Implementing the Metrology European Research Area – iMERA
ERA-NET Coordinating Action, Contract number: 016220
Contract Start Date April 2005, Duration 3 Years

WP2 - Systematic exchange of information and best practices

T2.8 - **Social and ethical issues of metrology**
Deliverable D2.10 Recommendations on ethical issues

Deliverable Due Date: March 2007
Date of Issue: April 2007

Task Participants:
SP (SE) as task leader, CMI (CZ) and NPL (GB) as team members, plus input from all partners

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Short description of work:

T 2.8 **Social and ethical issues of metrology** (**SP Sweden,** CMI, NPL + input from all partners)

Overseeing the ethical, gender and societal issues raised in 9.2 of the iMERA DoW, this task team T2.8 will work across the other project tasks to alleviate the risk of creating technical barriers to trade between Europe and its trading partners (linking with T2.7). They will promote understanding within and external to the project related to interoperability – both in measurement standards and measurement aspects of documentary standards and address certain aspects related to metrology access by developing countries. The task team will examine the issue and make appropriate recommendations to improve this situation.

REPORT STATUS : PU[1]

SUPPORT FOR THE COORDINATION OF ACTIVITIES

Structuring the European Research Area

[1] see back page for explanation

SP Sveriges Tekniska Forskningsinstitut
SP Rapport 2007:21
ISBN 91-85533-43-2
ISSN 0284-5172
Borås 2007

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SP Report 2007:21

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EXECUTIVE SUMMARY

Reliable measurement results are important in almost every aspect of our daily life, ranging from fundamental science, through industrial quality assurance, global trade to health, safety and Quality of Life. It is therefore natural to examine both the benefits and potential risks associated with metrology in ethical and societal terms.

Developing new measurement technology may initially seem far from social or ethical concerns. Metrology itself can be regarded as an enabling technology which, when developed in combination with other technologies – such as sensor technology – becomes more tangible. Many of social and ethical concerns that have been expressed in evidence on the nanotechnologies are not unique to those technologies.

A review has been made of earlier studies of ethical issues in science & technology, particularly nanotechnology, and consultation with groups such as the earlier EU METROTRADE group and the new EU MINET (Measuring the Impossible) network.

Potential ethical issues related to Metrological research are found of course in the traditional area of Trade, as is well known. But challenges also lie in avoiding the creation of a 'metrology-divide' between countries with different capacities for research and exploitation of new measurement technology. Particularly where metrology converges with other emerging and rapidly developing technologies, ethical issues might arise also in Information collection, human enhancement and military applications. These challenges can be met by dedicated programmes for knowledge transfer and for coordination of national metrology with conformity assessment actions.

In this final report of the iMERA Task 2.8 **Social and ethical issues of metrology** (D2.10 Recommendations on ethical issues) a number of recommendations are given aimed at handling ethical issues in the future EMRP and EURAMET:

- The EMRP should include an <u>interdisciplinary research programme</u> to investigate the social and ethical issues expected to arise from the development of some measurement technologies
- Consideration of ethical and social implications of advanced technologies (such as nanotechnologies and metrology) should form part of the <u>formal training of all research students and staff</u> working in these areas and, specifically, that this type of formal knowledge transfer should be listed in the European Metrology Research Programme
- Full use of <u>co-operation and networks</u> among the laboratory community and other metrology stakeholders (industry, authorities, etc) can give efficiently an input to many committees and working groups, achieving much more and having greater authority, reputation and influence than individual laboratories.

1 Introduction: framing social and ethical issues

This report covers the studies made in the ERA-NET iMERA "Implementing Metrology in the European Research Area" according to the following remit:

"Overseeing the ethical, gender and societal issues raised in 9.2[2] of the DoW this task team will work across the other project tasks to alleviate the risk of creating technical barriers to trade between Europe and its trading partners (linking with T2.7). They will promote understanding within and external to the project related to interoperability – both in measurement standards and measurement aspects of documentary standards and address certain aspects related to metrology access by developing countries. Anecdotal evidence suggests whilst women are reasonably represented at the postdoctoral level there is serious under representation in more senior metrology posts. The task team will examine the issue and make appropriate recommendations to improve this situation."

Reliable measurement results are important in almost every aspect of our daily life, ranging from fundamental science, through industrial quality assurance, global trade to health, safety and Quality of Life[3]. It is therefore natural to examine both the benefits and potential risks associated with metrology in ethical and societal terms.

Developing new measurement technology, as in the new European Metrology Research Programme[4], may initially seem far from social or ethical concerns. But as is evident from recent international debate, developments in science and technology do not take place in a social and ethical vacuum. Mention can be made of issues such as nuclear energy, agricultural biotechnology and embryonic stem cells. The present study of measurement technology will take much of its form from the recent investigation of the social and ethical issues of nanotechnologies by the UK Royal Society[5]. As pointed out in the conclusions of that study:

"many of the social and ethical concerns that have been expressed in evidence are not unique to nanotechnologies"

Metrology itself can be regarded as an enabling technology which, when developed in combination with other technologies – such as sensor technology – becomes more tangible.

Widespread acceptance of products where metrology is involved will depend upon a range of social factors including: specific technical and investment factors; consumer choice and wider public acceptability; the political and macro-economic decisions that contribute to the development of major technologies and outcomes that are viewed as desirable; and legal and regulatory frameworks. Both technological developments and society's needs can change unexpectedly, and foresight to twenty or more years is difficult. It is also important to look beyond the perspective of Western industrialised societies, to take account of the ways in which people in developing societies might respond to developments in metrology and its impacts.

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[2] Reproduced in Annex A of this report

[3] "Metrology: Who benefits and why should they care?", F Redgrave and A Henson, *MEASURE*, **1**, 30 – 6 and NCLSi 2005 Workshop and Symposium

[4] "Outline of the European Metrology Research Programme – the EMRP", iMERA Task 5.1, draft 4th December 2006

[5] The Royal Society & The Royal Academy of Engineering Nanoscience and nanotechnologies | **July 2004, http://www.royalsoc.ac.uk/page.asp?id=2472**

2 Impact of metrology and ethical & societal issues. Examples from Trade

In this section, examples of metrology-related issues in the context of economy and trade will be examined. Metrology has of course even other forms of impact in ethical and societal terms such as in the context of Quality of Life and Civil Liberties, as will be discussed in subsequent parts of this Report, and the trade and economic issues of metrology and their solution discussed in the present section will also be more generally applicable to other areas of impact.

