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to:	Mr Javier SOLANA, Secretary-General/High Representative
Subject:	Commission staff working document accompanying document to the Decision of the European Parliament and of the Council on the participation by the community in a European metrology research programme undertaken by several member states - Impact assessment report

Delegations will find attached Commission document SEC(2008)2949.

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COMMISSION OF THE EUROPEAN COMMUNITIES

Brussels, 3.12.2008
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COMMISSION STAFF WORKING DOCUMENT

Accompanying document to the
DECISION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL ON THE PARTICIPATION BY THE COMMUNITY IN A EUROPEAN METROLOGY RESEARCH PROGRAMME UNDERTAKEN BY SEVERAL MEMBER STATES

Impact assessment report

{COM(2008) 814 final}
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1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

1.1. Introduction - What is Metrology? Why Metrology?

Modern metrology has in Europe its roots in the French Revolution, with the political motivation to harmonize units all over France and the concept of establishing units of measurement based on constants of nature, and thus making measurement units available "for all people, for all time".

The earliest example of the importance of quality of measurement, comparability and traceability and its fundamental role in the construction of society can be traced back as early as 3000 BC., with the definition and establishment of the "cubit" as a standard unit of length and which was used to construct the pyramids. The cubit was established as the length of the Pharaoh's forearm plus the width of his palm. The cubit was a stick of wood, compared to a more durable "Royal cubit master" carved in granite and used as primary standard. The cubit became the first working standard to insure comparability in dimensional metrology. During the time of King Cheops, the great pyramid of Giza was built with this system and the uniformity of length measurement was achieved to a relative accuracy[1] of 0.05% over a distance of 230 m.

Example: The incredible progress of scientific resolution during four centuries (1609-2003)

The history of science over the centuries can be written in terms of improvements in resolution. From the beginning and all the way up to 1609, when Galileo's telescope first assisted human vision, scientific knowledge consisted of making descriptions and comparisons for events taking place at measurement scales accessible to the human eye, from about 10^{-3} (a tiny speck) and up to 10^{+7} meters (the Milky Way), some 11 orders of magnitude.

Now, 400 years later, scientific descriptions and comparisons take place at scales from 10^{-18} and up to 10^{+25} meters, some 44 orders of magnitude.

That is, from 1609 to 2003, scientific resolution improved an average of about 8 orders of magnitude per century (or 100 million-fold per century) in each of the 4 centuries since Galileo.[2]

There was always a need for unique measurement and reference systems which led to the creation of the Système International d'Unités (SI), or the International System of Units. The today valid SI was developed in 1960 from the metre-kilogram-second (mks) system. This system has gained unprecedented worldwide acceptance as definitions and standards of modern measurement units which fundamentally support creation of growth and wealth through knowledge with highest impact on global economy today. Though not the official system of units of individual nations, the definitions and specifications of SI are today globally accepted and recognized as references to define quantification and qualification of any goods or services.

National Metrology Institutes (NMI) are in charge of this work and implement the national metrology research programmes on the basis of institutional funding from central government agencies or ministries. Traditionally the NMI were oriented very much towards physical measurements. However national governments have recognised the need for change. For example the UK NMI which is the National Physics Laboratory (NPL) is today operating an extensive biotechnology programme, which represents NPLs major investments over recent years. Further more Designated Institutes (DI) are selected at national level due to their

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1 H.G. Semerjian and R. L. Watters 2000 - ISSN 0263-2241. "Impact of measurement and standards infrastucture on the national economy and international trade",

2 Edward Tufte, June 16, 2003 http://www.edwardtufte.com/

specific competencies, like e.g. in chemistry or biotech, to complement the metrology research done by NMI.

1.2. RTD and wider policy background of the action

For many years, the Community has made use of the various provisions of the Treaty in order to encourage greater coordination and cooperation between national research programmes in Europe. A major impetus came in the year 2000 when the Lisbon European Council in its endorsement of the Commission communication on the European Research Area (ERA) concluded that research activities at national and Union level must be better integrated and coordinated to make them as efficient and innovative as possible. The Lisbon European Council requested that the Council and the Commission, together with the Member States take the necessary steps as part of the establishment of a European Research Area to develop appropriate mechanisms for networking national and joint research programmes on a voluntary basis around freely chosen objectives.

In 2001, the Research Council considered that the use of Article 169 of the EC Treaty could lead to greater coherence and integration of national and Community programmes and research policies. The Council invited the Member States to identify possible specific topics for pilot programmes where the use of Article 169 would be appropriate, in close liaison, where necessary, with the Commission.

In 2004, the Competitiveness Council acknowledged the widespread interest in the ERA-NET scheme and encouraged the Commission to further develop it in FP7, supplemented by a new ERA-NET PLUS scheme which would allow the Community to top-up Member States joint calls with EU funding. The Council also invited Member States and the Commission to identify a limited number of areas for further application of Article 169.

In 2006, the European Parliament put emphasis on better coordination of regional, national and European research programmes and policies in its proposed amendments to the FP7 proposal. The Parliament report on the FP7 proposal recognised that fragmentation was a major obstacle to the success of the European research agenda, and suggested that "…it is vital that the Seventh Framework Programme should support the coordination of national and regional research policies and programmes" and that in order "to avoid fragmentation and overlapping competencies, there should be more cooperation between national and European research programmes, and between economic actors in the long-term research agenda."

End November 2006 the Commission presented to the Competitiveness Council a roadmap for all potential Art. 169 initiatives to be implemented during the start of FP7. As set out in the European Commission's FP7 proposal, implementing Article 169 implies that the participating EU Member States integrate their research efforts by defining and committing themselves to a joint research programme. In implementing Article 169 initiatives, the European Community goes beyond simply coordinating research programmes, in that it participates actively in the voluntary integration of scientific, managerial and financial aspects. The Community provides substantial financial support to the joint implementation of the national research programmes involved, based on a joint programme and the setting-up of a dedicated implementation structure. The lessons learned from FP6 did help to set up clear selection criteria for Art. 169 initiatives under FP7. Criteria for potential Art. 169 initiatives include:

- relevance to European Community objectives;
- clear definition of the objective to be pursued and its relevance to the objectives of FP7;
- a pre-existing basis (existing or envisaged national research programmes);

- European added value;
- critical mass, with regard to the size and the number of programmes involved and the similarity of activities they cover;
- Article 169 being the most appropriate means for achieving the objectives.

Four initiatives have been identified in the FP7 Capacities - and Cooperation Specific Programme[3]. However based on the level of "maturity" of all four initiatives, two Art. 169 initiatives "Ambient Assisted Living" (AAL) and EUROSTARS aimed at R&D performing SMEs have been implemented in 2007 while the Metrology initiative was further developed and brought to full maturity through an ERA-NET Plus action granted early 2007, the first year of FP7. In addition a full implementation of EMRP as potential Art. 169 on Metrology was already announced in the FP7 Cooperation Specific programme in the following way:

"The aim will be to launch and implement a cohesive joint metrology R & D programme integrating a number of national programmes, which will enable Europe to respond to the growing demands for cutting-edge metrology as a tool for innovation, supporting scientific research and policy. The initiative will support, in particular, the objectives of the European National Measurement Systems delivered via the National Metrology Laboratory networks."

In February 2008, the Competitiveness Council adopted a key issues paper to be submitted to the 2008 Spring European Council encouraging the Commission and Member States under the heading *"Investing more and more effectively in Knowledge, Research and Innovation": "The Article-169 initiatives AAL and Eurostars should be adopted before the summer of 2008, while the Council notes the Commission's intention to submit the remaining Article 169 Metrology initiative by the end of 2008 and the BONUS initiative in 2009 at the latest".*

In March 2008, the European Council urged the Member States and the Community to make swift progress on further initiatives and highlighted that the decisions on Article 169 initiatives and additional research initiatives should be taken as soon as possible.

The above list of declarations and actions demonstrates the clear and long-standing highest political support for the improved coordination of research activities in general and for the Art. 169 initiative on metrology in particular.

- Joint Programming Concept

The general policy objectives of the EMRP Art. 169 initiative are in line with the ideas for joint programming and better coordination of national programmes to enhance the EU's capacity to achieve its high level policy goals and respond to the major challenges it faces in the coming years: (1) to contribute to the achievement of the objectives of the revised Lisbon Strategy, notably growth and jobs; (2) to help Europe respond more effectively through research to key societal challenges such as climate change, energy supply, security (3) to contribute to the achievement of one of the central European Research Area (ERA) objectives. A communication from Commission[4] to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions entitled "Towards Joint Programming in Research" has been adopted very recently on 15 July 2008. The Communication is one of five policy initiatives planned by the Commission to follow up the

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[3] COUNCIL DECISION of 19 December 2006 concerning the specific programme 'Cooperation' implementing the Seventh Framework Programme of the European Community for research, technological development and demonstration activities(2007 to 2013) Annex IV

[4] COM(2008) 468 Communication from the Commission : Towards Joint Programming in Research: Working together to tackle common challenges more effectively

2007 Green Paper[5] "The European Research Area: New Perspectives" and is a further step in the creation of the "fifth freedom" by removing barriers to the free movement of knowledge.

1.3. Organisation and timing

The EMRP initiative as a potential Art. 169 had been introduced in 2007 into the Commission Forward Programming for a Commission decision to be taken during the last quarter of 2008 as a catalogue item[6].

In expectation of Article 169, the Member States have restructured the metrology organisation in Europe, launching a dedicated legal entity. The creation of such a legal entity was part of the preparatory work done via ERA-NET and was planned to be tested under FP7 via an ERA-NET Plus on metrology. The entity was created early in 2007 and is named: the European Association of National Metrology Institutes (EURAMET e. V.), which is a Regional Metrology Organisation (RMO) of Europe consisting 32 national metrology institutes from 32 different European Countries[7]. It coordinates the cooperation of National Metrology Institutes (NMI) of Europe in fields like research in metrology, traceability of measurements to the SI units, international recognition of national measurement standards and of the Calibration and Measurement Capabilities (CMC) of its members. Among these tasks, EURAMET is responsible for the elaboration and execution of a European Metrology Research Programme (EMRP). EURAMET e.V. is a registered association of public utility under German law.

It is expected that 21 of the EURAMET countries[8] are ready to participate in the Article 169. The countries wishing to participate in the EMRP Article 169 are those who have to date running national metrology programmes or have decided that in the frame of EMRP they would set up a national programme. They all have today already identified budget lines, agreed liability and cost sharing, and a fully developed work programme, management and governance structures.

Furthermore, EURAMET e.V. is piloting the EMRP through an ERA-NET Plus, addressing a limited number of themes from their work programme. The success of the ERA-NET Plus Call has already clearly demonstrated the ability to join national resources from 20 countries, organise and execute a joint Call and selection process, leading to committing 64M€ to 21 collaborative projects in late 2007. Results will serve Europe as a whole and this test case addressed all important implementation issues like for example intellectual property rights (IPR) issues. IPR issues seem not to cause any problem as the participating programmes act in a pre-competitive and regulation oriented fields (due to market failure) and ERA-NET experience has show that the national programmes are very keen to use the IPR rules of FP7.

Commission Internal Consultation

An Impact Assessment steering group met on the 01 July and a formal inter-service group (ISG) for the overall initiative was set up and met on 31 July 2008 under the responsibility of DG RTD, Directorate B. This group participated in the definition and development of the proposal for a European Metrology Research Programme and supported the Impact Assessment (IA) process of the planned initiative. Services had been invited to present their

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5 COM(2007) 161 final Green Paper - The European Research Area: New Perspectives

6 http://ec.europa.eu/atwork/programmes/index_en.htm

7 http://www.euramet.org/

8 Potential participants: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden and United Kingdom as well as Norway, Switzerland and Turkey

views at an early stage of the draft IA report and the preparation of the Commission proposal for such an action. The Joint Research Centre was not involved since it is likely to participate in the programme.

External Consultation

- Web consultation – report in annex

As part of the stakeholder consultation an online survey was conducted by DG Research between 7 May and 8 July 2008. A total of 162 responses to the online survey were recorded, with 64% (104 responses) replying on behalf of an organisation and 36% in an individual capacity. Of those replying on behalf of an organisation, the majority were from commercial organisations with less than 250 employees (26%), commercial organisations with more than 250 employees (21%) and higher education institutions (18%). The survey respondents were mainly involved in metrology research (54%) or in the take-up and use of metrology (28%). While the vast majority of the survey respondents were resident in Europe (the largest group being resident in Germany (49%) followed by United Kingdom (8%) and Switzerland (8%)), replies were also received from outside the EU, notably from USA, Singapore and Korea.

