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EUROPEAN FORESIGHT PROCESSES ON METROLOGY R&D

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Abstract: The background and the results of a first investigation on national foresight processes carried out in European countries, and what we learned from it, are here presented. This work is one of the basic tasks of the European project "iMERA" started in 2005. A questionnaire provided detailed information on the national activities of metrology foresight, in particular, information on:

- the number of countries performing foresight processes in metrology or in related areas,
- the number and the typologies of foresight processes in different metrology fields,
- the methodologies used,
- the frequencies of the foresight processes and the dissemination of related results,
- the level of participation of NMIs to national foresight processes and their feeling about the real utility of these kind of activities.

The survey gave an overview of the present state-of-the art of the metrology foresight processes, by focusing mainly on their characteristics rather than on their contents. The analysis show a large variety of national foresight processes on metrology R&D ranging from solid and highly formalised procedures to a much more informal and simple methodology. Many reported studies seem to have the characteristics of Forecasting and Strategic Planning rather than of Foresight exercises.

Keywords: Foresight, Regional co-operation, Metrology

1. INTRODUCTION

On the basis of the almost 20-year experiences of EUROMET - the European collaboration in measurement standards, from April 2005 14 NMIs, one EC-JRC and 5 Ministries are participating in iMERA (implementing the Metrology European Research Area), an ambitious 3-year project [1, 2] funded by the European Commission within the ERA-NET scheme.

The purpose of iMERA is to enable the national Governments of participating countries to increase the national and European impact of their research investments in metrology, specifically through a wider and deeper R&D cooperation among the countries. This project is running with a step-by-step approach. At first, by an exchange of information about the national programmes in order to identify and adopt the best practices thus increasing the impact of the national programmes and establishing a substantial increase in project level collaboration. Secondly, by launching joint research projects, with defined work plans, resources, responsibilities and time scales, funded by the existing national programmes. To facilitate this process, access to special metrological facilities is also being offered to all the project countries.

The final aim of the iMERA project is very ambitious, a European metrology R&D programme (open also to potential collaborators beyond Europe). This phase is now going to be anticipated with the preparation of a European Metrology Research Programme (EMRP) with the prospect of launching this initiative in a joint action between the European Commission and Member States in compliance with Article 169[1] of European Treaty, which may be a powerful tool in setting up and running metrology research programmes.

2. PURPOSE

Within the iMERA Project, one of the basic tasks is here presented. It is aimed to provide a broad overview of the processes of metrology (and technology) foresight at the basis of national programmes for long term planning of metrological activities. This because of the pivotal role of foresight in steering national programmes.

A widely accepted definition of foresight was given by the STRATA-ETAN Expert Group [3]: "*an important tool in the development and management of future-oriented innovation systems (…) it could be defined as a purposefully organised process bringing together expectations of diverse actors, about possible development paths, to formulate strategic views about the future that take into account broad social and economic developments*".

[1] "*In implementing the multiannual framework programme, the Community may make provision, in agreement with the Member States concerned, for participation in research and development programmes undertaken by several Member States, including participation in the structures created for the execution of those programmes.*"

The process of technology foresight, involves a systematic attempt to look into the longer-term future (more than three years) of science and technology, with the aim of identifying and assessing the areas of strategic research and emerging technologies which could have a strong impact on science, economy and society, including industrial competitiveness, wealth creation and quality of life.

The concept of foresight has diverged from forecasting and planning concepts due to greater attention in managing grey areas and ambiguities, rather than attempting to predict the future as an extrapolation from the past. These efforts have implied greater consideration for the interaction of a variety of players, interests, perspectives, disciplines, needs and decision levels and has lead to the need for a strategic and parallel vision not only of risks and problems, but also of opportunities. Foresight makes it clear that the approach has to be holistic to consider the interaction among technological, social, economic, political and cultural variables [4].

In terms of perspectives, the foresight survey here presented should set the grounds for the foundation and the operation of the post-iMERA institutions. To achieve this goal, a preliminary requirement will be a common template for the European foresight in order to harmonise the procedures and to get homogenous results. National foresights can still survive, but may have a different approach and, perhaps, a different template.

3. METHODS

The methodology was based on a direct survey with a questionnaire sent to all the EUROMET countries. Where dedicated metrology foresight studies are conducted, scope and methodologies have been collated. Likewise, the national approaches to ascertain metrology needs from industry or other foresight studies have been assessed. The first step for the drafting of the questionnaire was the identification of the main methods used in foresight exercises.

