Application of Foresight Methodologies

in the Nanotechnology Sector

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Outline

• What is **foresight**?

• How to design a **foresight process**?

• How to design a **foresight methodology**?

• How are foresight methodologies applied in the **Nanotechnology Sector**?

• What do we know about **Rusnano Foresight**?

• What do we know about **Foresight-based roadmaps**?
What is foresight?
Foresight is a process with key phases

Foresight is “a process which involves intense iterative periods of open reflection, networking, consultation and discussion, leading to the joint refining of future visions and the common ownership of strategies... It is the discovery of a common space for open thinking on the future and the incubation of strategic approaches”

(Cassingena Harper, 2003)

A more systemic look into the process was done by Miles (2002) who outlined five complementary phases: Pre-Foresight; Recruitment; Generation; Action; and Renewal.

[Diagram of the foresight process with numbered phases 1 to 5]

Source: Ian Miles
How to design a foresight process?
Foresight phases should be carefully planned

The Foresight Diamond

1. **Creativity**
   - Wildcards
   - Science fiction
   - Simulation gaming
   - Essay / scenario writing
   - Genus forecasting
   - Role play / acting
2. **Expertise**
   - Backcasting
   - SWOT
   - Brainstorming
   - Relevance tree
   - Logic chart
   - Scenario workshop
3. **Interaction**
   - Roadmapping
   - Delphi
   - Survey
   - Citizen panel
   - Expert panel
   - Morphological analysis
   - Conference / workshop
   - Key / critical technologies
   - Multi-criteria
   - Voting / polling
4. **Evidence**
   - Quantitative scenario / smic
   - Stakeholders analysis
   - Interviews
   - Cross-impact / structural analysis
   - Indicators / tsa
   - Patent analysis
   - Bibliometrics
   - Benchmarking
   - Extrapolation
   - Scanning
   - Literature review
   - Modelling

Methods relying heavily on the tacit knowledge of people with privileged access to relevant information or with accumulated knowledge.

Methods relying heavily on the inventiveness and ingenuity of very skilled individuals.

Methods relying heavily on the participation and shared views of experts and non-experts.

Methods relying heavily on codified information, data, indicators, etc.

R. Popper (2008)
How to design a foresight methodology?
Let us explore 2 demo cases with 6 methods

THE HANDBOOK OF TECHNOLOGY FORESIGHT

Concepts and Practice

Edited by Luke Georgiou, Jennifer Cassingena Harper, Michael Keenan, Ian Miles, Rafael Popper

PRIME Series on Research and Innovation Policy

http://www.e-elgar.co.uk/Bookentry_Main.lasso?id=3977
Methodology X (Forward)

- **Scanning**
  - Delphi
  - Wild Cards
  - Citizen Panel
  - Expert Panel
- **SWOT**
- **Wild cards**

**Evidence** + 
**Broad Expertise** + 
**Wild Creativity** + 
**Interaction** + 
**Local Expertise** + 
**Strategic Creativity**

Internal activity (possibly desk-work) aimed at identifying major synthesising outcomes in terms of current strengths and weaknesses as well as future opportunities and threats. Implications of main findings.

**Scanning**
Detailed analysis of main issues around a particular sector/theme of study (sub-contracted).
Methodology X (Backward)

- **SWOT**
  - Expert panels
  - Citizen panels
  - Wild Cards
  - Delphi

- **Scanning**

  - Large-scale activity (e.g. workshop) aimed at identifying strengths, weaknesses, opportunities and threats related to a sector / theme / technology / etc.

  - Strategic Creativity
  - Local Expertise
  - Interaction
  - Wild Creativity
  - Broad Expertise
  - Evidence

- **Wild cards**

- **Citizen Panels**

  - Internal activity aimed at identifying the success or failure of similar policy recommendations being implemented in comparable contexts, and internal activity aimed at identifying disruptive events and situations.
There are many methodology options, indeed!
What **methods** and **methodologies** are used in **Nanotechnology Foresight**?
Case 1: APEC study

Scope of the project
- Global

Main methods
1. Ten issues papers
2. Trends & Drivers
   - 29 experts
3. Workshops
4. Survey
   - Drivers
   - disruptions
5. Scenarios

Main results
- Alternative scenarios

Tegart, G. (2004), Nanotechnology: the technology for the twenty-first century, foresight, 6(6)

APEC identified 20 drivers using the STEEP:
1. society;
2. ageing population;
3. enhanced quality of life;
4. more effective health care;
5. technology;
6. scientific breakthroughs;
7. need for miniaturisation in production;
8. demands of information and communication technology industry;
9. economics;
10. novel/unique products to stimulate industry development;
11. investment in high technology;
12. rise of knowledge society;
13. environment;
14. clean and leaner production processes;
15. improved air and water quality;
16. new energy sources;
17. political;
18. national security issues;
19. changing patterns of S&T expenditure; and
20. public perception of technological change.

15 disruptive events changing the pattern of development of nanotech:
1. technical uncertainties;
2. nanotechnology fails to deliver;
3. inability to solve standards issues;
4. breakthroughs in current technical paradigms;
5. environmental/economic uncertainties;
6. major financial crisis;
7. Kyoto Protocol ratified by all economies;
8. major disruption of energy supplies;
9. public/societal uncertainties;
10. lack of public acceptance of nanotechnology;
11. major nanotechnology-facilitated advances in human health;
12. terrorism and national security;
13. global uncertainties;
14. World War III; and
15. widespread epidemic.