A full statistical report on the responses to each of the questions is attached. The most significant outcomes of this survey are highlighted in this section.

- *The effectiveness of European metrology research as implemented by the National Metrology Institutes (NMI) must be improved*

About half of the survey respondents (51%) agree that under today's circumstances there is too much duplication in the research conducted by the NMI (Figure 1a). A much more outspoken majority (82%) is of the opinion that metrology research would benefit from a better coordination of the national metrology research programmes (Figure 1b).

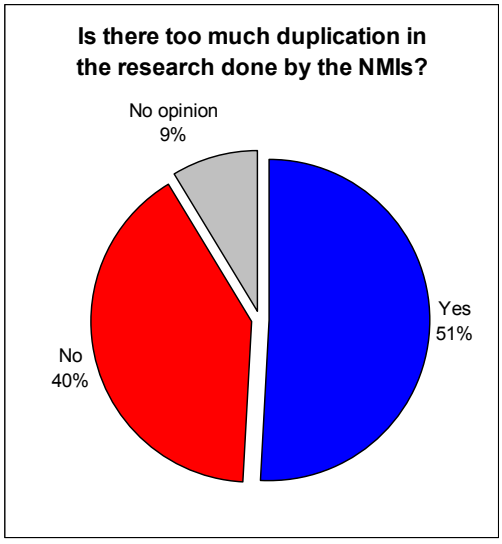

Figure 1a

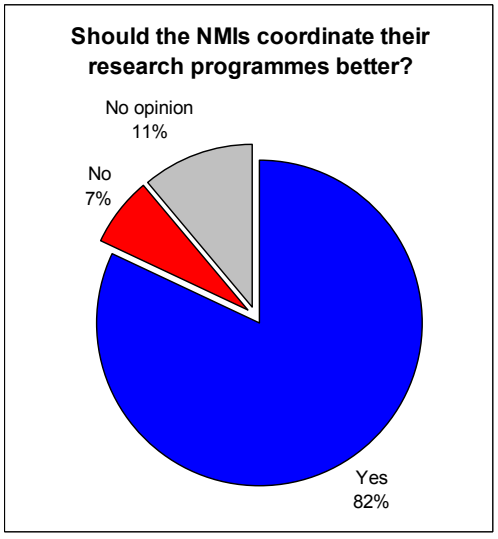

Figure 1b

From those respondents in favour of more coordination between the national metrology programmes, about two thirds (65%) find that this should be organised at European level.

- *Need for a trans-national priority setting in metrology*

A vast majority of the survey respondents (84%) are of the opinion that the National Metrology Institutes (NMI) should work together on joint priorities such as a single joint metrology research programme in order to tackle major European challenges (Figure 2).

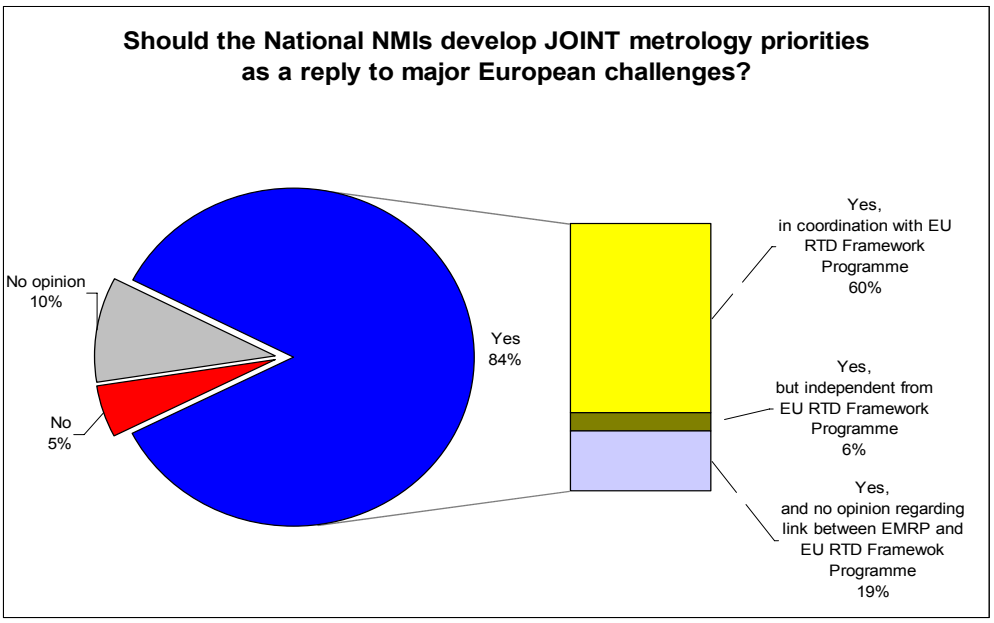

Figure 2

From those survey respondents in favour of such a joint priority setting, most are of the opinion that this should be organised in coordination with the EU RTD Framework Programme. This represents 60% of all survey respondents (Figure 2).

- *Openness of the EMRP*

Regarding the openness of the EMRP programme, half of the survey respondents (50%) prefer to limit it to European research performers in the field of metrology, while 20% are in favour of an opening to any research performers in Europe.

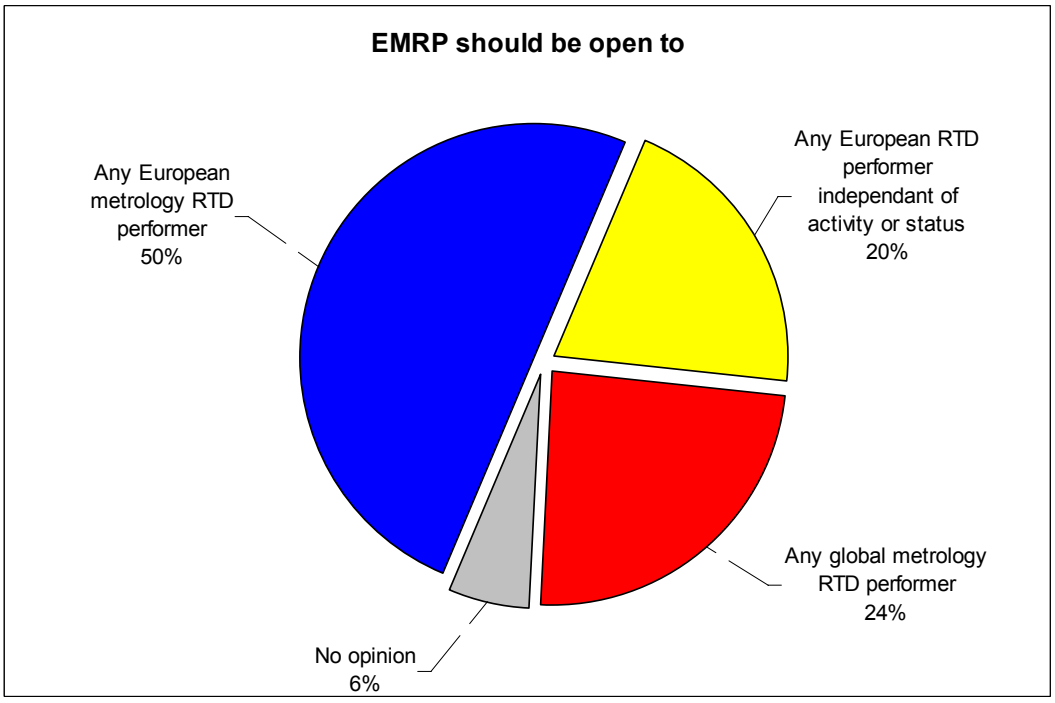

Figure 3

- Open Stakeholder meeting – 25 June 2008 (see annex)

In addition to the web consultation, a stakeholder consultation workshop was organised on 25 June 2008. The workshop was attended by 32 individuals from 8 different countries (see annex) and different international organisations. Beside several NMI and JRC essential organisations attending the meeting are listed below:

– BIPM - Bureau International des Poids et Mesures
– CEN - European Committee for Standardisation
– IMEKO - International Measurement Confederation
– CECIP - Comité Européen des Constructeurs d´instruments de Pesage
– EA - European cooperation for Accreditation
– MIKES - Centre for Metrology and Accreditation
– EUSPEN - European Society for Precision Engineering and Nanotechnology
– ORGALIME - European Federation of the European mechanical, electrical, electronic and metal articles industries

Issues like the status of the European Metrology system have been presented and discussed and the definition of the problem concerning European metrology research has been confirmed by stakeholders. Besides these fundamental questions some more specific issues like mobility and openness of the metrology research system were disused. E.g. the need for openness was confirmed however especially industry underlined the paramount importance that NMI and DI stay in the lead for metrology research. Inviting the wider research community to join in certain projects, as appropriate, was seen as an interesting and useful feature but not considered as the main driver for such a programme. There was a large consensus that the planned initiative is of utmost importance to modernise the European metrology system which was also confirmed in the written contribution from CECIP in annex. We believe that the general principles and minimum standards for consultation have been respected.

1.4. Opinion of the Impact Assessment Board

[Opinions of the IAB + actions to address recommendations; meeting of IAB in September]

2. PROBLEM DEFINITION

2.1. Metrology Research and its role in front of Europe's societal challenges

Metrology is a hidden, often invisible infrastructure of services necessary for modern and fare trade, for services in all societal and economic areas and communications. With a world trade increasing by more than 15 % per year, trade policies are vital to create an efficient and reliable world market[1]. Access to markets can be hampered by incompatible standards and/or the lack of uniform and accurate weights and measures. This translates into an important investment for societies since it has been estimated that countries advanced in industrial economy invest between 3 to 6 % of the Gross Domestic Product (GDP) for measurement and measurement-related operations[9].

Today's European and global Metrology investments and set up

Investments in metrology from the major economic associations translate into investments in metrology development for trade and technology. In 1995 the highest budget invested was in

[9] Comptes Rendus Physique Volume 5, Issue 8, October 2004, Pages 791-797, Fundamental metrology Measurement and society from Terence J. Quinn and Jean Kovalevsky

Japan before USA and Germany, followed then by France, UK, Canada and Italy[1]. Today's figures are not always available for all countries and all type of metrology related activities.

EUROPE

One important feature of the European landscape is i.e. the quite big difference in absolute budgets for general metrology activities and for research activities in particular; as a consequence the R&D work that is carried out in the different NMI varies a lot. For Germany, for example, the total budget for the NMI (in 2002) is 235 Mio EURO, while UK spends 139 Mio EURO. The third highest budget has Sweden with 45 Mio EURO, followed by France (23 Mio EURO) and Italy (21 Mio EURO). Smaller countries such as Belgium (3.15 Mio EURO) or even Greece (1 Mio EURO) have much more limited Metrology infrastructures.

Following the European analysis the iMERA (see annex) project we estimate in the past recent years the total European investment in metrology research projects at 120 million € per year and very much focused on physical metrology, while more and additional investments are expected into biological and chemical metrology. This amount stands for "real" research projects, similar to the planned EMRP type of research, excluding calibration or comparison efforts and also excluding infrastructure running cost. This amount, not easy to trace, 120 M € per year is "project funding" as reference value for the size of an EMRP to be developed. We are not aware of any study that attempts to address and identify the optimum level of investment in metrology research in the EU. However the independent major review of the UK national Measurement System carried out on behalf of UK Government by PA Consulting in 1999 gives some indication. It can be estimated that the UK investment being estimated still at suboptimal, according to the study, can serve as reference in terms of investment for Europe; however some 20% more investment was suggested as the optimum. In crude terms the UK presently invests some £60 M per annum on its national measurement system, around 1.25 M€ per million of population. Following the study the optimal level would be the order of 625 M€ to 750 M€ for total Europe, considering a 20 % increase as suggested by the study.

USA

The U.S. Commerce Department's National Institute of Standards and Technology (NIST) is the federal agency supporting the measurements and standards requirements of the USA. Recently, numerous prestigious publications such as The National Academy of Science's Rising Above the Gathering Storm and Compete America from the Council on Competitiveness have highlighted the importance of basic scientific discovery and innovation to economic growth and well-being.

