



*years of
collaboration
in European
metrology
1987-2017*

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30 Years of Collaboration
in European Metrology

1987–2017



“The trouble with measurement
is its seeming simplicity.”

– *Unknown*

Foreword

Our daily lives are surrounded by measurements; for clean running water or having an X-ray at hospital. Metrology, the science of measurement, is working behind the scenes to support the well-being of societies all over the world. The metrology community has collaborated for about 150 years, overcoming borders and fostering cooperation between states and societies. But still, metrology is the unsung hero in most parts of society. One of the organisations stepping up to change this is EURAMET, the European Association of National Metrology Institutes.

In 2017 EURAMET celebrates its 10th birthday; inaugurated on the 11 January 2007. 20 years earlier, in 1987, its predecessor EUROMET was founded. 30 years of close collaboration in European measurement are the result of these two important events. This is a good reason to pause and look back to reflect on how far the metrology community has come. This anniversary publication introduces EURAMET and outlines its history. It describes how visionary people contributed to a new idea of collaboration and made it a success. It explains where EURAMET found its place in global metrology and developed something unique: The European Metrology Research Programme. This publication will provide a vision for the future of the organisation and the European measurement community, who now face many new challenges.

The success of EURAMET would not have been made possible without all the people who participated in its development and it appreciates every single contribution over the last three decades. Taking this into account, the anniversary publication has been written by different authors; all of whom played an important role in EURAMET's history and present.

This booklet tells the story of the development of a committed community. It is written for all who contributed to the development of metrology in Europe. It is for members of the international measurement community and for those who are interested in getting a greater insight into this complex topic which seems so simple at first glance.

Our sincere thanks to all authors, editors and proof-readers – who put great effort into this anniversary publication. We hope all readers enjoy this booklet on 30 years of collaboration in European metrology.

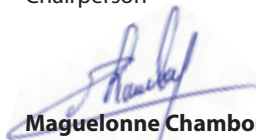
The editor of the publication and EURAMET's anniversary team – January 2017



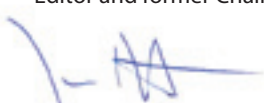
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Greeting by Terry Quinn

Director Emeritus of the BIPM

Metrology, the science of measurement, is part of the essential but largely hidden infrastructure of the modern world. We need it for high-technology manufacturing, human health and safety, the protection of the environment, global climate studies and the basic science that underpins all these. Highly accurate measurements are no longer the preserve of the physical sciences and engineering, many areas of chemistry, molecular biology and medicine are now dependent on the ability to make accurate quantitative measurements. International trade in all manufactured and agricultural products are strictly controlled by regulations that need accurate metrology for their implementation.

Huge efforts have been made in the last two decades to improve the reliability and accuracy of medical diagnostics. This not only benefits human health but reduces unnecessary costs by reducing the need for multiple tests. Increasing demands for safety and reliability of products have led to a much more closely regulated structure of world trade. An example is the regulations governing trade in agricultural products in respect of minute levels of residual pesticides and other potentially harmful substances.

Good metrology improves the quality and efficiency of manufactured products. There are a multitude of examples of this from modern motor vehicles with much improved reliability and fuel efficiency to passenger aircraft that can fly nearly half-way around the world non-stop. We have become accustomed to products and services that only work because of extreme accuracy in measurement. Satellite navigation is the most striking of these. GPS, for example, works only because atomic clocks in satellites are stable and can be adjusted to run with common time scales accurate to nanoseconds with their positions in space known to within a metre or so. Reliable long-term monitoring and prediction of critical parameters of the world's climate needs accurate measurements linked to reference standards that are themselves stable in the long term. As regards predictions from climate models, garbage in, garbage out!