Classifying foresight methods is somewhat problematic because they are rather flexible in their application and used often in combinations [5, 6]. We have tried to gather the main 13 methods used in foresight studies over the last decade into four groups:

- *Identifying Issues* (Environmental Scanning, SWOT Analysis, Issue Surveys): foresight studies usually begin with some sort of scanning and framing activity for identifying the issues on which the foresight will focus.
- *Extrapolative Approaches*: within this group Trend Extrapolation and Simulation Modelling have been borrowed by “Forecasting techniques”, whereas Genius Forecasting and Delphi method rely upon the opinions of experts to generate their results. Delphi is the method more used in formal foresight exercises: a survey is circulated, to the same set of respondents, at least twice; the respondents in later rounds receive feedback on the structure of responses from previous rounds and have the chance to modify their judgements in its light.
- *Creative Approaches* (Brainstorming, Expert Panels, Cross-Impact Analysis, Scenarios): foresight is considered a social and creative process. The key element to its success is the interactive process for new knowledge generation through Expert and Stakeholder Panels, frequently based on Brainstorming. A more formal creative method is Cross-impact Analysis. Scenarios is the most versatile and popular of all foresight methods.
- *Prioritisation* (Critical and Key Technologies, Technology Roadmapping): within this group, foresight studies are conducted with the primary aim of identifying priorities for technology development and/or research funding. For this purpose, the Critical (or Key) Technologies approach has been used extensively in the past. A more recent but increasingly popular method for setting research and technology directions/priorities is Technology Roadmapping.

The questionnaire was sent on July 2005 to all EUROMET members (except EC). We got responses from 19 countries (58%): all the 14 countries of iMERA partners, plus 5 non-iMERA partners (IE, ES, YU, PT, AT). Three of these latter reported that no foresight or other study relevant for metrology were carried out.

The questionnaire was structured in three parts:
Part A: general questions focusing on metrology foresight, but listing also other relevant studies useful for long term planning;
Part B: specific questions related to metrology foresight;
Part C: specific questions related to other foresight studies

4. RESULTS

All respondent countries (19) answered to the general questions of Part A. Only three of them have declared to be not aware of any foresight or similar process carried out in their territory including in some way metrology. Part B was filled in from 16 countries, even if four of them with no cases of foresight studies dedicated just to metrology, but only addressed to/including some metrology fields. Part C obtained answers only from 9 countries, ranged from 1 to 3 studies per country, but not analysed in this paper .

As resulted from the questionnaire, the information have been classified as declared by each country (Table 1) and the number of foresight studies dedicated to metrology (a1) or addressed to/including some metrology fields (a2) results to be quite high, respectively 35 and 18, for a total of 53 cases; also 18 other studies or processes useful for long term planning of metrology activities have been cited (a3).

Even if a total of 53 studies were presented as foresight studies, according to our analysis (with tighter criteria than those used by NMIs in their answering), only for 9 countries their cited studies did fit into a generally accepted definition of foresight (e.g. in terms of long-term future and in terms

Table 1. Foresight studies/processes carried out or used in each Country

Respondent NMIs	Country	iMERA Project partner	Foresight	Type of Foresight (*)		
				a1	a2	a3
BEV	Austria		N	-	-	-
CMI	Czech Rep.	X	Y	1	-	-
COSMT	Czech Rep.	X	Y	-	-	1
DFM	Denmark	X	Y	4	3	-
MIKES	Finland	X	Y	1	1	1
LNE	France	X	N/Y	14	5	
PTB	Germany	X	Y	-	2	7
NML-EI	Ireland		Y	3	-	-
IMGC	Italy	X	N/Y	1	-	2
NMi	Netherlands	X	Y	3	-	1
JV	Norway	X	N/Y	-	-	2
GUM	Poland	X	Y	1	-	-
IPQ	Portugal		N	-	-	-
ZMDM	Serbia & Montenegro		N	-	-	-
SMU	Slovakia	X	Y	1	-	1
MIRS	Slovenia	X	Y	1	2	-
CEM	Spain		Y	-	4	
SP (**)	Sweden	X	Y	1	-	1
METAS	Switzerland	X	Y	1	-	-
NPL (*)	UK	X	Y	3	1	2
	19 Countries		TOTAL	35	18	18

of expectations of diverse actors), thus reducing the total to 20 foresight studies.