With the President's American Competitiveness Initiative (ACI) and the passage of the America COMPETES Act, both the President and Congress recognize that "America's economic strength and global leadership depend in large measure on its ability to generate and harness the latest in scientific and technological developments and to apply these developments to real world applications." The ACI specifically highlights NIST as one of three key federal agencies that support basic research programs in the physical sciences and engineering. This research is critical to the innovation that underlies the United States' future.

Accordingly, the ACI calls for doubling, over 10 years, the funding for research at NIST, the National Science Foundation, and the Department of Energy's Office of Science. In fiscal year 2007 NIST received $439.6 million for Scientific and Technical Research Services, which primarily funds NIST labs.

ASIA excl. CHINA

The importance of metrology in the development of quality and consumers goods for international trade has been fully understood in Asia were important efforts in this domain are made in Japan and to a different level in other Asian countries. The situation is quite

heterogeneous in Asia with regards to metrology developments and economic impacts. Asian countries have organized themselves under the Asia/Pacific metrology program (APMP) which is collaboration between standards laboratories of Asia and the Pacific aiming at improving the measurement capabilities of the member countries. It was initiated by a Commonwealth Regional Metrology Programme[9] in 1980. In 1995, 21 countries and territories are active members of the APMP.

Japan in general plays an important role in this domain and is a key player in promoting both the metrology capabilities of the participating countries as well as indirectly reinforcing the economic trade potential of these countries. This important transfer of experience can be illustrated by the efforts of Japan to transmit the expertise for 6 quantities that are length, mass, temperature, volume, force and pressure to several Asian partners.

In general, the APMP activities are mainly constrained by financial limitations. The APMP does not operate from a single general budget but promotes its activities with series of individual separately funded projects[10]. The transfer of experience is by correspondence between participants, publications and conferences and workshops organized on a regular basis between the different participating countries.

CHINA

China is today a key economic power in the global economy. Major investments have been recently made to reinforce and promote Chinese metrology with respect to global trade issues. The Chinese national metrology institute was funded in 1955 and was profoundly restructured in 2005 when the National Research Centre for Certified Reference Materials (NRCCRM) was merged in the National Metrology Institute (NIM) covering then metrology, physics and chemistry. This is accompanied with a tremendous financial effort in the public support of funding for the R&D. In the 2001-2005 period, the financial investment in R&D in metrology was already on a constant regular and strong growth of more that 100 % for this period with a global budget of slightly less than 1 Million € (2001) raising to more than 2.28 Million €. This tremendous increase is already one of the largest if not the continuing largest investment of the development of metrology in general. This has been even more spectacularly raised after the launching in 2006 of the "Eleventh-Five-Year-Plan" were this investment in R&D in metrology has been multiplied by almost a factor of 10 in 2006 and reaching an level of investment of 23.55 Million € in 2007. Even so if the absolute figures in € seem low, the value for this investment is huge under Chinese research costs and the dimension of increase is extraordinary (From 2001-2007, nearly 25 times more investment). This huge public investment effort translates in the promotion of more than 440 on-going research projects in traditional metrology developments such as the atomic clock, the Watt balance, the measurement of the Avogadro constant, the primary method for isotopic abundance. Recent Chinese metrology approaches are promoting novel efforts in areas like biosciences, food safety, medicine, nano-scale metrology, metrology in material property in order to support their vigorous economic growth and development.

As the comparison shows the major economic powers in the world have recognized that technology R&D in metrology is critical to an advanced nation's long term economic growth. If the importance of measurements and calibration in the global process of trade can be easily apprehended and understood, we will however illustrate more precisely the importance of metrology in the further development of our society.

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[10] The Asia/Pacific Metrology Programme J-C Park et al 1995 Metrologia 32 61-62

Time: We can leap back to our time and evaluate the role of measurement in today's navigation and communications. Accurate time keeping is the key to precise navigation. The clocks used nowadays are atomic. The atomic clocks are now used in today's most precise navigation system for the GPS (Global Positioning System). The development of the European GALILEO satellite navigation system and as well as the existing GPS and its opening to the public market is now affecting our everyday life on a routine basis and has allowed a new economy to develop[8].

Health: The health system fully relies on accurate medical diagnostics. In the US, approximately one trillion $ are spend on health care. More than 20 % are directly or indirectly related to measurements. Improvements in reliability of chemical measurements are paramount in this domain. In the area of cholesterol measurements alone, it has been estimated that the measurement uncertainty was in the order of +/- 18 % in 1969 before any reference materials were available. New reference materials decreased the uncertainties of clinical laboratories to less than 7 %. This important improvement has been evaluated to translate into a 100 million $ of potential saving in the treatment cost for misdiagnosed patients together with increased levels of lives saved through timely and accurate diagnosis[1].

Example: Research needs for measuring Nanoparticles for health protection

The impact on human health of airborne nanoparticles is an area of growing concern. Nanoparticles can enter the body by inhalation, ingestion or absorption through the skin and are known to cause respiratory problems. Nanoparticles are produced from both natural and man-made sources such as combustion, traffic, manufactured material, dust, soot and pollen grains The market of commercial applications relating to nanotechnology is rapidly increasing, standing at around € 38 BN in 2001, and expected to rise to €152 BN by 2010 with nanoparticles accounting for around 40% of this figure. Our incomplete knowledge about the environmental and health effects of nanoparticles coupled with their increasing use for industrial applications requires a precautionary approach to exposure. Recent research results of airborne particles suggest the damage to human genes may be related to the particle size and potentially the surface area of airborne particles, with toxicity increasing with decreasing particle size. Research is needed to determine the quantity of nanoparticles in the atmosphere or workplace, and their effect on human health. This research will enable future health and safety legislation, environmental regulations and the development of robust new standards that can protect human health.

Trade: A recent and import trade barrier between Europe and Africa is related to the quality requirement for food products and their need to meet phyto-sanitary requirements for exportation. The European community has refused for a long time the importation of Lake Victoria fish because of questions related with its level of pollution. The countries concerned, Kenya, Tanzania and Uganda lost some 100 millions € during the 2 year ban which was lifted after adequate metrology, testing and quality assurance structures have been put in place on site to test the fish before exportation [8].

Environment and global climate change: There is now a clear consensus of climate change and recognition that human activities are influencing the climate. The emission of "greenhouse gases" is accepted for their potential role in climate changes. The Kyoto agreement on the limitation of these gases is slowly been implemented and it is obvious that the importance of accurate measurements will be essential in this domain. Indeed, the Kyoto quotas will require agreements of the trading parties to the measurements of the quantities of emissions traded. These delicate measurements will require long term stability of standards since one of the objectives is to follow the rate at which the amount of ozone is changing over decades[8]. Therefore all instruments used in climate studies will have to be traceable to SI units with careful estimation of the uncertainties to be able to estimate real trends.

Water Framework directive: Sound strategies for evaluating and monitoring chemical water quality require measurement systems capable of generating comparable data with excellent reliability. This domain will see in the future a very strong demand since the major driving force will be related with the implementation of Water Framework directive (WFD)[11]. This directive has the objective of achieving "good status" of all waters in Europe by 2015. According to DG Environment operational milestones linked to integrated river basin management planning through the EU, will rely on measurement of data and in this respect quality and comparability of data will be of paramount importance. In this respect, reference material will have to be produce in order to promote total quality control of the data collected on the field. However, if accurate and precise measurements can be obtained of routine contaminants levels in the laboratory, the challenge will be displaced at the sampling level on the field where it is well known that a large array of variability may occur changing rapidly the content of the samples collected. In this respect, the domain of the NMI dealing with these aspects of environmental metrology will have to tackle new challenges. It will be of utmost importance in order to contribute to the harmonization of the quality of the European water ways.

Most of these fundamental requirements (e.g. from trade to WFD) are hidden to the public at large and not necessarily well understood. The constant evolution of society, constrains on the environment and the new products and trade generate continuous move and new need for metrology research especially in relation to regulation. Many of these examples illustrate the paramount role of metrology and illustrate the permanent and rapid evolution of the requirements to calibrate, control and regulate new activities with appropriate measurements. All forms of physical and chemical measurement affect the quality of the world in which we live.

Against this background which clearly describes the increasing discrepancy between today's metrology research needs and the available European resources and their actual use, we are facing the following situation:

European metrology dilemma:

The "European metrology dilemma" is to permanently align metrology research efforts with societal needs which both are more demanding, more complex and therefore more resource intensive whilst still servicing existing "traditional" demands without any new or additional resources. At the same time:

- global needs for accurate and speedy measurement in traditional industries are increasing,

- new, emerging technologies put additional pressure on the measurement system and necessitate "entirely new types of measurement" and

- in many societal areas such as health care, environment protection, food safety or transport the recognition as to the importance of standards and measurement is growing rapidly and relate directly to legislation,

while available European resources are not increasing nor used in an optimal manner.

There is a constant need to improve the efficiency and effectiveness of public investments in metrology research via better cooperation and coordination while there is in addition the need to continuously re-focus research efforts and to invest more in public metrology research to cover the increasing number of research needs. Metrology is by its very nature a field where public investment is needed due to market failure.

[11] DIRECTIVE 2000/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2000 establishing a framework for Community action in the field of water policy

2.2. The need to improve the organisation of Europe's public R&D cooperation and investment in Metrology

Due to its horizontal character, supporting a range of scientific fields and economic sectors, metrology has a strong public good character[12]. Results in metrology research and knowledge inevitably are of use to more than one single actor, thus the private incentive to engage in scientific Metrology Research is very limited. Metrology research is also a supporting activity for government regulation, standardisation and policy making. Hence, national governments have a concrete interest to set up metrology research capacities to ensure that their countries have the means to establish and use standards that are needed for certain regulations or to adopt international standards to the local or specific marked conditions.

The analysis of the main drivers is listed below and summarise what is in essence today's metrology dilemma:

- First, the global needs for accurate and speedy measurement in a wide range of traditional industries in terms of complexity and in terms of required accuracy are increasing. Europe needs to be at the leading edge of metrology research to support growth and jobs in many fields. The US system for example identified more than 700 measurement needs for industry, the majority of those within traditional industries[13].
- Second, new, emerging technologies put additional pressure on the measurement system and in fact necessitate "entirely new types of measurement". This new pressure not only relates to simply "more" measurement, but to new forms, to exploratory measurement that will "open the way to deeper understanding and, ultimately, to new applications and markets[14]".
- Third, in many societal areas such as health care, environment protection, food safety or transport the recognition as to the importance of standards and measurement is growing rapidly and relate directly to legislation. The link of measurement to societal issue areas is of direct relevance for policy at European level. The European BSE crisis for example has been a new unknown and unpredictable societal challenge to metrology research and in particular to reference materials.

Example: BSE Crises

When BSE crisis occurred in the middle of the nineties, it resulted in a widespread scare amongst consumers. Beef consumption in EU 15 at that time – then estimated at around 7 million tons per year – collapsed completely down to a total 10% as a consequence of loss of confidence with consumers. This represented a huge economic impact.

Adequate European and national legislation was introduced to remedy the situation. EC 999/2001 requires mandatory testing of cattle older than 30 months. In 2002, this resulted in about 11 million BSE tests per year at a cost of 45€ per test meaning a total of nearly half a billion € only for testing.

Confidence in test results was critical not only for food safety but in particular to restore confidence amongst consumers. Various research groups at national or international level had been developing tests since the middle of the nineties and later on different companies produced and commercialised

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12 Swann, G.M.P (1999): The Economics of Measurement. Report for Department of Trade and Industry, National Measurement System Policy Unit, p.64, www.dti.gov.uk/tese/swann.pdf

13 NIST (2007a): An Assessment of the United States Measurement System: Addressing Measurement Barriers to Accelerate Innovation. NIST Special Publication 1048, Gaithersburg. http://usms.nist.gov/usms07/usms_ assessment_report_2006.pdf

14 NIST (2007b): An Assessment of the United States Measurement System. In Brief. http://usms.nist.gov/usms07/usmsinbrief_feb12_web.pdf

these tests. However a lack of data on reliability of these newly developed tests persisted. Independent metrology research was urgently required to assure validity of the new tests. Under the mandate of the EC's Consumer Protection General Directorate, the EC's metrology institute (the Institute for Reference Materials and Measurements of the Joint Research Centre) took the lead and combined its metrology research programme with that of other competent research laboratories (for example at oversees the National Veterinary Laboratory and the Institute for Neurodegenerative diseases, California).