The present iMERA project includes a Task (1.5) addressing the Impact of Metrology[6].

A number of evaluations of the economic impact of metrology in recent years have come with impressive estimates of significant impact as a certain percentage of productivity in Europe and elsewhere.

Regarding the effectiveness of money spent on European metrology, the study "*The assessment of the economic role of measurements in modern society*" commissioned by the European Commission[7] and published in July 2002 comes to the following conclusion (taken from the executive summary):

"Our main finding is that this area of activity is extremely important in economic terms both because of the absolute size of measurement activity and because of the significant and wide ranging benefits it produces in underpinning technological innovation, growth, industry, trade and social programmes. Europe spends more than €83 billion per year, or nearly 1% of EU GDP, on measurement activity from directly quantifiable sources alone. Adding in social spending on health, environmental regulation, safety testing, anti-fraud projects and normal day-to-day activity raises this figure considerably. By comparing these costs with estimates of the benefits of measurement, we can see that this money is well spent. Our econometric estimates of the economic impact of measurement activity show that this spending generates almost €230 billion of directly estimable benefits through application and from the impact measurement knowledge has on technology driven growth. This is equivalent to 2.7% of EU GDP. Put another way, for every euro devoted to measurement activity nearly three euros are generated by way of directly estimable benefits alone. This is true even without taking into account the very large benefits to society in terms of health, safety and the environment, which would raise the benefit to cost ratios even further."

It might be tempting to assume that the potential economic results of metrology – greater gross domestic product (GDP), greater efficiency and less wastage in industrial processing, greater innovation and growth – will be entirely positive across society or across the range of developed and developing nations. However, in general the introduction of new technologies creates both 'winners' and 'losers'; for example, as employment is displaced from one sector to another.

2.1 Trade difficulties due to lack of international acceptance of test & measurement results

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[6] iMERA 2005 "Implementing Metrology in the European Research Area", http://www.euromet.org/projects/imera/index.html
[7] DG-Research GROWTH Programme Contract No: G6MA-2000-2002; Geoffrey Williams *et al.*, Pembroke College, Oxford, 2002

Examples of recent studies of the impact of metrology on international trade include the EU project 'MetroTrade' and an OIML study of pre-packages[8].

Trading may be food products from the developing countries[9], environmental goods or perhaps of the very latest nanotechnological products[10]. In any case, different estimates of the values and qualities of goods can be at the root of many technical barriers to trade (TBT), as is well-known[11],[12],[13]. These are serious issues since some estimates indicate that as much as 80% of traded goods[14] are subject to conformity assessment, for which measurement and testing provide essential objective evidence for decision-making.

TBTs can arise if there are differences between consumer and producer in:

- conformity assessment
- written standards and/or directives
- estimates and treatment of uncertainty
- metrological traceability

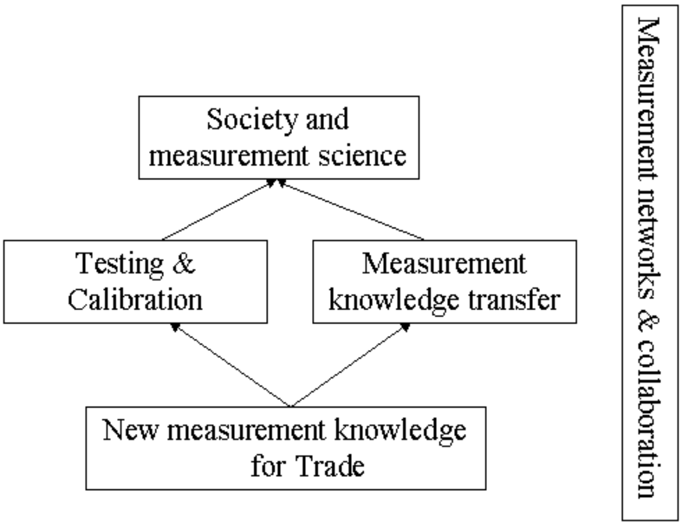

Figure 1 Critical success factors for trade performance

Principal ways of solving or avoiding such measurement-related trade difficulties are shown in figure 1. In addition to improved measurement quality through better testing and calibration methods, other critical success factors such as new knowledge creation and good knowledge transfer are internationally recognised as essential in enhancing trade and innovation[15], [16].

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[8] "The economic importance of legal metrology in pre-packaging", J Birch 2007 *OIML Bulletin* **XLVIII**, 19 - 24

[9] FT 2004 "Food safety fears 'used as excuse to ban imports' ", *Financial Times*, 040406

[10]Henson A and Pendrill L R 2005 "Global R&D for global nanotechnology standards", NCSL 2004 and Métrologie 2005 conference (this session), Lyon (FR) 20th June; CEN BT/WG166 Nanotechnology, http://www.cenorm.be/cenorm/businessdomains/businessdomains/materials/nanotechnology.asp; ISO TC229 Nanotechnologies
NICe 2005 « *Nordic nanotrade* », project coordinator SP (SE)

11Erard L 2003 "Metrological support to international trade. The MetroTrade project" Métrologie 2003 congress Toulon (FR)

[12] MetroTrade 2003 MetroTrade & RegMet web-site: http://www.metrotrade.dk;

[13] JCDCMAS 2004 "*Building corresponding technical infrastructures to support sustainable development and trade in developing countries and countries in transition*", http://www1.bipm.org/cc/JCDCMAS/Allowed/Background_documents/Background_paper_final.pdf

[14] "Metrology: Who benefits and why should they care?", F Redgrave and A Henson, *MEASURE*, **1**, 30 – 6 and NCLSi 2005 Workshop and Symposium

[15] DTI 2003 "*Competing in the global economy: the innovative challenge*", DTI Innovation Report (UK) December 2003 http://www.npl.co.uk/met/dti_steer/innovation-report-full.pdf

[16]DOC 2004 "*Standards and Competitiveness – Co-ordinating for Results. Removing Standards-Related Trade Barriers Through Effective Collaboration*", US Dep. of Commerce, Pre-print May 2004

Trade difficulties caused by suppliers and consumers making different assessments of the value and quality of goods on the basis of different measurement standards, with insufficient metrological traceability or incorrect treatment of uncertainty of the results, can be alleviated by increasing mutual confidence in measurement results through international harmonisation of standards and interlaboratory studies[17]. Such arduous studies must however make full use of co-operation and networks among the laboratory community as examined in the present EU ERA-NET iMERA project.