4.1. The assessment of future needs in metrology

This section analyses the main results of Part A of the questionnaire.

A first important result was to understand which subjects carry out the assessment to identify the future metrology needs in each country and how this assessment is structured. The identification of future metrology needs is mostly carried out by NMIs (56%) and Governments/Ministries (22%). Other subjects mentioned are Agencies (7%, involved only in ES and IE) and Other (15%). It should also be noted that, due do the multiple choice in answering, the NMI percentage of 56% (over the total number of choices) rises to 94% (15 out of 16) of the respondent countries.

As expected from the correlation with the previous question, the assessment of future needs structured by technical area (EUROMET TCs) was the most common answer (56% of choices and 94% of countries), followed by the assessment structured by industry (18%), by market and for the whole economy (both at 11%) and other (4%).

The analysis of the foresight methodologies used was made separately for :

- Future needs arising from industrial or societal developments (such as in health and environment)
- Needs in new areas (such as nanotechnology and biotechnology)
- Needs for longer term work on the SI (improvements, fundamental constants).

The methods adopted did not depend significantly on where the needs originated. In the first two cases (industry/society and new areas), Environmental Scanning, which typically involves systematic analysis of some documentary sources to identify important developments in each study area, is used in all countries and this is followed by the Expert Panels, used in 11 out of 16 countries (69 %). As expected, in the assessment of Needs Related to the SI, which is a subject closer to NMI competence, the method of Genius Forecasting has a more important role.

By considering a breakdown on the typology of environmental scanning, there is again a clear distinction between the first two cases of industry/society needs and needs in new areas and the case of long term work on SI. In the first two cases, the Environmental Scanning has been carried out mainly through the Consultation of Stakeholders (in 13 cases corresponding to the 81% of the respondent countries) and then through the use of CIPM studies, of EUROMET projects and of other foresight studies (especially those coming from industry). In the case of long term work on SI, the stakeholder consultation loses importance in favour of more specific sources of contribution (CIPM, EUROMET TCs). Furthermore, it

has to be noted that almost always the foresight methods were used in combination.

4.2. Analysis of metrology foresight processes

Also the Part B of the Questionnaire was filled in by all respondent countries. The countries were requested to fill in this part for each single study identified in part A under the categories a.1 (foresight dedicated to metrology) and a.2 (foresight addressed to/including some metrology field).

The number of foresight studies listed by each country under the categories a.1 and a.2 of Part A was quite high, 35 and 18 respectively, for a total of 53 cases, but in only 26 cases did the NMIs complete a specific questionnaire in part B. In particular, only for 16 cases under the category a.1 and 10 cases under a.2. As a consequence, the following results refer to these 26 questionnaires. In spite of this, the percentages reported are calculated with respect to the total number of choices expressed for each question (which can be more than 26) because, in the majority of the cases, multiple answers were possible.

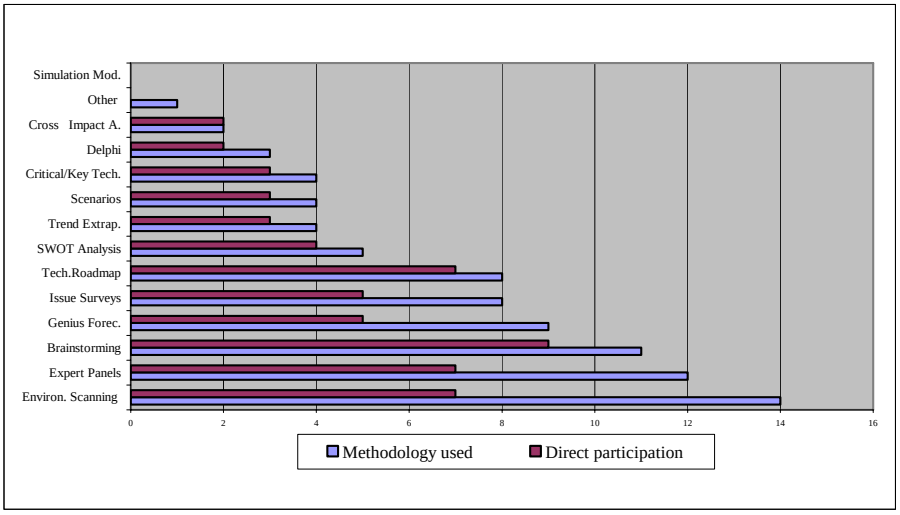
A first important information is that, in 21 out of the 26 foresight studies (81%), the National Metrology Institute participated in the study. The Extent of the foresight studies was mainly national (19 cases, 68% of the 28 answers given to this question), in 9 cases international (e.g. Nordic, European) but never at local level. In the majority of the cases, the Time horizon of the foresight studies was 3-5 years (48%), in 11 cases (38%) 6-10 years, more consistent with the time span of a foresight study, and only in 2 cases more than 10 years. The strict application of the time criteria of foresight definition would have further reduced the number of proper foresight studies.