In Europe metrology institutes and metrology research programmes are already overloaded with traditional measurement areas supporting industrial needs and have difficulties to cope with additional needs like for example the measurement needs in the Quality of Life sphere at European level. The pooling of knowledge between all capable institutes led to great achievements. As a consequence of increased competition, the subsidy per test dropped from 20€ to 7€ per test kit, corresponding to a conservatively estimated accumulated direct saving in the period 2002-2006 of 250M€.

This example illustrates that modern EU policy and legislation can only be implemented if reliable measurements are available.

- Fourth, for many technological areas, above all hardware and software technologies, the demand for interoperability leads to rising demand for measurement and standardisation. Accordingly, for the Semiconductor industry, for example, the NIST has conducted econometric analyses that show the economic benefit of measurement activities. Above all measurement activities for semiconductors, the benefit - cost ration is 3:1, that means one Dollar invested in measurement infrastructure returns three dollars in economic impact (this figure is very similar to the one calculated for Europe[15]).

- **Exploiting Europe's full research potential facing global competition**

Funding Metrology has traditionally been a high national priority and the organisation of the field varies greatly in Europe[14]. In many countries the metrology structure is highly centralised, in others it is partly decentralised (such, for example, France). A full review is given in Spencer/Williams[14] 2002 and Erard[16] et al. 2002. What is important, though, is that the Metrology research community is a specialised community only loosely linked to research organisations, academia or industry in the respective countries due to is traditionally mainly public missions as core of their statutes. Many of the NMI are fully nationally owned, some or semi-public and a range of smaller institute are in fact private. The NMI are at the core of national measurement infrastructure. While some only serve as reference labs, others provide internationally recognised primary standards, some have in addition to scientific work and services also commercial interests. Discounting the scientific comparisons (which are not classed as R&D by the NMI, and which by definition require collaboration) EURAMET estimates that currently no more than some 5 % of NMI and DI research activities is addressed collaboratively.

Europe has a largely fragmented metrology research system with a few centres of excellence like the German NMI or the UK NMI and others (only to name the largest). Still theses centres of excellence are neither directly connected between each other in their research activities nor in using/accessing their respective national research infrastructures. They are therefore subject to many possible duplication of work and inefficient use of high-performance and expensive research infrastructures. At the same time they would benefit

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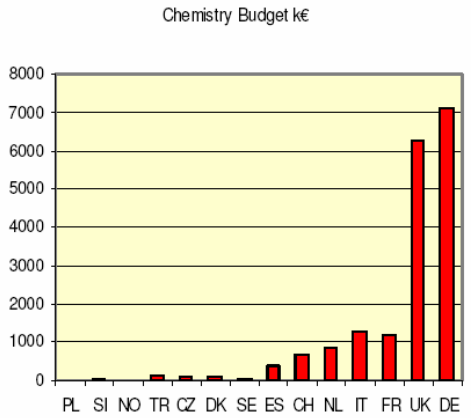
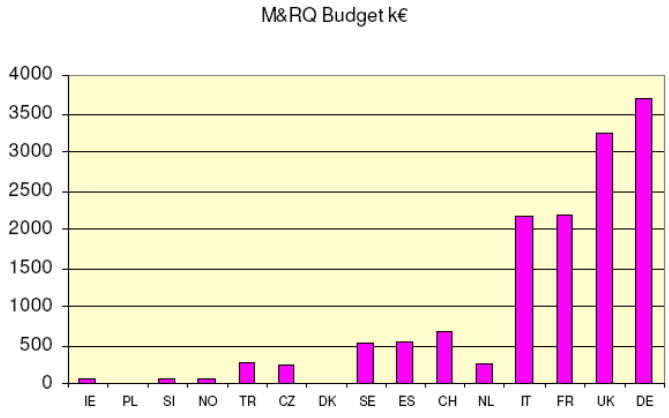
15 Spencer C.G. and Williams G.A (2002) " The role of public bodies in measurement infratechnology" mimeo. Pembroke College, Oxford

16 Erard et al. 2002: A Panorama over the European Union Metrology Infrastructure, Final report to the European Community and the European Free Trade Association, Paris

from competition and peer pressure on an international scale. The comparison graphic[17] below shows for example the large overlap in investment between countries in field like chemical metrology or Mass and Related Quantities (M&RQ) research (the values are annual averages from 2002-2004). EUROMET[18] have assessed several hundred cases (200-300) were different NMI are working in the same field, but where certain barriers prevented any collaboration (e.g. misalignment of detailed deliverables/objectives, differences in timing of resources, limitations on travel and mobility, inflexibility in national rules or funding etc). An interesting example for risks of duplication and need for coordination is the new definition of the kilogramme. After the International Prototype Kilogram had been found to vary in mass over time, the International Committee for Weights and Measures (known also by its French-language initials CIPM) recommended in 2005 that the kilogram be redefined in terms of fundamental constants of nature. At the present time, different experiences are developed as for example "watt balance", "realisation of NA" with Si solid state standard (sphere), "ion accumulation" and all studies connected to those experiences (Si density standard, X-ray interferometry on Si, surface analysis, etc.). In this field, many countries finance major research activity related the new determinations of value of some constants like (Planck constant) or NA (Avogadro constant). There is clear evidence that this is a typical concrete example of duplication risks if the work is not well coordinated at European level.





Other examples of huge duplication exist for example in the so called "Calibration and Measurement Capability Statements" or CMCs. In a process beginning in 1999 (and broadly completed in early 2004) all of the NMI and Designated Institutes declared their capabilities openly following a common nomenclature. These declared capabilities were subject to peer review before being accepted. Having completed this review, the CMCs are entered by the Bureau International des Poids et Mesures (BIPM a body of the intergovernmental Metre Convention) in a publicly accessible database[19]. Some 71 countries - the more developed economies - entered CMCs. The total CMCs is just over 20 000 of which Europe declares around 10 000 or half of the total. Europe and the USA have, in round terms, similar measurement capability, yet the USA declares only approximately 2250 CMCs. Some of the 4:1 ratio is explained by the need for locally delivered services with different languages in Europe. However if we look at the "big 4" European metrology R&D performing countries (Germany, UK France and Italy) who all develop their capabilities "in house" through their nationally funded metrology research programmes we find they have 4050 CMCs compared with the USA 2250 CMCs, implying significant research duplication does exist in Europe.

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17 iMERA ERA-NET Deliverable

18 Since 1 July 2007 EURAMET e.V. is the successor of EUROMET.

19 BIPM key comparison database http://kcdb.bipm.org/

Smaller Member States have excellent scientific knowledge in different metrology relevant fields (e.g. Nanotechnologies) but are unable to build their own metrology research capacities due to the lack of critical mass in their countries and the huge start-up investments which are needed. They could largely benefit from an integrated European approach under which they could tie close links in selected fields of their scientific excellence and directly cooperate with other NMI or DI which are toady recognised centres of excellence at global level.

Europe runs a risk of falling behind the U.S., the key competitor in metrology research at global level. The U.S. President's Fiscal Year 2009 request for NIST to get the institute back on track to double NIST's budget over 10 years; intention is to enable NIST to continue to aggressively lay the science and technology foundation recommended by many reports and proclamations on U.S. innovation and competitiveness. The U.S. administration declared that it is paramount that NIST strengthens its current core competencies and move rapidly and wisely toward realizing the vision of being the world's leader in creating critical measurement solutions and promoting equitable standards.

In addition to the major drivers of the metrology dilemma mentioned above, there appears to be – across Europe – certain inertia in NMI within Europe, a tendency to being a closed shop with path dependent R&D programmes and little linkages to academia and to the build up of the next generation. This system failure has been apparent on national level, and an Europeanization and modernisation of programming can change this situation and generate positive effects.

The Problem

Against this background the European metrology research system supported by solitary national intervention logic concerning research programming has to overcome the "Metrology dilemma".

The European potential in metrology research is not fully exploited to assure the optimal answers to societal challenges. Joint action between Member States and Community is missing in order to be able to address the issues raised above and to provide for a modern and challenge oriented joint and optimized research effort in metrology. Any new approach needs to increase the available resources and can only be successful if it takes fully the existing national systems into account, integrates them into a true European programme which should lead to a real step-change and modernisation for the existing national systems. The detailed areas of problems can be spelt out as follows:

- No efficient and effective co-ordination and integration of NMI and their national programmes
- Too little Interaction of NMI with science community and modernisation of the overall European metrology system
- No approach to address jointly the grand challenges to European society
- Not enough support to regulation preparation and policy advice
- No or too little capacity building in new Member States
- Not enough access to infrastructures
- Not enough Mobility and Human Resource development
- Not enough Global cooperation

2.3. Metrology Research as part of the "fifth freedom" – reducing fragmentation – creating synergies at all levels to ensure global leadership

In the case of metrology research, the public R&D programmes are characterised by clearly defined objectives, a set budget with often fixed duration, a pre-define set of research actors and a closed national system of setting up solely national projects of limited size and impact.

This type of institutional forms of programmes established in the concerned Member States would benefit from:

- research excellence and critical mass to strive jointly for global leadership
- healthy competition between trans-national research groups
- integration of relevant science from other relevant fields
- Capacity building in certain MS
- researchers mobility (especially for young researchers) imbedded in the strategic research activities to assure future researcher generations to be able to work at trans-national level

However, the societal returns to these public metrology research programmes can be increased by improving the organisation of European Metrology research scene via more and better cross-border programme collaboration and coordination. The costs to Europe of non-coordination can therefore be viewed as the non-realisation of these significant benefits.

- **Subsidiarity and European added value of EMRP**

It is of course important to establish a clear basis and rationale for Community action in this area. The right for the Community to act in this field is set out in several articles of the Treaty which make provisions for research coordination and cooperation between Member States and the Community. Article 165 stipulates that "the Community and the Member States shall coordinate their research and technological development activities so as to ensure that national policies and Community policy are mutually consistent". It also allows the Commission, in close cooperation with the Member States, to "take any useful initiative" to promote such coordination. Obviously Article 169 invites the Community to 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".

In order for Community action to be justified, it is also necessary for the subsidiarity principle to be respected. This involves assessing two aspects. Firstly, it is important to be sure that the objectives of the proposed action could not be achieved sufficiently by Member States in the framework of their national constitutional system (necessity test). In the case of the proposed process for an EMRP, purely inter-governmental actions aimed at coordination of public metrology R&D have not expanded in recent years and would not add financial resources nor integrate the EMRP in the Framework Programme and in the wider creation of ERA. Therefore, Member States are unlikely to be able to address these problems acting alone.

The second aspect to consider is whether and how the objectives could be better achieved by action on the part of the Community (test of EU value-added). The rationale for EU action stems partly from the trans-national nature of some of the key challenges (for example, health care, environment protection, food safety or transport) where Member States need to act together to properly tackle the problems at trans-national level. But it can also be justified in terms of offering the potential for greater scale, scope and effectiveness of the concerned public R&D programmes in Europe.

3. OBJECTIVES

3.1. General policy objectives:

The general policy objectives of the initiative is to enhance the EU's capacity to achieve its high level policy goals and respond to the major challenges it faces in the coming years:

- To contribute to the achievement of the objectives of the revised Lisbon Strategy focussing on four priority areas: (1) concern for citizens, (2) concern for the environment, (3) a more competitive economy, and (4) knowledge and innovation
- In particular to invest more and better in knowledge for growth and jobs and to take steps towards the so called "fifth freedom" – the free movement of knowledge within ERA.
- To contribute to the realisation of the European Research Area (ERA) by implementing a genuine "European Metrology Research Area" (MERA).
- To help Europe respond more effectively to key societal challenges such as environmental protection, health care, food safety, or public security through research striving for scientific excellence in human potential and institutional resources.

3.2. Specific objectives:

In order to contribute to achieving these general policy objectives, it will be necessary to improve the efficiency and effectiveness of public metrology research programming in Europe in areas where it is facing major societal challenges. Specific objectives are:

- Structuring the ERA through coordinating and partly integrating national public metrology research programmes to provide solutions to important European societal challenges.
- Improve the efficiency of Europe's fragmented public metrology research approach.
- To increase the impact of these programmes, both S&T impacts (scientific excellence, pooling of resources, data and expertise, achievement of critical mass, facilitating programme optimisation) and economic and societal impacts.
- To remove barriers[20] between national metrology research programmes and to foster sustainable cross-border cooperation e.g. through mobility of young researchers, scientists and academic staff and to open up the national programmes to inter-disciplinary cooperation with researchers and scientists from other fields in particular relating to new and emerging technologies.