What then is the current situation and what are the prospects in Europe for enhancing international trade through better measurement networking?

2.2 European and international metrology and Trade

At the start of the decade, the EU and the US made a declaration of co-operation in metrology with the overall objective of facilitating trade[18].

On the one hand, a detailed description of the existing metrology infrastructure was satisfactorily in place as part of an advanced and mature system. This has been clearly reported in recent years, through European and international projects, such as the « Panorama over EU Metrology Infrastructure »[19] and the CIPM Mutual Recognition Agreement (MRA)[20].

On the other hand, challenges have lain in overcoming an earlier 'lack of cohesion and co-ordination' in metrology questions in the Commission and between NMIs[21]. Norms, quality and accreditation were all addressed at European Community level – but what about metrology? At the same time, demands are increasing for metrological infrastructure in a number of new fields – biotechnology, food, nanotechnology etc – with clear trade relevance.

These challenges to European metrology have been subsequently addressed in a succession of EU projects[22],[23]. The present study is part of the latest in this series, namely the EU ERA-NET project iMERA[24]. A summary of the role of metrology in general conformity assessment, particularly in Europe, is given in section 10 of this report.

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http://www.technology.gov/reports/NIST/2004/trade_barriers.pdf

[17] Pendrill L R and Schmidt A 2005 "*Facilitating international trade by using measurement laboratory networks*", 2005 MÉTROLOGIE 2005 Congress Lyons (FR) 20 – 23 June

[18] Julin A 2002 "*Trade, regulation and measurement*" at Joint MetroTrade and RegMET workshop on regulatory issues, Geel (BE), May 2002
http://www.eotc.be/Events/Eotc/regmet/dls/Julin.pdf

[19] BNM 2004 "A Panorama over the European Union Metrology Infrastructure", final report to the EU and EFTA, www.bnm.fr/pages/divers/panorama%20final%20report%20(inc%20links).pdf

[20] BIPM 2005 « *Mutual Recognition Agreement* » http://www.bipm.org/en/convention/mra/

[21] Julin A 2002 "*Trade, regulation and measurement*" at Joint MetroTrade and RegMET workshop on regulatory issues, Geel (BE), May 2002
http://www.eotc.be/Events/Eotc/regmet/dls/Julin.pdf

[22] MetroTrade 2003 MetroTrade & RegMet web-site: http://www.metrotrade.dk;

[23] MERA 2003 « *Planning a European Metrology Research Area* », http://www.euromet.org/projects/mera/

[24] iMERA 2005 "Implementing Metrology in the European Research Area",
http://www.euromet.org/projects/imera/index.html

3 A ‘metrology-divide’?

Several of the major long-term impacts of for instance nanotechnologies upon global society: for example, that it will provide cheap sustainable energy, environmental remediation, radical advances in medical diagnosis and treatment, more powerful IT capabilities, and improved consumer products, could equally be associated with metrology. Indeed it is well known that metrology has profound implications for global society and the economies of many nations, dating at least back to the first international treaty of 1875 – namely the Metre Convention. Many of the debates where metrology has been – rightly or wrongly – associated with barriers to trade show that technological developments have not necessarily benefited all of humankind, and some have generated very definite ‘winners’ and ‘losers’.

As with nanotechnologies, concerns have been raised over the potential for advanced technologies – including metrology in part - to intensify the gap between rich and poor countries because of range of capacities of different countries to develop and exploit these technologies, leading to a so-called ‘technological divide’. If global economic progress in producing high-value products and services depends upon exploiting scientific knowledge, the high entry price for new procedures and skills (for example, in the medical domain) is very likely to exacerbate existing divisions between rich and poor (P Healey, written evidence quoted in the Royal Society report).

In all parts of the World, consumers when confronted with complex industrial products may have difficulties making independent judgements about product merits and safety.

Patenting is often regarded as a positive indicator of intellectual property[25]. However, as experience in genetics shows (Nuffield 2002), patents that are too broad or that do not strictly meet the criteria of novelty and non-obviousness, can work against the public good. There is a concern that broad patents could be granted on nanotechnologies, for example on processes for manipulating or creating materials, - perhaps even where metrology has been enabling - which would stifle innovation and hinder access to information, not least by those in the developing world. As highlighted in the Royal Society report on intellectual property (Royal Society 2003), it is vital that patent offices monitor the complex and rapidly changing developments in science and technology so that any patents which are granted are appropriate and support rather than constrain research and innovation.

Metrology can of course have beneficial applications for the developing world and for the environment, for example by reducing carbon dioxide emissions through improving renewable energy technology or better healthcare through better measurement. One should be observant that concerns such as raised for nanotechnologies about becoming another ‘opportunity lost’ for developing countries might even apply to metrology.

As suggested for nano- and other technologies, policy decisions about future directions of metrological research and development could include:

- Can future metrology be steered towards wider social or environmental goals (for example, cheap sustainable energy generation and storage) rather than towards meeting short-term or developed world ‘market’ opportunities (for example, cosmetics)?
- If a ‘technological divide’ develops, what can governments do about it? For example, to the extent that the products of metrology become essential to normal participation in society,

[25] Intellectual property issues in Metrology are studied in the iMERA Task 2.5 (SP, SE Task Leader)

should public authorities try to rectify the divide in an appropriate way? Where the products are luxury goods, can their demand and supply reasonably be left to the market?

- The governance of metrology and other rapidly developing technologies must in some way be designed to incorporate the perspectives and objectives of governments, the market and civil society.