3 driver-based scenarios
1. **Nano-paradox.** By 2015, products based on nanotechnology had achieved clear technical success in many areas but widespread adoption and acceptance of the full potential has been clouded by uncertainty and nanotechnology is scarcely visible.

2. **Green energy triggers collapse in energy markets.** By 2012 significant breakthroughs enabled car manufacturers to abandon petrol-fuelled vehicles and switch over to mass production of new fuel-efficient hydrogen-powered vehicles.

3. **Nanotech wins the war!** By 2010 instability in the Middle East and disruption of oil supplies led to a major war, involving both conventional and biological weapons. Redoubled efforts on nanodevices for virus detection and on energy systems enabled a coalition of Western powers to win the war.
**Case 2: Danish study**

**Scope of the project**
- National Foresight

**Main methods**

1. **LR**
   - International Foresight
   - National nanoscience

2. **Survey**
   - >100 responses

3. **Three thematic reports**
   - 12 experts

4. **One report on risks**

5. **Technology-oriented Workshop**
   - 20 experts

6. **Interviews/surveys of public perceptions**
   - 29 individuals

7. **Action plan/roadmapping**

8. **Conferences**

**Main results**
- Recommendations

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**Why make nanotechnology a national priority?**

- Nanotechnological research in Denmark
- Nanotechnology in Danish industry
- Hazards and environmental and ethical considerations

**Recommendations on research, education and innovation policy**
Case 3: Thai study

Scope of the project

- **Sectoral foresight**

Main methods

1. **LR**
   - Tech. roadmaps

2. **SWOT**

3. **Mini-Delphi**

4. **Roadmapping**

Main results

- **Recommendations**

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1. **LR (incl. review of technology roadmaps)**

   The Semiconductor Industry Association (SIA) (2003) in the USA created a Technology Roadmap for 2001-2016 that shows emerging products including targeting sensors, logic devices, data storage devices, image displays and communication devices.

2. Analysis of the **SWOT analysis** of Taiwan’s semiconductor industries combined with the *Annual Report on Republic of China Economics in 2003*

3. **Delphi survey** with 12 experts with at least ten years of relevant experience; at least a Bachelor’s degree; at least five years of experience as a research project leader or a business management executive (e.g. assistant vice-president or higher).

   - Business Environment (evaluation of the importance of the main topics) – internationalization...
   - Industry structure – cooperative industries by specialties and foundry business.
   - Technological progress – evaluation of importance, attraction factors and probability of realization.
   - Market forecasting – global vision, global position, and industrial structure cycle.

4. **Roadmap**

   **Note:** Future work may experiment with scenarios
MONA (2005), *Merging Optics and Nanotechnology*, EU-funded.

**Case 4: EC study**

Scope of the project

- **Supra-national**

**Main methods**

1. LR
2. Internal workshop
3. Roadmapping
4. External workshops

**Main results**

- **Strategies**
- **Recommendations**
What about Rusnano Foresight?
Main Areas of Activity in Rusnano

RUSNANO employs a number of instruments to support its core activity:

- **Foresight-based roadmaps**
- Infrastructure programs
- R&D projects
- IP protection
- Educational projects
- Market development
- Certification, standardization and metrology
- Provision of nanotechnology products safety
- Popularization and public communications
- Information services
- Participation in legislative improvement
- International cooperation
- Establishing a place for discussion of nanotechnology development in Russia (Nanotechnology International Forum), etc.
What do we know about Foresight-based roadmaps?
EFMN: Mapping Foresight Practices in the World

- EFMN Mapping has produced a vast amount of information on foresight unprecedented in the world.

- The mapping has been useful to understand foresight practices in Europe and other regions of the world.

First argument

- methods are chosen based on their “intrinsic attributes”
  - their nature
    - Qualitative
    - Quantitative
    - Semi-quantitative
  - their capabilities, i.e. the ability to gather or process information based on:
    - Evidence
    - Expertise
    - Interaction
    - Creativity

Second argument

- methods are chosen based on fundamental elements and conditions influencing the foresight process; in other words, foresight process needs matter.
Foresight methods attributes: 1 Nature vs. 2 Capabilities

On “average” foresight studies use from 5 to 6 methods

Figure 6 Capabilities of most commonly used foresight methods

5 methods on average

5 methods on average (without extreme cases)
Let us focus on the Methods Mix
**Understanding the “Methods Mix”**

**Frequency of combinations**

- **L (or blank)** = below 19%
- **M** = 20-39%
- **H** = 40-59%
- **VH** = above 60%

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**Figure 15** Methods mix – or methods combination matrix (MCM) (Popper 2008)

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**Legend:**
- Low (blank): moderate (M); high (H); very high (VH); bold = qualitative;
  italic = quantitative; normal = semi-quantitative

**Note:** 888 cases

**Sources:** EFMN and SELF-RULE (2008)
Visualising the “Methods Mix”

Frequency of combinations

L (or blank) = below 19%
M = 20-39%
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VH = above 60%

Popper (2008)
Common methods used in “Foresight-based roadmaps”

**Frequency of combinations**

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- H = 40-59%
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*Popper (2008)*
Final remarks

- There is no “ideal” methodological framework providing the “best” combination of methods.
- There is no “ideal” number of methods to be used in a project.
- So, the methodology must be chosen after objectives are defined and not the other way around.
- The selection of methods may be affected by resources, such as:
  - project budget
  - availability of expertise
  - political support
  - technological and physical infrastructure, and
  - time.
- Having valuable human resources is essential and although such people do not necessarily need to be foresight specialists, they will often require intensive training courses in order to build internal capacities and know-how.
Thank you!

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