The capability to do all this resides in the ensemble of the world's National Metrology Institutes (NMIs) that maintain, improve and disseminate the International System of Units, the SI. This is the modern version of the metric system created in France at the time of the French Revolution. The NMIs do this acting together under the auspices of an intergovernmental treaty, the Metre Convention, drawn up in 1875 with a specific purpose: 'pour assurer l'unification internationale et le perfectionnement du système métrique' (to assure the international unification and perfection of the metric system). The Convention created the first international scientific institute, the Bureau International des Poids et Mesures (BIPM) to maintain and disseminate the units of length and mass based on the new international standards finally adopted in 1889. The BIPM was placed under the direction of a Comité International des Poids et Mesures (CIPM) itself under the authority of a Conférence Générale des Poids et Mesures (CGPM).

With the creation of the Physikalisch-Technische Reichsanstalt (PTR), Germany, in 1887, the National Physical Laboratory (NPL), UK, in 1900 and the National Bureau of Standards (NBS), USA, in 1901, the major industrialised states of the world led the way to the present worldwide network of such institutes. The role of the Metre Convention was broadened by a second convention in 1921 which included extension of the range of BIPM activities and broader responsibilities for the CIPM. Following the Second World War, advances in science transformed the world and metrology was no exception. Research at the frontiers of science became an essential part of modern metrology.

In different regions of the world, notably in the Asia Pacific Region in 1977 and in the Americas a little later, NMIs began to work together more formally and Regional Metrology Organisations (RMOs) were set up. In Europe in 1973 an informal collaboration had already begun, known as the Western European Metrology Club WEMC, which became EUROMET in 1987 and in 2007 was formalised and became EURAMET.

Towards the end of the 20th century it became clear that while the Metre Convention provided the formal basis for international metrology, something more specific was needed to meet the increasing needs not only of accreditation but also of the manufacture of high-technology products by multinational companies having factories in different parts of the world.

In 1999 under the authority given to it by the Metre Convention, the CIPM set up a Mutual Recognition Arrangement, referred to as the CIPM MRA. It is now signed by the directors of NMIs of 57 States adhering to the Convention, 41 associated states of the CGPM and 4 international organisations. Its aim is none other than the realisation in a quantitative and open way of the first part of the mission of the Metre Convention, namely, 'to assure the international unification of the metric system (now the SI)'. Central to the operation of the CIPM MRA is a Joint Committee of the Regional Metrology Organisations and the BIPM, known as the JCRB. In this way the RMOs have been formally brought into the operation of the Metre Convention. The CIPM MRA, in which EURAMET plays an important role, is now the cornerstone of world metrology.


Another aspect of the work of EURAMET has been its increasing role in organising and running European research in metrology. This is now its other important activity. It has gained the confidence of European institutions, notably, the European Commission and the European Parliament. With its responsibilities for the European Metrology Research Programmes (EMRP and EMPIR), EURAMET is now a key player in European science.

As someone who has been involved in international metrology for quite some time – from 1973/74 when I was international secretary for John Dunworth, then Director of the NPL and one of the driving forces in the creation of WEMC, to my time as Director of the BIPM from 1988 to 2003 and much involved in drawing up of the CIPM MRA, I have been well placed to observe the development of European metrology. It gives me great pleasure to have this opportunity of congratulating EURAMET and all those by whose efforts it is such a success on its anniversary and to pass on my best wishes for the future.



Terry Quinn

Director Emeritus of the BIPM



0. A Short History of Measurement

0. A Short History of Measurement

Metrology is the science of measurement. Measurements are so much a part of our daily lives that we often take them for granted and possibly don't even notice them. We buy food by the gram or kilogram, diesel and petrol for our cars by the litre and we pay for electricity by the kilowatt hour. However, many people do not know the difference between metrology and meteorology.

Measurement systems have been in existence since the beginning of human civilisation. Ancient cultures developed sophisticated metrology systems. The Egyptians, for example, established standard length or 'the royal cubit' around 3000 BC. The royal cubit is roughly the distance of your elbow to the tip of your index finger, or the length of the forearm of the Pharaoh. This length was cut into a black slab of granite and stone copies of it were distributed to different building sites in Egypt. Workers at

the building sites were provided with wooden copies, which had to be compared with the stone copy once a month. This principle of a hierarchy in standards is still used today.