4 Convergence of Metrology with other Technologies

4.1 Convergence refers to the multiple ways in which a technology – such as metrology and nanotechnology - may combine in the future with other developments in new technology (reflecting their genuinely interdisciplinary nature). Convergence is likely to generate a range of social and ethical challenges, as exemplified below.

5 Metrology-enabled Information collection and the implications for civil liberties

Quality-assured measurement has always played a key role in ensuring reliable information transfer, through synchronisation and spectrum allocation. Disruption of modern communication systems because of time and frequency problems can lead to difficulties in many sectors of society, including the media, alarm, police, military and emergency systems, e-Government, financial transactions, tele-medicine etc.

Metrology, with its close affiliation with for example nanotechnologies, promises considerable advances in developing small and cheap sensing devices, enabling a range of features that will make smaller, longer-lasting sensors possible. Indeed, sensors may be seen as an ‘embodiment’ of metrology. The convergence of nanotechnologies with IT and metrology could provide the basis for linking complex networks of remote sensing devices to significant computational power. Some nanodevices may be widely incorporated in other products. Such developments could be used to achieve greater safety, security and individualised healthcare, and could offer advantages to business (for example in tracking and other monitoring of materials and products). However, the same devices might be used in ways that limit individual or group privacy by covert surveillance, by collecting and distributing personal information (such as health or genetic profiles) without adequate consent, and by concentrating information in the hands of those with the resources to develop and control such networks.

This issue is clearly one where metrology plays an enabling role in promoting societal changes that have both positive and (if the technology is abused) negative consequences. While the underlying legal and ethical issues raised by such developments are unlikely to be any different in principle from those society has faced in the past across a whole range of healthcare and consumer issues, vigilance is still necessary.

6 Metrology-enabled Human enhancement and Quality of Life

As mentioned in the Introduction, reliable measurement results are important in almost every aspect of our daily life, including health, safety and Quality of Life[26].

[26] “Metrology: Who benefits and why should they care?”, F Redgrave and A Henson, *MEASURE*, **1**, 30 – 6 and NCLSi 2005 Workshop and Symposium

This includes monitoring of the human environment, such as in food safety and environmental monitoring, particularly potential risk factors such as pollutants of various kinds as well as monitoring of the human condition itself, in healthcare, diagnosis, treatment and therapy.

Metrology can be regarded in a general way as dealing with complementing the basic human 'five' senses with instrumentation and measurement technology in monitoring products and processes of all kinds. It is natural therefore that metrological development can be exploited in enhancing human sensing. However, certain types of human sensory enhancement are not without controversy. The UK Royal Society study of the nanotechnologies has a more detailed discussion on this item[27] which may be equally applied to metrological-enabled enhancement. An example of a current EU project in this area is 'ENHANCE'[28].

During the present study, a consultation in this area was performed by the iMERA Task team with the new EU NEST project MINET "Measuring the Impossible"[29]. Seeking to provide a reproducible basis for qualifying and quantifying what are essentially 'soft' measurements (subject to human perception and interpretation) is a particularly challenging scientific endeavour. Individual projects in the NEST Pathfinder Measuring the Impossible (MtI) programme are addressing various aspects of this problem. The MINET project aims to maximise these project outcomes by promoting synergy and information exchange, with the longer-term goal of building a broad Europe-wide MtI community.

7 Military uses of Metrology

Metrology has always offered significant advances and advantages in defence capability – the very word 'calibration' for instance is of course closely related to the calibre of weapons.

Echoing the points made above about the prospects for the development of pervasive sensing, the main initial defence impact in the future is predicted to be in information systems using large numbers new and cheap sensors, as well as in information processing and communications. There are ready examples of metrological applications in these contexts, such as time & frequency synchronisation. Metrology might combine with for example nanotechnology developments enabling pervasive nanosensors to contribute to national defence capability through early detection of chemical or biological releases, and increased surveillance capability. In addition, 'a whole range of military equipment including clothing, armour, weapons, personal communications will, thanks to low cost but powerful sensing and processing, be able to optimise their characteristics, operation and performance to meet changing conditions automatically'.

Military developments raise several obvious social and ethical issues, most of them once again not confined to metrology.

A related issue arises from the fact that much of the basic knowledge and technology needed to achieve military capabilities using applications of metrology and other rapidly developing technologies will be produced within the civil sector, and hence is potentially available to a very wide range of parties, including non-state actors. Metrology as an enabling technology may also contribute to such developments.

[27] The Royal Society & The Royal Academy of Engineering Nanoscience and nanotechnologies | **July 2004, http://www.royalsoc.ac.uk/page.asp?id=2472**

[28] http://www.enhanceproject.org/

[29] MINET "Measuring the Impossible, Network", EU NEST 04329, coordinator Stockholm University, Prof Birgitta Berglund <http://minet.wordpress.com/>

8 Metrology knowledge transfer as a means of mitigating ethical, gender and societal concerns

One of the key actions in any programme addressing ethical, gender and societal aspects of rapidly developing technologies, such as metrology, is to provide for efficient knowledge transfer.

In studies of Science and Society[30], the importance of knowledge transfer with the following parts of society are emphasised:

- *Europe's future depends on the young*

Cultivating an interest in science & technology at an early stage and the ability for critical thinking. New/improved means of transferring knowledge about metrology (and its societal implications)

- *Improving public engagement with research*

New/improved means of transferring knowledge about metrology (and its societal implications)

- *Embedding the societal dimension in science*

Implementing societal concerns in the proposed EMRP, for example

- *Institutional links between science and society*

Involving civil society in research activities

To this list could be added out-reach activities directed to other sectors of society proportionally under-represented in science and technology, such as women, minorities and the developing world.

8.1 Stakeholders in metrology

The ERA-NET iMERA has in fact several tasks addressing stakeholder interaction and knowledge transfer (KT). This gives ample opportunity of spreading awareness and obtaining feedback, and encouraging active participation, from various societal groups not immediately in the measurement research sphere. An initial task was the organisation of a European workshop at the end of 2005 which will identify opportunities for the practitioners to improve national KT activities [iMERA T1.4]. A summary of the iMERA Knowledge Transfer study has been published[31].