3.3. Operational objectives:

In order to promote the above improvements in impact and efficiency, the operational objectives are:

- Through the use of the appropriate instrument, to promote cross-border public research programme coordination and integration as well as structuring effects, notably the achievement of critical mass and sharing cost and burden between public funded metrology research cross Europe. Expected output would be a large number of Member States involved in EMRP.

- Address the grand challenges (e.g. climate change) and areas with pressing metrology needs (e.g. new and emerging technologies like for example nano- biotech- healthcare-metrology) with a new type of cooperative research projects. Such projects allow an increased speed at which solutions can be found are highly "resource intensive" and shall provide for a new type of trans-national cooperation as well as for multidisciplinary

[20] ERA-NET Review 2006 - The Report of the Expert Review Group: Experience not only in the field of metrology has testified to the fact that the barriers to coordination were very real. These included practical barriers stemming from, for example, the heterogeneity of national and regional rules, laws and regulations governing domestic research spending, as well as the more mundane barriers created by language and currency differences. They also included more entrenched cultural or institutional barriers related to the low priority given to international cooperation, mobility of research staff and to the coordination of national programmes in general.

approaches. Expected output would be a large number of large size strategic projects building on specific strength of some NMI and DI and addressing grand challenges.

- Enable a number of countries in particular some “new” MS or candidate countries to launch for the first time their proper national metrology research programmes and build up their own metrology research capacities fully integrated in ERA, with direct opening-up towards cooperation opportunities with large and world wide recognised NMI-centres of excellence. Expected outcome would be to enable all new Member States to build metrology research capacity.

- Open access for trans-national and multidisciplinary research teams to unique research infrastructures and facilities to foster scientific excellence, pooling of resources, data and expertise. Expected outcome would be a large number of existing metrology research infrastructures jointly used in EMRP projects.

- Increase generic collaboration between national metrology research programmes with the relevant science community at European level notably in fields like new and emerging technologies. Integrate scientists and academic staff from the wider scientific community in to the European Metrology Research area and support their mobility into the EMRP research system. Expected outcome would be that in average per project at least one RTD performer not being NMI or DI is involved. In average per project at least one mobility grant is given and a high number of PhD students are involved.

- Modernisation leading to a drastic change in the programming of national and European research priorities to invest more in public metrology research to cover the increasing number of research needs whilst still servicing existing "traditional" demands. This allows a paradigm change: metrology organised around themes (e.g. climate change) and not around technologies. Expected outcome would be a large number of advanced technologies imbedded in EMRP projects.

- Foster mobility of "early-stage" researchers from NMI and DI as part of a sustainable European approach preparing future generation of researchers to strive for scientific excellence as bearing in mind the importance of trans-national research cooperation. Expected outcome would be that in average per project at least one "early stage" researcher grant is implemented.

- In metrology research, Europe should speak with one voice to strengthen its influence and to foster cooperation at global level. Through concerted action and joint action, Europe could better become a collective actor in international negotiation as well as for international collaboration. Expected outcome would be a substantial number of generic cooperation activities with non-European research actors.

- Metrology research has to become a supporting activity for government regulation and standardisation at national and at European level. Hence, governments and Commission have a concrete interest to set up metrology capacities to ensure that Europe has the means to establish standards that are essential for policy making and certain regulations and/or to adopt international standards to the local conditions. Expected outcome would be a large number of EMRP projects with direct reference to upcoming regulation.

- Support to industry needs and economic growth through up-front public metrology research to strengthen existing and emerging sectors especially those where the EU can

achieve world market leadership. Expected outcome would be a large number of patents granted, publications and other dissemination activities.

4. PRESENTATION OF THE POLICY OPTIONS

We now consider a number of concrete policy options to reach the above listed general, specific and operational policy objectives to overcome the problem stated above. As regards progress made in recent years in the field of European metrology research programme coordination and considering the legal possibilities for the Community to intervene in the field of research, five policy options have been identified and developed. The options for Community action are guided by the logic and intervention mechanisms of the Framework Programme 7. Beside no action these options therefore refer to either indirect or direct Community actions (research funding) under FP7, which would match the existing national intervention logic concerning research programming in different Member States.

The options are labelled as follows on the basis of their main characteristics.

(1) Policy Option 1: "No further Community action"; status quo, no further action on EMRP – may lead to intergovernmental approach

(2) Policy Option 2: "Bottom-up community indirect action – light coordination" under FP7 programmes and themes (Cooperation – Capacities Programmes). The aim would be to use the ERA-NET scheme and/or the ERA-NET Plus scheme but addressing isolated issues theme by theme and in the FP programme part by programme part. This option is the "business-as-usual" option

(3) Policy Option 3: "Top - Down community indirect action – Reinstall metrology theme in the FP" – Part under FP7 or preparation of FP8 and reinstall a Community Programme on Metrology (e.g. FP5)"

(4) Policy Option 4: "Article 169 – programme integration through community indirect action "; Community action to achieve MS programme integration via Article 169, as indicated in the F7 Cooperation specific programme

(5) Policy Option 5: JRC – direct action; a single European metrology research programme to be implemented via JRC to cover metrology needs at European level

The difference between these five options lays in the way in which the Community intervention is set up – either as an indirect action or a direct action. Therefore the different options should be seen as exclusive, as they can not easily be implemented cumulative, without creating additional fragmentation in the metrology field. The main characteristics of each policy option are discussed in detail in the following sub-sections.

Each of these five options has advantages and disadvantages when it comes to joint metrology action across Europe. As paragraph 3 spells out, the objectives and rationale for a (joint EU and Member State) action in Metrology includes a more optimal use of the potential that is today fragmented in multiple NMI and metrology research organisations. The comparison of various options will focus on how the possible options may or may not lead to the necessary modernisation of the metrology research system and how they may help to address the challenges identified.

5. ANALYSIS OF IMPACTS OF THE OPTIONS

5.1. Option 1: No further Community action

Should Policy Option 1 be chosen, the situation as we find it today may not remain in place due to the absence of any political and/or or financial Community intervention (ERA-NET or other coordination tools). It will most likely deteriorate as it could be foreseen that Member States will invest less if the domain of metrology research as the area does not to appear as a European priority area. The status quo and separation between the Member States' programmes will remain; the likelihood of research groups of newcomer countries to hook up with experienced and high level research teams in more advanced countries will be low. There will be no follow up of the ERA-NET activities, and the Member States will have to take collaborative action themselves. EURAMET will return in its default position to act as a network to exchange experiences, but no optimisation of programming will take place between the Member States unless a number of MS decide to set up an intergovernmental cooperation scheme.

5.2. Option 2: Bottom-up light coordination

Policy Option 2 would continue the route that has been taken with the ERA-NET in FP6 and ERA-NET-Plus at the start of FP7. This option would need no further institutionalisation. EU policy domains and research fields (e.g. energy, environment) can be easily involved directly into the coordination with MS programmes and well conceived interaction mechanisms with various metrology oriented ERA-NETs will be key. A coherent joint long term programmatic approach will not take place as in the case of a genuine European research programme. In addition the influence on modernisation of the national metrology research systems will be much slower and less important.

5.3. Option 3: Reinstall Community Metrology theme in FP

Policy Option 3 needs no major institutional set up. It would create a dedicated research programme for metrology where the metrology community and the whole science community as well as industry in general can compete for funding under FP rules. It provides the opportunity to focus in particular on new technological challenges in emerging fields, thus contributing to the modernisation of the sector. This route is similar to Option 2. It will probably have no major effect on the existing national metrology research systems and integration between the national programmes and infrastructures. Due to a project by project approach it will not assure to create critical mass in all fields and no coherent long term research programming can be developed. It will likely increase the gap between the larger, advanced players and the newcomers as the threshold to enter becomes higher. In addition, while FP5 had a metrology research programme (Standards, Measurement and Testing - SMT), it received little political support to be continued in FP6. This could also happen in the decision making process towards FP8. Lessons can also be learned from the 5 year assessment of FP5 in 2000 by an independent panel. The panel recommended concerning the Standard, Measurement and Testing (SMT) programme the following*: "Given the specific needs and the horizontal character of measurement and testing, the Panel recommends the instatement of SMT as an independent, co-ordinating Specific Programme with a larger budget."* This general recommendation indicates already the specificities of the programme and potential difficulties to integrate such a programme into the Framework Programme as a *coordinating character* and *increased budget* is recommended. The recommendations was as such not implemented at that time, when FP6 was set up. In contrary, at the start of FP6 a Coordination Action of national metrology programmes (iMERA) was started.

5.4. Option 4: Article 169

Policy Option 4 (Art. 169) creates a platform for joint EU and Member State research programming, thus creating a coherent and long term research agenda with critical mass. The active participation[21] of the European Commission can safeguard an emphasis on mobility, openness and a focus on emerging areas. The combination of EU and national funds creates a critical mass that has certain likelihood to stimulate structural changes in the national metrology research systems. The linkages with industry are not explicit at EU level and stay rather at national level. This option will require substantial institutional changes that will likely take time and complex negotiation with MS to implement.

5.5. Option 5: Joint Research Centre (JRC) direct action

Policy Option 5 implies that metrology research will take place in isolation from the Member States their respective research programmes and related infrastructures and thus having little influence on restructuring the national metrology research systems and no feeling for the needs of Member States. Additional bottlenecks are the recruitment requirements for JRC and the lack of competition in the metrology field, which by its nature needs competing research tracks to find the most reliable solutions. The links to the science community in large and to industry in MS will be of very limited nature and not up to the levels needed.

Table 1 below, sums up the consequences, advantages and disadvantages of each possible route, as regards the optimal use and mobilisation of metrology capacity in Europe.

Table 1 Advantages and disadvantages of Five Options

	Consequences	Advantages	Disadvantages
Policy Option 1 "No further Community action"	EUROMET defaults to networking forum No EU funding needed No increase of resources	MS might be more inclined to start intergovernmental initiatives (with variable geometry)	The current status quo between countries will remain; No capacity build up in countries with low metrology research competences; MS will likely decrease national expenditures No further joint strategic planning of metrology research; Financial leverage smaller; Less effort in European wide challenges; No joint cooperation at global level; No common voice; NMI modernisation processes much slower and more heterogeneous; Openness of system will not increase
Policy Option 2 " Bottom-up community indirect action – light coordination"	MS are solely in the lead Multiple variable geometry	No new institutionalisation; Less EU finding needed; Integration with other research; themes of FP7 will be easier; Light mobility actions	Openness of system will not increase; Many individual projects will not lead to coherent; research approach; NMI modernisation processes much slower and more heterogeneous; No critical mass; Risk of duplication due to multiple actions; NMI will not be likely to make a strategic division of labour and develop integration; Lower levels of integration
Policy Option 3 "TOP - DOWN community indirect	Horizontal metrology programme EU budget increased	No new institutionalisation; Dedicated programme with clear thematic focus; Will be better accessible for non-NMI research groups; Provides opportunities to focus on emerging technologies	- No joining up or coordination of all best potential in Europe to tackle certain issues, but competition of smaller teams, leading to outsiders when concerted action would be needed, cooperation would be on small scale level mainly; NMI will not be likely to make a strategic division of labour and develop integration; Lower levels of integration;

[21] The Commission will be consulted on calls under preparation and up-dates of the EMRP programme

action – Reinstall metrology theme in the FP" (e.g. FP5)	Needs linkages with FP mobility programme	and new domains	NMI modernisation processes much slower and more heterogeneous; Gulf between larger and smaller partners will grow; Long selection procedures; Less critical mass; Uncertainty due to low success rates will prevent NMI to integrate FPs in their programming strategies
Policy Option 4 Art 169	Potential rationalisation of services in some countries	Long term programming; Attuning national research strategies to European strengths and competences; Financial leverage; EU political buy in – support to EU policy making; Critical mass in research effort; Mainstreaming metrology research to other policy domains; Dedicated mobility actions; Greater leverage in World Trade; negotiations; Alignment to growth industries; Ability to deal with trans-national issues; Implementation of fit for purpose EU regulation; Integration of JRC with national metrology research; Avoid duplication of frontline research efforts; Better conditions for cross-fertilisation between people, institutions, countries	Requires new institutionalisation; Will take some time to implement appropriate governance structures; Linkages with industry stay at national level
Option 5 JRC Direct action	JRC to take lead in defining programme EU budget increase	No new institutionalisation; More responsiveness to EU needs	Isolated from national NMI work; Isolated from national metrology needs; Serious new staffing issues; No effect on modernisation of NMI; No effect on openness of system Little effect on mobility; New Member States will not be linked in Unique single institute does is not favourable for inter-comparability (no healthy competition) MS will likely decrease their expenditures

Option 1 – *"doing nothing"* – might be even a step back compared to today's situation as today Commission is assuring a light coordination mechanism via ERA-NET and ERA-NET Plus. Option 1 being an option where may be intergovernmental approaches would be developed is as such not a Community policy option and not viable to address the problem stated at Community level. Option 5 is the sole option which considers a Community intervention in form of a direct Community action. This option, even so having potential strong scientific impact, does not at all build on the major problem issues which are integration and building the "new approach" based on the existing national programmes. Even so that within the intervention logic of FP7 this option would be legally feasible it is considered as an option not being realistic in front of the stated problem.