Another important information concerns the Scope of the foresight studies. Also in this case, multiple choice responses indicate a combination of scopes: all metrology (33%), EUROMET TCs (30%), emerging technologies (26%), and Other (11%). The breakdown analysis between EUROMET TCs does not show a significant difference, with a resulting index ranging between 6 (F and PR) and 9 (T and EM). Amongst the emerging technologies, only 4 countries have quoted a specific field (biotechnology, nanotechnology, energy and environment, production techniques, ICT, electronics and microelectronics, optical technologies, life and health science, chemistry, space application, food). The "other scopes" of foresight studies included developments in specific scientific fields (e.g. electrochemistry, radiation dosimetry, materials science, mass metrology) and broader and more societal challenges (e.g. living in a networked world, individual and secure; understanding thought processes; healthy and vital throughout life by prevention; creating open access to tomorrow's world of learning; the bionic house; needs-specific innovation through customer integration; healthy nutrition – knowledge, markets and cultures).

Other information emerging from the survey concern the Promotion of foresight studies and methods used specifically. The studies cited were mainly promoted or conducted by Governments and NMIs, the latter having a rather high rate of participation As for the corresponding general questions of part A, the preferred methodologies were (Table 2): Environmental Scanning (16%), Expert Panels (14%), Brainstorming (13%), Genius Forecasting (11%), Technology Roadmapping and Issue Survey (both with 9%), but with a wider presence of the other methods with respect to the general information in part A. In 67% of the cases there was a direct participation of the NMI in the different type of foresight methods, with a lower incidence of Brainstorming (16%), followed by Environmental Scanning (12%). It is interesting to underline that Delphi, the method more used in other fields, especially those involving social and economic aspects, is quite uncommon in metrology foresight studies (4%).

About the Cost, only seven countries provided an estimate of the cost of some of foresight or similar studies identified in Part B: in eight foresight cases the estimate is of the total cost, in two of them the annual cost is also

Table 2. Methods used in Foresight processes and direct participation of NMIs

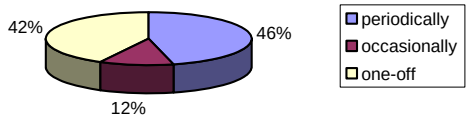


included, in other three cases only the annual cost is given.

Even if the data available are very limited, the information provided about the total cost of the foresight studies gives us an idea of the amount of money spent for this reason, which ranges from 2 000 € to 60 000 € (however the number of years these figures cover is not always clear). Only the annual cost of 1 000 000 € reported by UK refers to a programme formulation process with an average of 7 programmes per year. In fact UK foresight studies are carried out in each technical programme formulation, there are 21 programmes within the UK NMS, and the formulation of each one involves a self-contained foresight study.

The frequency (Table 3) of the cited foresight studies was periodic in 12 cases (46%), one-off in 11 and occasional only in 3 cases. In the majority of the cases (70%) the foresight has been running between 0-3 years ago, in 4 cases (15%) it was running at the time of the questionnaire.

Table 3. Frequency of Foresight studies



Always with the possibility of multiple choice answers, the outcomes of foresight processes were mainly papers and reports, in 24 cases of the 39 answers (62%), workshops, in 13 cases (33%), and Other (5%).

According to the opinion of the respondents, only in 28% of the cases were the outcomes of these foresight studies used *very much* for planning the NMI activity; in the majority of the cases *not very much* (32%), but in no cases *not at all*. In 42% of the cases foresight outcomes did not give rise significantly to a modification of the previous NMI plans, only in 19% of the cases did the foresight outcome impactthe NMI planning *much* or *very much*. In 20 cases (83%) these outcomes have been used as inputs for national prioritisation.