Perhaps one of the more essential ingredients in encouraging fair trade and more generally in conformity assessment is efficient **transfer of measurement knowledge** between producer and consumer, where measurement and testing experts act as intermediaries. Alongside traditional training courses, there should be increasing attention paid to the educational and knowledge transfer opportunities of interlaboratory comparisons involving both primary and secondary measurement and testing laboratories[32],[33],[34].

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[30] EURAB 05.035 "Science and Society": An agenda for a responsive and responsible European science in FP7, European Research Advisory Board, Final Report, September 2005 [http://europa.eu.int/comm/research/eurab/pdf/eurab_05_035_wg6_final_report-rev_160905.pdf]

[31] iMERA T1.4 KT, "Study of Metrology Knowledge Transfer in the European Research Area", Pendrill L R and Tellett G 2006 report to iMERA, *SP Report* **2006:24**, ISBN 91-85533-09-02, http://www.sp.se/metrology/Mera/iMERA/iMERA_documents/SP_2006_24_iMERA_T1_4_KT.pdf

[32] EPTIS 2005 http://www.eptis.bam.de

[33] CFI 2007 Nordic Centre for Intercomparisons, http://www.intercomparison.org/

[34] "A programme to support the quality of measurement results in Europe", M Kühne, S Bennett and H Ischi 2006, EUROMET

As part of the planning of a European Metrology Research Area, in the earlier EU project MERA[35], a European Metrology Stakeholders consultation was made about increased co-ordination in a European metrology research area. The consultation covered many different kinds of stakeholders in metrology, ranging from multinational instrument manufacturers to the European Physical Society[36].

Many of Europe's trade associations, representing industrial sectors which are major end users of NMS services (automobile manufacturers, chemical industries, electrical appliances, etc), who were consulted in the MERA project, failed to respond. Of the 5% who did respond, a typical statement was:

This European trade association: "*… represents and defends the interests of this industry in legal and trade policy, internal market, environmental and technical matters; liaises with intergovernmental organisations; and manages industry initiatives and joint programmes – particularly in the field of research. As an umbrella organisation, we have also recognised about 100 sector groups and affiliated associations.*

As we have neither the expertise nor any working group with our members on metrology issues, I am afraid we are not in a position to fill in your questionnaire."

Judging by the frequency and type of response to the questionnaire, perhaps especially from the European trade associations, it seems that national metrology systems (NMS) and the concept of traceable measurement are reasonably unknown of and/or 'invisible' at the European industrial level.

- This could be a reflection of the fact that European trade associations are still most active at the national level. The majority of calibration services are admittedly still delivered to the industries of these trade associations at the national, rather than European level.
- At the same time, a lack of appreciation of metrology at the European trade association level could be a disadvantage in, for instance, influencing the European Commission about future policy issues

It was therefore recommended in the MERA project that the European NMS consider further how to improve collaboration with stakeholder organisations[37]. There is increasing awareness that a key component in national metrology is the role of industry, not only as a so-called "end-user" of NMS services, but increasingly as an active partner with national metrology in measurement knowledge transfer and even in metrological research.

The present study in the context of the EU ERA-NET project iMERA[38], which has resulted in the formulation of a European Metrology Research Programme which includes a programme for Metrology Knowledge Transfer not only amongst the immediate NMI community but also importantly as a 'two-way' exchange between NMIs and 'external' stakeholders[39].

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[35] MERA 2003 « *Planning a European Metrology Research Area* », http://www.euromet.org/projects/mera/
[36] Pendrill L R 2003 "European Metrology Stakeholders Consulation", *SP Report* **2003:13** http://www.sp.se/metrology/eng/documents/MERA_WP6_SP_Report2003_13.PDF
[37] Pendrill L R 2003 "European Metrology Stakeholders Consulation", *SP Report* **2003:13** http://www.sp.se/metrology/eng/documents/MERA_WP6_SP_Report2003_13.PDF
[38] iMERA 2005 "Implementing Metrology in the European Research Area", http://www.euromet.org/projects/imera/index.html
[39] iMERA T1.4 KT, "Study of Metrology Knowledge Transfer in the European Research Area", Pendrill L R and Tellett G 2006 report to iMERA, *SP Report* **2006:24**, ISBN 91-85533-09-02, http://www.sp.se/metrology/Mera/iMERA/iMERA_documents/SP_2006_24_iMERA_T1_4_KT.pdf

9 Conformity assessment and Measurement & Testing

Many measurements and tests provide invaluable data for decision-making in the conformity assessment of entities of many different kinds, ranging from physical products to services, as discussed in various scenarios above. There is increasing interest in various sectors of society in conformity assessment of product in general, and efforts are underway, for instance, in the European Union, to provide a uniform approach to conformity assessment [EU Commission 2006]. Not surprisingly, conformity assessment and metrology are both important when regulating safety and other essential collective protection requirements for public interest issues, such as health, consumer or environmental protection etc with regard to potential risks which freely-marketed products could present while at the same time as enhancing innovation, growth and welfare. Traditional areas of conformity assessment, such the legal metrology of diverse kinds of measurement instruments (for instance, for metering[40] of the utilities and different kinds of energy and of commodities (for instance, pre-packaged foodstuffs[41]), while in themselves subject to modernisation and extension, can provide useful models and templates for conformity assessment routines in other and wider sectors of societal interest and concern.

In the context of a revision and extension of the EU's New Approach to Conformity Assessment[42], the content of a common horizontal Act will attempt to include:

"• possibly the legal base and budgetary support for a Union programme for metrology and inter-comparisons"[43].

In the new organization EURAMET, amongst the aims are:

"h) representing metrology at the European level and promoting best practice to policy and political decision makers with regard to the metrological infrastructure and European co-operation;

i) co-operation with European and international organisations responsible for quality infrastructure, in particular by participation in the preparation of harmonized technical documents."[44]

9.1 Mitigating trade difficulties and other societal issues through increased measurement confidence

One key issue which can lead to improved confidence in measurement and testing, thereby mitigating the risk of measurement TBTs as well as facilitating conformity assessment more generally, is the availability of interlaboratory comparisons (ILC) to cover more efficiently a wider field of testing and measurement[45].