Against this general analysis of all five policy options we are of the opinion that Options 1 and 5 are not viable alternatives to address the problem stated above and we will therefore limit the further detailed discussion to options 2, 3 and 4 in the following chapter which will give a detailed and direct comparison of the remaining options.

6. COMPARING THE OPTIONS

A wide range of impacts need to be considered in this comparison considering the operational objectives, which have been explained in detail under chapter 3:

- Co-ordination & integration of NMI and national programmes (cost reduction, reduce fragmentation and duplication, joint strategic direction)
- Addressing Grand Challenges
- New MS: capacity building
- Open access to infrastructures
- Interaction with science community
- Modernisation of the metrology system
- Mobility and Human Resource development
- Global cooperation and position of Europe in the world
- Support to regulation
- Support to industry and economic growth

Boundary conditions for this assessment are listed below and have been explained in chapters 1-2:

(1) we have a metrology dilemma in Europe:

(2) the activities in Europe must not only be intensified (more budget) but also be organised more effectively, efficiently;

(3) in order to exploit the potential of metrology for grand challenges and industry demand at the same time the national systems themselves must modernise also at national level (open up to the non-NMI academic, multi-disciplinary world, increase the attractiveness for young researchers)

(4) Europe cannot afford not to mobilise all talent, expertise and infrastructure across Europe, especially taking into account the massive investments for metrology in other parts of the world (see above).

A detailed comparison of each option how it could achieve the operational objectives is presented in the following table. We try to present in detail the coordination mechanism for each of the options and how each of the options performs in terms of programming, avoiding thematic overlap, pursuing complementarities, and in terms of consistency and critical mass. The table format is used to allow easy comparison of the options.

Objectives	Option 2 Light coordination
Co-ordination & integration of NMI and national programmes (cost reduction, reduce fragmentation and duplication, joint strategic direction)	Bottom up ad-hoc joint calls within ERA-NETs coordination will be limited to smaller topical areas. High-level policy decision-making will not be bound in. No additional EU funding will make scale and scope dependent on MS
Grand Challenges	Specific ERA-NETs can focus on grand challenges, but scale and scope will be limited. By binding other EU-DGs contribution to EU policy making can be increased.
New MS: capacity building	MS can join in through joint calls within ERA-NETS.

Objectives	Option 2 Light coordination
Open access to infrastructures	Difficult to achieve here
Interaction with science community	Could be ensured through joint programming but NMI will be dominant. Depends on MS safeguards to ensure newcomers to come in.
Modernisation metrology system	Due to smaller scope of joint calls the European metrology system will be affected only partially. In addition, the linkages of NMI (which are often closed shops) to academia, one important dimension of modernisation, could not be triggered, as the light coordination could not offer enough additional funds for grants from outside the NMI system
Mobility and Human Resource development	Light coordination could in fact focus on training and mobility rather than research. However, the integration of training into a common research programme and the scale of common activities would be most likely sub-critical.
Global cooperation and position of Europe	The critical mass of the joint activity is needed in order to speak credibly with one voice. If there is no major Commission contribution through light coordination and no credible investment in sustainable structures, international negotiations and co-operations will most likely remain fragmented within Europe, with small countries losing out.
Support to regulation	The potential lack of a common vision and a European focus due to sub-critical commitment by the Commission would render any activity to better serve the needs for European regulation more challenging. At the same time, the focus of national programmes and organisations would remain more nationally oriented, and the coordination of the national programmes, which would carry more weight as compared to the ERA-NET Plus
Support to industry and economic growth	Here light coordination could, at the national and regional level, function as well as Art 169. For some actors, especially SME in countries with strong systems, a light coordination would at first sight be more welcome as the core of the metrology business would stay national. However, the light coordination would mean less spending in metrology, given the metrology dilemma this would certainly in the long run trigger down to industry and even calibration for SME etc. Further, for the peripheral countries the situation would not improve, national structures would not be built up as rapidly and the local actors would less rapidly be able to tap into coordinated infrastructures in other EMRPO countries (provided that the infrastructure exchange and the coordination of core capacities functions well in EMRP)

Objectives	Option 3 FP
Co-ordination & integration of NMI and national programmes (cost reduction, reduce fragmentation and duplication, joint strategic direction)	The cooperation would be on institute and team level through joint proposals and projects, the spill over effect to national programmes and structures will be very limited. Especially in small countries the national programmes would align strongly to the priorities of the European programmes (in order to maximise participation from their countries) which would then lead to a lack of variety and maybe even a dysfunctional specialisation in small countries for their own constituency.

Objectives	Option 3 FP
Grand Challenges	The FP metrology programme would have the big advantage to formulate very clearly priority areas that are fully in line with the political objectives and grand challenges as defined at the European level. All jointly funded activities would thus directly contribute to the common goals.
New MS: capacity building	The linkages of institutes within FP proposal as a means to build up structure is highly problematic, history shows that "cohesion" and structural build up through FP has limitations, and incentives of the new member states to invest in institutes that might or might not be successful in the FP consortia would be limited.
Open access to infrastructures	The access to infrastructure would be limited to concrete project and their purpose as well as to a limited set of actors. Access would not be driven by the portfolio of activities across Europe and could not be develop systematically. However, if FP would finance large scale networking, NoE type of platforms, infrastructure access could be developed as a major goal of the individual large scale project, and the evaluation would have to make sure that broad access and exchange is guaranteed. As with the 169, the question would arise how to deal with the sustainability, how to build structures that would last beyond the large scale project funding. Art 169 would, allegedly, mobilise self-interest in sustainability much stronger, as the responsibility would be with the NMI from the beginning, not with selected coordinators of large projects.
Interaction with science community	As with infrastructure access, the cooperation with scientists would be ad hoc and based on small scale projects. It could, however, be demanded in the call for tenders in respective working programmes and could be incorporated in large scale networking projects to build virtual centres of excellence. If this would lead to a break up of national fragmentation is questionable, but for the FP funded structured it could trigger interaction.
Modernisation metrology system	For modernisation in terms of opening up to the science system see above. In terms of turning towards more programme funding and peer review in the national systems it is highly unlikely that FP budget would have repercussions on the national level. In terms of organising national institutes and programmes along challenges and issues, the big countries might not follow the FP approach, while smaller systems might align with the priorities set out for metrology in FP and thus start to change in that direction.
Mobility and Human Resource development	Given the instruments the FP 7 has so far, mobility and training is normally dealt with through grant schemes like "Marie Curie" which however have no thematic integration. The developments in certain NoEs have shown that training and mobility an be integrated into FP activities, and if FP would fund long term, large scale structures such as networks or platforms, this could be integrated into those structures as major precondition for funding.
Global cooperation and position of Europe	The FP cooperation alone is no means to create European actors in the international scene, it needs coordination also of national potential and a strong commitment of national funding agencies and ministries to join forces for international activities. In addition, the more critical mass, the more credible for international partnerships, thus individual projects in FP would not be a sound instrument here.
Support to regulation	The support to regulation at European level could eventually be in-built into the respective FP work programme, demanding networks that are

Objectives	Option 3 FP
	funded for supporting regulation and policy making more generally. The existing potential in Europe could be mobilised through dedicated calls. However, experience shows that the coordination within the Commission, between ERA and FP on the one hand and the thematic areas (both within DG Research and in other DGs) is highly demanding, and positive effects could only be assumed if this coordination is taken care of.
Support to industry and economic growth	Depending on the type of programme and projects financed, the working programme could demand a strong link to and with industry and could in fact steer R&D towards industry needs. A link to JTIs and industrial large scale project could be built, calls in non metrology programmes could offer the opportunity to integrate metrology institutes. On national level, those who are not competitive for the FP would loose, the imbalance within Europe would most likely increase. The overall effect here depends, of course, on the magnitude of the budget, it if equalled the Commission contribution to the Art 169 then many industry-oriented activities would be possible. However, the effects on the ground, for SME in small countries, would be marginal if existent at all, while Art. 169 would help to build up structures.

Objectives	Option 4 Art 169
Co-ordination & integration of NMI and national programmes (cost reduction, reduce fragmentation and duplication, joint strategic direction)	Through a dedicated European metrology research initiative with Member States and the European Commission involved in joint programming the possibilities for coordination and integration will be strong given the leverage effect of additional EU funding and joint responsibility for the execution of the research programming. For some time national strategies have already identified the need to address challenges on the European Research Agenda. The difficulty has been responding to these needs. Individual countries do not prioritise on their own research in activities that will become an equal public good for all 27 Member States over activities that are seen to advantage the investing country. The establishment of a joint programme provides the solution, with common issues addressed in the joint programme, national issues addressed in the national programme.
Grand Challenges	The rationale behind the potential Article 169 initiative is to broaden the scope of metrology even further and to improve the potential in newer areas such as health, environment and food safety. The contribution from the EU would ensure a strong link to grand challenges, while the national interest in the programme would ensure a strong discussion on how to link European and national challenges and policy goals.
New MS: capacity building	iMERA has already let to capacity building across smaller countries. This has been done with a view to increased coordination. Art. 169 would – most likely – continue this trend.
Open access to infrastructures	The joint programming and the discussion about concrete projects as well as strategic planning of the programme offers a strong opportunity for infrastructure access and coordination, especially as it enhances the transparency across Europe. However, this is a potential that needs to be realised through conscious and systematic action rather than hoping for a self-dynamic process.
Interaction with science	The provision to spend 10% of the budget for grants for "outsiders" would

Objectives	Option 4 Art 169
community	ensure a minimal engagement, and care would be needed to guarantee that this engagement would be backed by institutional commitments behind the individual grants and that the grants are given not only to junior researchers or post docs, but to senior researchers form academia as well
Modernisation metrology system	The option would substantially support the idea of modernisation. The national programmes would be modernised between themselves and especially through the integration and influence with the FP. Article 169 will aim at fostering **excellence** by calling for **specialisation** of certain national centres. As an example the UK National Physics Laboratory is not anymore doing certain traditional work on pressure equipment and started very recently to advise UK companies to cooperate with the Italian National Metrology Institutes or Designated Institutes. This type of arrangement started in the perspective of closer cooperation between NMI under EURAMET e.V. and in perspective of the Article 169 Initiative. It shows the potential to create real centres of excellence in specific important fields and allows for higher degrees of European integration. In parallel to the further support to metrology, there is a whole set of "newcomer" countries (those that may currently have limited research activities or no NMI) who could contribute to solve the Metrology Dilemma through new capacity building and become new centres of excellence in particular new niche fields.
Mobility and Human Resource development	The option allows for tailor made mobility modules fully integrated and adapted to EMRP.
Global cooperation and position of Europe	Europe could speak with a single voice on metrology research to the world. Strategic partnerships at global level would become possible. Europe's position would be strengthened compared to other regions.
Support to regulation	To contribute to European regulation could be ensured through Art 169 through the influence of the Commission as co-sponsor.
Support to industry and economic growth	Co-ordination at European level may not lead to a worsening of local service provision. There have been worries that especially SMEs in Europe are not inclined to turn to other NMI in other countries for their queries. However, the service provision for industry is not in the core of the coordination activity (which is about R&D) and there is a potential gain through a better coordinated activity as local industries can get access to specialised European expertise.

The following Table 2 summarises the previous analysis and shows how the three viable options compare in terms on impact on the objective of a Community action in metrology research.

