The Agency then reiterates its desire to work with stakeholders to develop the necessary information to make educated decisions