Interlaboratory comparisons, as organised by measurement and testing networks, can demonstrate the equivalence of measurement and testing performance amongst laboratories

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[40] EU Commission 2004 MID "Measurement Instrument Directive" *PE-CONS 3626/04* MID 2004/22/EC (2004), http://europa.eu/eur-lex/pri/en/oj/dat/2004/l_135/l_13520040430en00010080.pdf

[41] EU Commission 2005 "Metrology, Pre-packaging" http://ec.europa.eu/enterprise/prepack/metrol_requir/inmetrolog_requir_en.htm

[42] EU Commission 2006 FOREWORD TO THE ELEMENTS FOR A HORIZONTAL LEGISLATIVE APPROACH TO TECHNICAL HARMONISATION (Certif Doc 2005 – 16 Rev 2 - SOGS N529 EN), European Commission, http://ec.europa.eu/enterprise/newapproach/review_en.htm; http://ec.europa.eu/enterprise/newapproach/pdf/draft_certif_2005_16_rev2_foreword.pdf

[43] "A programme to support the quality of measurement results in Europe", M Kühne, S Bennett and H Ischi 2006, EUROMET

[44] EURAMET Byelaws 2007, §2.2 Purpose of the Association

[45] Erard L 2003 "*Metrological support to international trade. The METROTRADE project*" MÉTROLOGIE 2003 congress Toulon (FR)

made in different countries, thereby encouraging mutual confidence and facilitating international trade. Such comparisons also provide an important opportunity for improvement through the **educational benefits** to participating laboratories, alongside the development of calibration and uncertainty guidelines.

Concerning the identification of missing interlaboratory comparisons (ILCs) and proficiency tests (PTs), measurement and testing networks provide a platform for collection of information from individual members. These networks can also support laboratories with similar activities to exchange experiences and even to organize their own "interlaboratory comparisons". EPTIS, the European Proficiency Test Information System, is a European project establishing a database and information on PTs on the internet[46] and offers the possibility to submit calls for missing PTs.

In the field of metrology, the intercomparisons organized by EUROMET for the NMIs already cover a wide range of applications and therefore the infrastructure already works. Within a cooperation of networks including also accreditation bodies, such intercomparisons could increasingly and usefully include secondary and accredited calibration laboratories[47],[48].

A key question in conformity assessment is the nature of the **interface between the legislator and the technical expert**. The New Approach might be understood as implying that 'horizontal' issues are almost always administrative/legislative in nature (such as accreditation or market surveillance) while technical issues are mainly sectorial and thereby 'vertical' and implicitly 'orthogonal' to the legislative. While this is mainly the case, one should nevertheless try to extract as many as possible 'horizontal' technical issues which are common to a number of sectors.

One important example of such a 'horizontal' technical issue in conformity assessment is the treatment of measurement (test) **uncertainty and associated risks in decision-making in conformity assessment** which both legislators and metrologists can contribute to[49]. The more recent N560-1 EN document[50], Conformity Assessment chapter IV, page 8 Article 17, emphasises the need to assess "the nature of the risks involved" and how "risks can be managed".

Another issue is the decisive role that many **documentary standards** play in conformity assessment of product, and require measurements, data, validated test methods or reference materials to function. NMI researchers provide key expertise within committees on measurement or testing issues, and related activities such as sampling, data quality and statistical treatment of results[51]. One example is the area of nanotechnology, where a unique opportunity exists to facilitate trade and growth in norms for advanced products and

[46]EPTIS 2005 http://www.eptis.bam.de

[47] "A programme to support the quality of measurement results in Europe", M Kühne, S Bennett and H Ischi 2006, EUROMET

[48]CFI 2007 Nordic Centre for Intercomparisons, http://www.intercomparison.org/

[49] "Optimised measurement uncertainty and decision-making when sampling by variables or by attribute", L R Pendrill 2006 Measurement Volume 39, Issue 9 , November 2006, Pages 829-840, Advanced Mathematical Tools for Measurement in Metrology and Testing, http://dx.doi.org/10.1016/j.measurement.2006.04.014.

[50] EU Commission 2006 N560-1 EN 2006-0906 "A HORIZONTAL LEGISLATIVE APPROACH TO THE HARMONISATION OF LEGISLATION ON INDUSTRIAL PRODUCTS," European Commission, http://ec.europa.eu/enterprise/newapproach/review_en.htm

[51] H Källgren, M Lauwaars, B Magnusson, L R Pendrill and P Taylor, 2003 "Role of measurement uncertainty in conformity assessment in legal metrology and trade", *Accreditation Quality and Assurance*, **8**, 541 - 547, Springer-Verlag Heidelberg

measurement on the nanoscale by pre-normative research[52]. As noted above, metrologists' interaction with the different stakeholders active in standardisation work essential to better trade and innovation can be substantially improved through better networking.

9.2 Networks in Measurement & Testing and Conformity Assessment

Full use of co-operation and networks among the laboratory community can give efficiently an input to many committees and working groups, achieving much more and having greater authority, reputation and influence than individual laboratories. Additionally, network organisations provide an infrastructure to inform and obtain feedback from the laboratory community and principal metrology stakeholders. Networks can also be more active at the European and international levels, complementing standardisation bodies and trade associations.

European metrology needs to support conformity assessment and address public interest issues by improving and more efficiently transferring measurement knowledge. In particular, European measurement and testing networks across the traditional divides need to be strengthened further in order to match corresponding international efforts at removing societal issues associated with metrology. The importance and efficiency of the existing laboratory networks is well recognized. In Europe, the organizations EA, EUROLAB, EURACHEM and EUROMET co-operate as the 4E organizations. The 4E co-operation is a valuable tool to transform multilateral agreements (MLAs) and mutual recognition agreements (MRAs) into practice. It is recognized that the 4E co-operation has increased over the past years; e.g. through mutual opening of the working groups and committees, joint committees as well as regular meetings of the 4E chairpersons. In the future, authorities and regulating bodies should be also included much more. If harmonization of national rules cannot be achieved at once, then recognition of the equivalence of the different national rules needs to be agreed so as to allow mutual acceptance[53].