Table 2 Overview of potential impacts of three options

Impact on:	Option 2 Light Coord.	Option 3 FP	Option 4 Art 169
Efficiency of co-ordination, integration of NMI and national programmes	Medium	Very Low	very High

Effectiveness of co-ordination, integration of NMI and national programmes	Medium	Low	High
Grand Challenges	Medium	High	High
New MS: capacity building	Low/Medium	Low	Medium/High
Open access to infrastructures	Low/Medium	Low	Medium/High
Interaction with science community	Low/medium	very High	Medium/High
Modernisation metrology system	Medium	Low	High
Mobility and Human Resource development	Low	Very Low	Medium
Global cooperation and position of Europe	Low/medium	Low	High
Support to EU regulation	Low	Low	High
Growth: Service to industry	Low	Low	Medium
Growth: Support to emerging sectors	Medium	High	High

In this and the previous chapter we have shown that all three feasible and realistic options have their pros and cons. Sophisticated econometric models for quantitative input-output model to ascertain the added value are not existing or reasonable as (1) the cause-effect relations are too complex, (2) the structural effects of the various options for the future cooperation, coordination and integration of national metrology systems cannot be quantified but only assessed in a qualitative way.

This comparison illustrated that the impacts of an Article 169 European on the objectives regarding a metrology action, are the strongest.

We come to the overall conclusion that time is ripe for an Art. 169 initiative in metrology. The initiative is important both for the advancement and modernisation of the European metrology research system and as support for those industries and scientific fields that need more and more sophisticated metrology activities.

The major findings of the Impact Assessment process can be summarised as follows:

First, the "metrology dilemma" is a reality, not only in Europe, but also in other parts of the world. The examples have confirmed that the demands on the metrology research and service provisions are growing both in the traditional industries as well as in new technology based industries. The demands are growing at a rate that needs a significant change in the organisation of metrology as well as a significant increase in the budgets for metrology research. Interestingly, even in the US the discussion on the metrology dilemma has led to worries about the lack of coherence and efficiency losses, even if compared to the fragmented system in Europe the US already have a highly centralised and well equipped metrology system.

This points towards a second argument: The comparative analysis with the US but also with Asia, especially China has shown that those competitors and partners are investing heavily in

metrology. Even if the overall absolute budget of China might still seem modest compared to Europe, the rate of increase is enormous and an end of that growth not to be expected. The relative importance of metrology is growing in other parts of the world.

Thirdly, metrology has a direct importance to contribute to problem solving and policy goals in Europe. The more Europe is defining grand challenges, the more policy is oriented towards those challenges, and the more Europe is also the reference for crisis management that involves accurate measurement and testing (as was the case with BSE), the more a European concentration of metrology research is sensible.

Fourthly, Art. 169 would mobilise additional funds, both at the European level and at National level also due to reduction of duplication. In 14 of the potential 21 participating countries, representing some more than 95% of the budget, the national programmes are well established programmes implemented in isolation and, as result, leading in the past to areas of overlaps. In the remaining 7 countries new budgets have now been identified with the specific purpose of allowing participation in the EMRP Article 169 Initiative. The resulting high level of scientific integration will generate two main advantages:

- Reduction of overlaps and duplication may release additional resources for other activities in the order of at least 10-15% of the existing national budgets.

- Reduction of traditional metrology research through new and modern joint programming of metrology research under EMRP estimated to be of the order of at least 10-15% of the existing national budgets

Policy Option 2 and 3 do not allow strategic investment, nor strategic savings (resources such as metrology facilities and highly trained metrology staff can not be switched on or off at short notice), so the economic savings would be close to zero. The charm of the Art. 169 in terms of financing is the leverage it would have on both levels, the national and the European. The strong signal form the Commission and the request for clear national commitment if countries want to participate has led to strong signals from some member states to increase investment, especially from small countries that apparently have started to enhance their metrology capacities with a view to concerted action and partly pooled resources. The Community contribution would ensure that truly European interest (grand challenges, ad hoc crisis management) would be reflected in the working programme of the new Art. 169 EMRP, without limiting national activities and binding them solely to the European dimension of the programme. The European landscape grows and strengthens both the future excellence and critical mass in the field. 6 New Member States are committed to fund and build up own metrology capacities. All other new Member States, with the sole exception of Cyprus but also including Croatia have joined the EURAMET e.V. association and will benefit from technology transfer measures. EMRP will provide for large scale and strategic research projects able to support smaller countries in particular in building up their own metrology research capacity. Furthermore the cooperation with the wider research Community, especially in countries with low metrology capacities will facilitate preparation for possible new Designated Institutes or even facilitate them in setting up their own National Metrology Institutes.

Fifthly, from all alternatives compared, the Art. 169 would best contribute to a modernisation of the national structures, not only in terms of trans-national programme integration, but also in terms of inserting more competition and advanced "research programming elements" into the metrology research systems, along with peer review and monitoring etc. The competition aspect between the concerned NMI and DI is very limited under the Options 2 and 3, and it

applies mainly under Option 4. To date there are roughly 100 National Metrology Institutes and Designated Institutes in Europe. They receive today through the national budgets for metrology research a kind of institutional funding which guarantees their activities in the planned domains without competing with either similar institutes from other countries or without competition under the same national programme in their own country. Option 2 would assure some competition for funding, however the order of magnitude would be much smaller compared to Option 4 (probably only in the order of 20 -30% of the national budgets as extrapolation from ERA-NET Plus action). Option 3 would not coordinate national funds and therefore not bring any national funds into competition. Under Option 3 the Community contribution could be granted based on competitive calls, however limited to the available amount, meaning far below the planned EMRP budget. Therefore a critical mass and substantial calls for proposals assuring a large competition are less effective under Option 3 than under Option 4. Real and healthy competition under Option 4 fully involves the national programmes and programme owners directly (e.g. at the priority setting) and not only the research performing organisations like NMI and DI. In some countries competencies regarding health, energy etc. are focused outside NMI, and linking systematically up with those RTD performers in order to participate in EMRP projects, would be a major change and provide for more multi-disciplinarity approaches. This important link with academia and the wider science community would be fully embedded in EMRP. No other alternative discussed could do this job as effectively.
Sixthly, the overall goals of the EMRP initiatives are valid and the catalogue of goals in line with the challenges European metrology research is facing. The goals fit the European context to contribute directly to the Lisbon process and if implemented appropriately, metrology research could be at the forefront of creating the ERA based on joint initiatives of member states and the Commission, with "marble cake" structures of joint and separate budgets and responsibilities, making the best of synergies, specialisation and competition.

However, the fact that metrology should have a sound and growing budgetary basis and European and national budget be partly pooled would – isolated – not justify an Art. 169 approach. It is the leverage of the Art. 169 in terms of fully re-organising research in metrology in Europe and the repercussion this will have on the national level that might have an even greater impact.

7. EX-ANTE EVALUATION AND COST- EFFECTIVENESS ANALYSIS

As stated above the NIST of the U.S. has conducted econometric analyses to determine the economic benefit of measurement activities. NIST concludes as an example that measurement activities for the semiconductor industry, achieves the benefit - cost ratio of 3:1. One dollar invested in metrology returns three dollars in economic impact. This figure is very similar to the one calculated for Europe. Against this background we believe that many of the objectives stated in the IA report can be achieved and the core of the argument for an Article 169 is better coordination and additional funding in Europe for Metrology. In essence, the argument is that only an increase in budget and a much more cost-efficient use of the available capacities can satisfy the needs of Europe's industry, policy making and society. Analyses done in the context of the various MERA and iMERA activities stress the Metrology Dilemma in front of the main competing region in the world the U.S. In the US we find one single national system, some of the measurement activities are scattered across the country but all R & D efforts are centralized in a limited number of places mainly located in Gaithersburg or in Charleston. Europe has a much more fragmented situation which urges for better coordination of the efforts taking place in different countries. In stead of addressing e.g.

topic by topic the relevant needs in the Framework Programme a single and integrated European programme assures a coherent approach cross all participating countries. Key elements supporting the cost effectiveness of the selected option are as follows:

- The initial estimation of an optimal budget can be achieved most efficiently by combining national and EU budgets.

- The EU additional investment of estimated 200 M€ over 6-7 years seems very cost efficient compared to the U.S. doubling over 10 years with even higher absolute figures.

- Building on existing programmes, infrastructures and experiences makes the start and implementation most cost-efficient.

- No new programme agencies have to be created and the implementation is based on the experience gained in the participating national programmes.

- No specific additional Commission staff resources are needed for the implementation as the service dealing with programme coordination can follow the EMRP. A well organised coordination between Commission services may achieve very high impact on EMRP with no additional staff resources.

Another key issue to assure cost-effectiveness are the challenges ahead. New, emerging technologies put additional pressure on the measurement system and in fact necessitate "entirely new types of measurement". This new pressure not only relates to simply "more" measurement, but to new forms, to exploratory measurement. This type of projects will be particular complex and have large interdisciplinary approaches. Costs for this type would be at least 2-3 times higher due to larger consortia and new and more complex approaches. The EMRP approach represent in this respect a very cost efficient solution compared to uncoordinated national approaches and links in addition the wider science community in. Coordination cost could be estimated up to 20-30% of the cost compared to the integrated approach of Article 169, which shows that option 2 and 3 are very costly with much lower degree of programme integration as compared to the chosen option 4.

The newly created EMRP shall be focused and concentrated on the dedicated medium to long term needs and new challenges. Lower levels of investment from the Community side are estimated as sub critical and would not allow influencing substantially the coordination and cooperation of the existing national programmes. Furthermore the metrology needs could not be covered as mentioned above. The other options/approaches considered would neither raise the necessary funds nor achieve the concentration and coordination of the existing national metrology research activities. Pure coordination instruments would not allow such a high level of integration (scientific, management and financial) and therefore not be able to implement such an ambitious programme as EMRP.

Metrology is by nature a horizontal activity, supporting a range of scientific fields and economic sectors. It thus has a strong *public good* character due to market failure and private incentive to engage in Metrology is therefore extremely limited. Further, metrology is a main supporting activity for government regulation and standardisation. Hence, national governments as well as the Community have not only a concrete interest but also the need in setting up metrology capacities to ensure that their countries have the means to establish standards that are needed for essential regulations or to adapt international standards to the local conditions. In building a European integrated approach the initiative represents for the

preparation of standards and new regulation a cost efficient solution for the Community, as the coordination link to the responsible national authorities and research programmes is very short and well established within EMRP.

The cost for implementing the programme are estimated at 16 M€ in total covering all costs for the programme implementation. For the Community this will even be considered as a ceiling to be respected by the dedicated implementation structure. This figure of 4% of the total programme cost is below the costs for EDCTP and in the same range of the operational cost for EUROSTARS and AAL initiatives. This figure is estimated as e very good value for the implementation of such an ambitious international research programme.

The Commission own human resources are estimated as a maximum of +/- one AD 8-12 grade full time Scientific Officer over the programme duration estimated at 6-7 years. This period will last mainly from full implementation as of 2010 until latest 2017 when also a final evaluation of EMRP is foreseen. The preferred option implies therefore very low administrative burden on the Commission side.

The wide range of impacts and changes which are expected from the initiative could not be achieved at same cost through any other option or any other instrument of the Framework Programme. The initial criteria of FP7 for preparing Article 169 have been closely followed and are the guarantee for selecting the most appropriate instrument and assuring cost-efficiency. The EMRP programme is largely using national infrastructures assuring limited Community investments for this costly part of metrology research projects. Solutions presented in other options could not achieve the set objectives – especially in view of coordination and integration - and would most likely be much more costly for the Community.

In principle there are only two minor Risks connected to this initiative. The first one is related to missing financial and political commitment of Member States. However this risk has been largely avoided through the preparatory phase in iMERA and iMERA Plus. In addition Member States have already in 2006 flagged that commitment going also financially clearly beyond 200 M€. The second risk is only linked to the designated implementation structure and its capabilities to implement EMRP. Also here a large scale test under iMERA Plus reduced the risk drastically; Further more will a planned ex-ante audit assure that all necessary requirements for the EMRP implementation are in place are in the process to be put in place.

Financial integration and role of EURAMET e.V.