5. DISCUSSION

The survey showed that the processes in use are rather different between countries, ranging from highly formalised procedures to a much more informal methodology. For example, an NMI reports that, even in absence of a specific metrology foresight study that is referred to for its strategic planning, a number of existing technology foresight studies are used both for the NMI planning and for supporting the proposed work plan at the division level.

Generally, the interest for foresight studies is increasing in the metrology community. Some NMIs who have not reported formal foresight studies, will probably be involved in foresight studies in the near future. Those who have participated in foresight exercises suggests that the process should be improved in the direction of systematisation and fixed periodicity of them, larger involvement of stakeholders, extension of the study to cover the whole metrology in the country and a moving from a technical approach to a more socio-economic description. The aim is to make more solid the chain of planning and projects (implementation of prioritisation) as a consequence of foresight processes, also as an added value in facilitating a closer European collaboration.

By considering that among others, part of the NMIs strategy is to provide users with a fully operational, traceable and reliable measurement system and infrastructure, metrology was therefore catching up with the needs of industry, trade and regulatory requirements. Because new metrology foresight processes began only recently and were often composed by two processes, a national foresight and an operational metrology foresight, the process can also be seen from reverse: where now are the society needs which pulls metrology.

Distilling metrology needs from stakeholder actual needs is a living process, that is, to have a good picture of what the current metrology needs are, queries on calibrations to be provided, on seminars and hands-on trainings, on key technology and on industry and services needs as well, must be issued on a regular basis. However, the knowledge of the current needs of stakeholders seems to be not enough for the metrology institutions of being promoter of society development. A subtle risk is to focus on the near future, thus lacking of the long-term vision.

6. CONCLUSION

The national foresight processes, as collated from this survey, give a first overview of the present state-of-the art in this subject. They are rather different among the respondent countries, with a large variety ranging from rudimentary elements to formal studies.

Many reported studies seem to have the characteristics of Forecasting and Strategic Planning rather than of Foresight exercises. The questionnaire itself has promoted learning. The central role of NMI motivated experts is confirmed, but NMIs need to be more open outwards.

Even if the quantitative assessment is based on partial data from 19 countries and the analysis itself can be somewhat subjective, the questionnaire provided a great deal of information on the national metrology foresight activities, in particular important information related to:

- the number of countries performing foresight processes in metrology or in related areas,

- the number and the typologies of foresight processes by different metrology fields,
- the methodologies used,
- the frequencies of the of foresight processes and the dissemination of related results,
- the level of participation of NMIs in national foresight processes and their feeling about the real utility of these kind of activities.

From this survey, it was clear that foresight methods are rather flexible in their application and are frequently used in combination. In general, the preferred methodologies resulted to be Environmental Scanning, Expert Panels, Brainstorming and Genius Forecasting. In the detailed information provided for each single study, a wider presence is reported of other methods like technology roadmapping.

In the majority of the cases there was a direct participation of the NMI to the different kind of foresight methods, with a prevalence for Brainstorming and Environmental Scanning. On the other hand, Delphi, one of the most popular foresight method in other fields (especially for social and economic aspects), is quite uncommon in metrology foresight studies. These outcomes about the use of methodologies can be explained by the fact that in many countries the approach to foresight is still in an early stage of development and needs to be better exploited and improved both as perspective and methods.

In fact, methods like Environmental Scanning, Expert Panels, Brainstorming and Genius Forecasting, can be very useful and give important results especially in the first steps of foresight processes, due to their easier way of implementation and lower cost, but in the long run they should be supported also by methodologies more specific and with a broader view, like Delphi, Technology roadmapping or Cross-impact Analysis.

Furthermore, the UK case excluded, also from the low amount of money involved in foresight studies (as emerges from the cost declared only for very few of them) emerges their early stage of development and, more in general in the majority of the countries, a global approach to long-term-planning in metrology not yet enough holistic and foresight-driven.

The foresight should set the grounds for the foundation and the operation of the post-iMERA institutions. Along the chain given by Foresight, Strategic planning, Prioritisation, Programmes and, only at the end, Projects.

What emerges from the survey is the need to improve the knowledge of the foresight processes and their impact on R&D programmes, finding out more about most effective way to conduct foresight studies, in order to establish a Joint European Metrology Foresight, besides the national ones.

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