At the global level, amongst recent developments in alleviating international measurement-related societal issues has been the creation of a new CIPM joint committee – JCDCMAS - linking scientific metrology to other organisations in the trade and conformity assessment spheres, such as legal metrology, standardisation, accreditation and trade associations[54]. The OIML in October 2004 organised a well-attended Trade Forum in Berlin, and established a Permanent Working Group on Developing Countries[55]. ILAC and UNIDO have recently published informative guides to the role of laboratory accreditation in facilitating world trade as part of the extensive programmes of those organisations[56].

10 Gender aspects of Metrology[LP1]

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"T2.8 Working group on ethical, gender and societal issues (SP Sweden, CMI)
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[52] Henson A and Pendrill L R 2005 "Global R&D for global nanotechnology standards", NCSL 2004 and Métrologie 2005 conference, Lyon (FR) 20th June; CEN BT/WG166 Nanotechnology; ISO TC229 Nanotechnologies

[53] "A programme to support the quality of measurement results in Europe", M Kühne, S Bennett and H Ischi 2006, EUROMET

[54] JCDCMAS 2004 "*Building corresponding technical infrastructures to support sustainable development and trade in developing countries and countries in transition*", http://www1.bipm.org/cc/JCDCMAS/Allowed/Background_documents/Background_paper_final.pdf

[55] OIML 2004 « World Trade Forum » http://forum.oiml.org

[56] UNIDO 2003 "*Laboratory Accreditation in Developing Countries: Tested Once – Accepted Everywhere*", Working paper No. 2 ILAC/UNIDO

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Overseeing the ethical, gender and societal issues raised in 9.2 of the DoW
this task team will work across the other project tasks to alleviate the
risk of ... Anecdotal evidence suggests whilst women are reasonably
represented at the postdoctoral level there is serious under-representation
in more senior metrology posts.  The task team will examine the issue and
make appropriate recommendations to improve this situation."
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This will be submitted as a separate deliverable report – D2.11 'Recommendations to improve the gender balance in European metrology' via Task 2.8.

11 Conclusions

Metrology can be expected to have an impact across many branches of science and technology and influence a range of areas of human endeavour. Some applications of metrology may raise significant social and ethical concerns, particularly those involving a convergence of metrology with other developing technologies, such as nanotechnology. **Evaluating longterm social or ethical impacts is a considerable challenge**. In the near- to medium term, many of the social and ethical concerns that have been expressed in evidence are common to a number of rapidly developing technologies (nano, bio etc). The fact that they are not necessarily unique does not make these concerns any less valid.

In this report a range of social and ethical issues relating to the development of metrology have been identified that would benefit from further study. Potential ethical issues related to Metrological research are found of course in the traditional area of Trade, as is well known. But challenges also lie in avoiding the creation of a 'metrology-divide' between countries with different capacities for research and exploitation of new measurement technology. Particularly where metrology converges with other emerging and rapidly developing technologies, ethical issues might arise also in Information collection, human enhancement and military applications. These challenges can be met by dedicated programmes for knowledge transfer and for coordination of national metrology with conformity assessment actions.

The cost would be small compared with the amount spent on research on metrology, the applications of which could have major social and ethical impacts. Therefore, **we recommend that the EMRP should include an interdisciplinary research programme to investigate the social and ethical issues expected to arise from the development of some measurement technologies**. Finding inspiration from similar recommendations for the nanotechnologies, this programme would ideally include research grants and interdisciplinary research studentships, which would explicitly link normative and empirical inquiry. Research studentships could involve taught courses to familiarise students with the terms and approaches used by natural and social scientists, pooled or within institutions.

We recommend that the consideration of ethical and social implications of advanced technologies (such as nanotechnologies and metrology) should form part of the formal training of all research students and staff working in these areas and, specifically, that this type of formal training should be listed in the European Metrology Research Programme. The EMRP should ideally support and expand the provision of short courses, bringing together junior researchers and doctoral students in science, engineering and social science to address the ethical and societal implications of technological developments.

Full use of co-operation and networks among the laboratory community can give efficiently an input to many committees and working groups, achieving much more and having greater authority, reputation and influence than individual laboratories. Additionally, network organisations provide an infrastructure to inform and obtain feedback from the laboratory community and principal metrology stakeholders. Networks can also be more active at the European and international levels, complementing standardisation bodies and trade associations in the wider area of conformity assessment and addressing a spectrum of issues of public interest.

Annex A Quote from iMERA DoW

Potential ethical and gender aspects

Reliable measurement results are important in almost every aspect of our daily life, ranging from fundamental science, through health and safety to global trade. Metrological traceability provides measurement results that are comparable and form an objective base - with quoted references and estimated uncertainties - for decision-making in conformity assessment.

Therefore, whilst the proposed research in itself has little direct ethical or gender consequences, metrology does play an essential role by providing for objectivity and transparency in support of decision-making and confidence-building in many sectors of society where potential ethical and gender aspects are likely, as exemplified below.

Example of social, ethical and gender aspects	*Potential problems associated with lack of comparability of measurement results*	*Example*	*Measurement-related solutions provided by proposed research*
Global trade between producers and consumers	Creates unnecessary Technical Barriers to Trade (TBT)[57]. This is a severe handicap, especially for developing countries.	Use of different measurement procedures to detect antibiotics in shrimps exported from China to EU[58].	Pre-normative measurement research. Interlaboratory comparisons. Agreed metrological (traceability, uncertainty) procedures for decision-making
Complex industrial products	Consumers in complex technological societies have difficulties making independent judgements about product merits and safety.	New nanotechnological products[59] are both promising but also source of fear.	Metrology standards provide for interoperability and exchangeability of parts and systems – act as mediator between specialist technical world of products and processes, and social world of people
Information in communication systems	Insecure data and information transfer in essential systems such as e-Government, tele-medicine etc.	Lack of time synchronisation leading to confusion in information from different signals.	Provision of common time for instance through synchronisation over the Internet.
Health & safety, pharmaceutical and other chemical sectors	Can be hazardous in leading to incorrect diagnosis and treatment.	Contaminants in medicines. Cholesterol in human blood.	Development of certified reference materials.