The bulk of EMRP projects can only be funded through a 'virtual common pot", imposed by the set up of the existing national metrology research programmes. This approach is compulsory as the participating programmes are neither cash programmes nor classical R&D funding programmes implemented via calls for proposals. Instead these programmes represent a part of the governmental budgets towards the National Metrology Institutes (NMI), in future partly earmarked for the joint EMRP initiative and consumed by NMI and Designated Institutes (DI). The entire Community contribution to EMRP will stay at the level of the dedicated implementation structure EURAMET e. V., without transferring any Community funds to any participating national programme. This approach is established for the first time in an Article 169 initiative and demonstrates the absence of any "re-nationalisation" of Community funds. The Community Contribution will be managed centrally by EURAMET e.V. and will be directly provided to final research beneficiaries participating in research projects or receiving researcher grants independent from their nationality. This modus operandi assures full transparency concerning the use of the Community contribution and

contributes to the protection of the Community financial interest. On the long term EURAMET e.V. will become a sustainable structure for metrology research coordination.

Under Option 2 EURAMET e.V. could function only as a central meeting point where national programmes would, on a fully voluntary basis, be enabled to coordinate their research activities. However no formal role would be given to EURAMET e.V. and no scientific, managerial nor financial integration would be achieved under Option 2. Clearly the impact on existing national programmes will be minor and no long term perspective concerning research coordination can be expected. Under Option 3 EURAMET e.V. would play no role at all and impact on programme coordination does not exist.

Other issues illustrating efficiency and partly cost-effectiveness of the chosen approach are raised in the following chapter. Many lessons learned from the EDCTP implementation have been taken into account during the preparation of the EMRP initiative.

8. MONITORING AND EVALUATION

In setting up the possible action and provide for proper monitoring and evaluation the lessons from the van Velzen report[22] have to be taken into account. Major condition for success is the existence of a true cross-European ownership, with joint programmes between the interested Member States and autonomous and well functioning pre-existing structures. More generally, Van Velzen's prerequisites set standards for any forthcoming initiative. The report sums up "*Suggestions to the European Commission for new Article 169 initiatives"***.** The most relevant van Velzen recommendations are listed below in bold and the EMRP status in italic:

- Assess the performance and suitability of pre-existing common structures;

The structures are established and have been successfully tested in the ERA-NET Plus.

- Require a clear joint ownership statement, a pact with long-term obligations and sanctions;

The EMRP 2007 document was issued by the iMERA ERA-NET, which includes a mixture of National Metrology Institutes (NMI) and Ministries from a total of 14 countries. The EMRP 2007, and the Article 169 has been fully endorsed by the ministries from 21 countries. Whilst all countries are somewhat limited in making long-term budget commitments due to national law, the initiative effectively switches budgets already existing nationally.

- Define general rules for the common funding pot or other possible national contributions.

The EMRP Article 169 will follow a model concerning its financial integration, which combines a partly real common pot with a virtual common pot. It is noted that Member States generally will make resources available in terms of their programmed publicly research staff and facilities, rather than large amounts of cash.

- There must be pre-existing national programmes;

Pre-existing fully fledged national public metrology R&D programmes or metrology related targeted research actions have existed for many years in 14 of the 21 countries. New programmes were launched in a further 7 countries to participate in the ERA-NET Plus, and in preparation for Article 169.

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[22] Independent External Review Report - European and Developing Countries Clinical Trials Partnership (EDCTP Programme)

- There must be available budgets, or a strong commitment to make them available;

The budgets are available, an outline commitment, with full Ministry support, of 273 M€ was made in the summer of 2006 from the original 14 countries. Since that time, and particularly recognizing the success of the ERA-NET Plus Call, a number of the original countries have indicated a desire to increase their portion of the Article 169 budget The clear commitment of the players, the strong track record over time, and the enthusiasm following the ERA-NET Plus pilot phase indicate this will not be a difficulty.

- There must be a common work-plan, objectives, milestones, sound governance;

The common work plan - the EMRP 2007 - is in place already, the consortium has submitted informally an outline time plan for the Article 169, and sound governance is already in place and demonstrably working. The EMRP programme has a very strong strategic focus. It has been prepared by 21 NMIs in accordance also with their respective ministries. Other relevant stakeholders have been largely consulted in workshops focusing on topics like Health, Environment, Nanotechnologies etc. The strategic focus is well set and Commission will be formally consulted call by call on this focus.

- The Article 169 entity has full control on how to spend the money;

This is already the case for the ERA-NET Plus which is fully controlled by EURAMET e.V. the not for profit legal entity. It was particularly noticeable that all participating countries fully supported the ranking list as evaluated by the referees, and although there were winners and losers there was no dissent irrespective of the relative success of any particular country. The same approach will be applied under Article 169.

- There is adequate representation at a level where individuals can take decisions;

The structures for decision-making are well thought through and have demonstrated already that they place appropriate representation at the right levels.

- There is a clear evaluation procedure; the overall criterion is one of excellence;

This was indeed the case for the ERA-NET Plus, and the metrology community seem very comfortable with the expectations of the Commission with regard to evaluation. The Commission sent an observer to the ERA-NET Plus evaluation, with free and unhindered access to all aspects of the process and people involved, and is able to give a clean bill of health to the process. Furthermore the independent Research Council has also given a favourable opinion of the process and outcome. Article 169 will take the same approach and FP7 criteria will be applied for evaluation of proposals.

This remaining part of this section will both include recordable integration indicators and qualitative progress indicators that need to be assessed by experts. The monitoring and evaluation will be accompanied by an annual reporting done by the Dedicated Implementation Structure (DIS) referring to the indicators introduced below on the basis of the expected actions within the EMRP programme.

Evaluation of the EMRP will take place at a midterm evaluation and at an ex-post evaluation both conducted by an independent expert group being the key actors in this process. These two evaluations shall be compete and thorough as described in this chapter and shall enable to take decision concerning continuation of the initiative. The result of the two evaluations can be published by the Commission.

The DIS will be asked to submit on a call by call basis the information required for the indicators and for the self-assessment, starting with data for the year before EMRP begins.

Beside the specific objectives which will be monitored by quantified indicators the general and specific objectives will also be closely monitored. Indicators at general level could be:

- Achievements related to the objectives of the revised Lisbon Strategy. In particular "return of investment" in knowledge for growth and jobs
- Realisation of the European Research Area (ERA) by implementing a genuine “European Metrology Research Area” (MERA).
- Number of societal challenges such as environmental protection, health care, food safety, or public security addressed by EMRP

In order to contribute to achieving these general policy objectives, it will be necessary to improve the efficiency and effectiveness of public metrology research programming in Europe in areas where it is facing major societal challenges. Indicators at the level of specific objectives could be:

- Level and deepness of integration achieved at EMRP to provide solutions to important European societal challenges (which challenges addressed)
- Level of improvement in % to today of the efficiency of Europe’s fragmented public metrology research approach. And the related impacts
- Removing all barriers between national metrology research programmes resulting in sustainable cross-border cooperation

Review via indicators at operational level and evaluation

Beside a midterm review, an ex-post evaluation will be conducted by an independent expert group to evaluate the progress of all general, specific and operational objectives in the different action of the planned programme. The main impacts are expected towards the end of the EMRP programme. The final impact will be analysed not later then 2017. The group will base its assessment of the operational objectives on the following specific indicators:

- Number of Member States involved in EMRP and national programmes actively coordinated
- Number of new MS building up metrology capacities
- Number of research organizations (not being NMI of DI) involved in EMRP projects
- Number of research infrastructures jointly used in RTD projects
- Number of research projects which are build on the specific strength of NMI and DI and their infrastructures and their impact on primary standards,
- List of advanced technologies employed in the developments of primary standards can and should be transferred to new and challenging research activities
- Number of EMRP projects with direct references to regulation
- Number of mobility grants implemented
- Indicators: total Ph.D.s trained in metrology
- Total number of metrology researchers involved in EMRP projects by age class and seniority level
- Number of generic cooperation activities with non-European research actors.
- Number of publications
- Number of presentations at congresses
- Number of presentations at standardisation technical committees or working groups
- Number of patents granted

The expert group will further assess impact of EMRP on the integration of national metrology programmes, restructuring of the metrology networks and programmes, impact on ERA in general.

The proposed EMRP overall Budget

The annual estimated research budgets for projects like foreseen and outlined in the type of projects and reflecting the priorities of EMRP is today 120 M€ per year for all EMRP member countries together. Over a six year programme this budget adds up to a total of 720 M€, which are today spend completely independent, uncoordinated and fragmented over 21 Countries and many technologies. In the analysis of iMERA it was estimated and discounted the portion of R&D project spend where coordination/collaboration at European level would not bring benefits like, research close to market, small and short-term research, specific research needs on a single country, restricted by national law of security considerations, research of high national prestige. Based on the above iMERA analysis the estimated portion of potential "European" project funding that could realistically be freed from direct national control arrived at a core budget of 200 M€ over 6-7 years considering a reserve budget of 100 M€.

With the proposed Community Contribution of 200 M€ matching another 200M€ MS contribution EMRP would shift drastically from fragmented and purely national RTD investment in metrology research towards a structured and balanced investment at National and EU level.

- Today:
720 M€ (National) > 0 M€ (European)
100 % (National) 0 % (European)
- Tomorrow:
520 M€ (National) 400 M€ (European)
56 % (National) 44 % (European)

The budgetary planning for EMRP has two major impacts. Firstly it increases the total available resources by 200 million €, while at the same time due to reduced duplication also existing national resources can be feed for new tasks. Secondly it shifts the today's solely national research programme funding to a balanced situation where 44% of the overall financial research resources are implemented in a European programme. The fact that metrology should have a sound and strongly growing budget does not justify an Article 169 approach on its own. The cost of non-coordination can not be realistically estimated. Also the leverage of the Article 169 in terms of organising research in metrology in Europe and the repercussion this will have on the national level and the modernisation can not be calculated realistically. However the overall 38% growing investment over the coming 6 years is expected to generate a huge benefit clearly beyond this percentage.

Openness to the wider research community

Major NMI and the stakeholder community have been especially asked how much of their actual RTD work is today done by the wider research community. This cooperation which is today articulated by subcontracting or other cooperation agreements (MoU) was indicated by several NMI ranging from 1% up to 5% of the national research project budgets. During the same stakeholder consultation meeting this order of magnitude was confirmed by other organisations and industrial representatives were even partly in favour of either no opening to the wider research community or only extremely limited opening. Against this background we believe that a +/- 10 % opening of EMRP to the wider research community through researcher excellence grants is a well balanced figure. This approach supported with very dedicated mobility grants to address specific objectives, seems to be the most promising answer to the problems raised.

In order to make an Art. 169 meaningful for a structuring and modernisation of the field and to strike the right balance between building up structure, supporting policy goals and

contributing to high level, leading edge research, we propose a set of recommendations that should be considered when implementing this Art. 169 initiative:

The set up and implementation of the EMRP Art. 169 must ensure:

- a governance that finds a balance between the inter-national interest mediation and the European interest, and between offering R&D options and contributing to clear European goals and problem solving. The Commission would need an expert based (not simply politically defined) voice in defining programmes – and where appropriate even in having access to a specialised fund for short term "emergency calls for proposals" (see the example of BSE etc.). This must not, however, a dominance of short term political interference. EMRP Art. 169 must remain an R&D programme including academia, not an enlarged service provision.
- a balance between convergence and coordination on the one hand and competition and variety on the other hand. The fact that most countries have still Art 169 that not a majority has the dominance in defining the one and only solution, but that through external peer review minority trajectories are not ruled out systematically.
- that the effects on the small Member States should be closely monitored in order to avoid a further broadening of the capability gap across Europe and to mobilise all talent in the periphery; the EMRP shall be open to any EU Member State if they wish to join.
- that the involvement of academic and other scientists that are not directly members of the EMRP is broad and high level.
- that the mobility aspect of the approach is and remains strong.
- a strong focus on optimal usage of infrastructure across Europe, extending even to infrastructure road mapping for the future, to avoid duplication but guarantee mutual access.
- a balance between generic, horizontal aspects of metrology and the theme and issue oriented activities.
- pre-competitive research defined together with all concerned stakeholders.

ANNEXES

Annex 1
Stakeholder consultation on the preparation of a European Metrology Research Programme (EMRP) via a potential Article 169 of the Treaty -Analysis and responses to the online survey

Annex 2
Report of the workshop on "Stakeholder consultation on the preparation of a European Metrology Research Programme (EMRP) via a potential Article 169 of the Treaty", 25 June 2008, Brussels

Annex 3
iMERA Task report 1.1 – Deliverable on the national landscaping in metrology research

Annex 4
The European Metrology Research Programme - the EMRP (Version 2007)

Annex 5
iMERA Plus Research Council Opinion