[57] "Transatlantic Economic Partnership", EU/US, created May 1998, http://www.europa.eu.int/comm/trade/issues/bilateral/countries/usa/index_en.htm
[58] "Metrological support to international trade", http://www.metrotrade.dk
[59] "Science & innovation investment framework 2004 – 2014", §7.14 Science and Society, DTI (UK) July, ISBN: 1-84532-031-X, http://www.hm-treasury.gov.uk

Example of social, ethical and gender aspects	*Potential problems associated with lack of comparability of measurement results*	*Example*	*Measurement-related solutions provided by proposed research*
The environment	Can lead to incorrect and unfair decisions in environmental monitoring aimed at guaranteeing long-term durable sustainability.	Trading in greenhouse gases[60]: ”Achieve stabilisation of greenhouse gas concentrations …to prevent dangerous anthropogenic interference with climate …” ”Preserve integrity of internal market” ”Avoid distortions of competition.”	”Reporting of emissions which are measured shall include: — Total emissions; — Information on the reliability of measurement methods; and — Uncertainty.”

Knowledge transfer

The ERA-NET iMERA has several tasks[61] addressing stakeholder interaction and knowledge transfer, thus giving ample opportunity of spreading awareness and obtaining feedback from, and encouraging active participation from, various societal groups not immediately in the measurement research sphere. In addition, the project management plans a specific task[62] about dissemination and PR and advice as a means of promoting iMERA to external stakeholders.

Despite its importance, metrology is often omitted in considerations at many levels of policy-making and opinion-forming in science and innovation. This ranges from an under-representation of metrology and measurement-related issues both nationally and at the European level in technological road-mapping and foresight; R&D plans; few university courses in metrology, to a lack of measurement lessons in schools and popular science activities. Reasons for this include the ‘horizontal’ nature of metrology in that it impacts almost every technological and societal sector and thus ‘belongs nowhere in particular’, as well as an inherent ‘invisibility’, where correct measurement often leads to no high-profile event.

Metrology is a subject that the general public can readily relate to; because measurement is something everyone performs and is subject to in everyday life. There is thus great potential, by increasing and improving metrology education at all levels, to contribute to wider programmes aimed at promoting equality and counteracting trends of young people of both genders and ethnic minorities away from technical and scientific training and careers[63]. A more ‘measurement informed’ public will also be better prepared to appreciate the significance of any measurement result and to make independent judgements about product merits and safety in an increasingly complex technological world. Thirdly, if innovation is “the successful exploitation of new ideas”[64], then metrology provides a necessary support to innovation at every step in the value chain from idea to finished product. Knowledge transfer

[60] “Establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC”, EU Directive 2003/87/EC Annex IV, Official Journal 2003, L275/32, 2003-10-25
[61] iMERA §§1.1, 1.4, 2.1, 2.8, 3.1, 4.4
[62] iMERA §T6.1, T6.4
[63] “Science & innovation investment framework 2004 – 2014”, §6 Science, Engineering and Technology Skills, DTI (UK) July, ISBN: 1-84532-031-X, http://www.hm-treasury.gov.uk
[64] ”Competing in the global economy: the innovative challenge”, DTI Innovation Report (UK) December 2003 http://www.npl.co.uk/met/dti_steer/innovation-report-full.pdf

in metrology with industries – in particular, small and medium-sized enterprises – is thus a key activity in the context of promoting growth through innovation.

Initial studies of European and international metrology knowledge transfer[65] will be followed up in the proposed work.

Third country participation

Metrology has long been on the international collaborative agenda – the world's first global treaty was the Metre Convention from 1875, which is administered by the International Bureau of Weights & Measures (BIPM) [66]. In addition to continued bilateral contacts between each national metrology system and the BIPM, the various national metrology systems have in the last decade or so formed regional organisations allowing for increased co-ordination of metrological activities, reflecting increased globalisation of trade and industry as well as more extensive demands for traceable measurement. The European collaboration between the NMIs in the EU and EFTA states called EUROMET[67] was established in 1987 and has indeed provided the initial forum for formulating the present iMERA proposal. EUROMET covers co-operation in the development of national measurement standards and measuring methods; optimisation of the use of resources and services; improvement of measurement facilities and making them accessible to all members; and the performance of comparisons to ensure a better coherence of measurements. Similar regional metrology organisations have been formed in most of the world's major trade regions[68]. These in turn have links, either individually or jointly through the BIPM, to many of the key international organisations with measurement interests[69].

There are of course lessons to be learned from the experience of non-EU national and regional metrology programmes and interested organisations, and a specific task to this effect is envisaged in the present proposal (task 2.7)[70]. The task will also identify whether there are areas of research where interregional collaboration would be beneficial – as is the case for the Avogadro project - and feasible, and if so identifying potential collaborators beyond Europe.

[65] "NMS KT International Best Practice Study", Optimat/DTI (UK) July 2003
[66] "Metre Convention and the MRA", http://www.bipm.org/en/convention/
[67] http://www.euromet.org
[68] APMP (Asia-Pacific); COOMET (Euro-Asia); SADCMET (Southern Africa); SIM (The Americas)
[69] Codex Alimentarius Commission; IAEA; ILAC; ISO; OIML; UNESCO; UNIDO; WHO
[70] §2.7 iMERA

Acknowledgments

The authors are grateful for a fruitful collaboration with all other members of the iMERA project and other colleagues. The authors are grateful for a fruitful collaboration with all other members of the former MetroTrade project (EU G7RT-CT-2000-05004, project coordinator DFM, other project members: BNM, NPL, EUROLAB, SP, MIRS, INMS and IRMM) as well as for the support from the EU Commission for the project in which much of this work was performed.

The partners wish to acknowledge and thank the European Commission for supporting the project iMERA project (EU *contract no 016220*, project coordinator NPL) as an ERA-NET Coordinating Action under "Coordination of Research Activities" of the 6th Framework Specific Programme "Integrating and Strengthening the European Research Area" in which much of this work was performed.

Explanation of Report status (one of the following):

PU = Public
PP = Restricted to other programme participants (including the Commission Services)
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