Different national standards became a serious obstacle to cross-border trade during the industrial revolution at the beginning of the 19th century. Complex industrial infrastructures like railway systems required frequent maintenance and spare part services. This was made very clear at the industrial world exhibitions in London 1851 and Paris 1867 but it took until 1875 that the major industrial countries of that time agreed in the 'convention of the metre' to an international measurement system based on the metre, the kilogram and the second. In order to create, disseminate and improve the artefact standards of the kilogram and the metre, they created the world's first metrological research laboratory called the 'International Bureau of Weights and



Egyptian pyramids, an early example of a set of buildings which was built by using a measurement system
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Measures' or BIPM, located near Paris. By 1889 this laboratory had created the international standard of the metre and the kilogram and had produced the national copies and distributed them to the member states.

Soon after the creation of the BIPM it became clear that metrological research was also an important tool at a national level to develop

and improve national industrial capabilities. Today almost all countries have a National Metrology Institute (NMI) that provides measurement standards and the traceability to the International System of Units (SI) for industry, science and society.

The BIPM focused on top-level measurement standards and did not cover the field of what people today call legal metrology. This type of metrology is primarily concerned with the accuracy of measuring instruments used in trade such as weighing scales in grocery stores or petrol pumps at service stations. As a result, in 1955 a second international metrology organisation was established in Paris, the 'International Organisation for Legal Metrology' (OIML). In some countries, the responsibility for legal metrology rests with the NMI while in others, separate institutions have been established, dedicated to legal metrology.

During the second half of the 20th century, NMIs



Representatives of Europe's metrology community who signed the EUROMET Memorandum of Understanding in Spain, 1987
Courtesy of CEM

located in the same regions, for example in Europe, began to work more closely together, due to the significant increase in cross-border

trade. This led to the creation of Regional Metrology Organisations (RMOs). EURAMET is the RMO for Europe.



1. Highlights from the 30 Years

1. Highlights from the 30 Years

It is incredible to think that it took nearly 100 years after the Metre Convention to foster systematic multilateral collaboration among NMIs. The process began in 1972 when an informal international committee held meetings at NPL, the National Metrology Institute in the UK. At these meetings, the committee decided to hold the Western European Metrology Conference at NPL in 1973. This conference led to the creation of the Western European Metrology Club (WEMC) in 1974. Although the new WEMC collaboration was informal and not mandatory, this bottom-up approach was extremely successful. It gave birth to several important European organisations such as: The Western European Calibration Cooperation (later European Cooperation for Accreditation, EA); the Western European Legal Metrology Cooperation (WELMEC); and EUROMET, today EURAMET, the European Association of National Metrology Institutes.

'The Club' 1974–1989 – the Starting Point of European Metrology Collaboration

Around 80 people from 16 countries including representatives of the European Commission (EC) and the BIPM, attended the Western European Metrology Conference in 1973, in the UK. This led to the foundation of the Western European Metrology Club (WEMC), also known as 'The Club'. An important outcome of the conference was the general perception that metrology collaboration in Europe would be important in the future, but meetings should be restricted to those with major national responsibility in metrology. Therefore, the original purpose of WEMC was to regularly bring together directors of European NMIs, to enable them to exchange ideas as well as to agree on new initiatives. In 1974 the first WEMC meeting was held at Germany's NMI, PTB in Braunschweig. Subsequent meetings were held every two years and later annually. In 1973 the EC's Community Bureau of Reference (BCR) was established. This spurred on the formation of WEMC as many were worried at that time that the EC was planning to one day assume responsibility for metrology in Europe. But this was not the case, and the European Commission

Metrology Collaboration Becomes 'En Vogue'

As experts began to see the benefits of metrology to cross-border trade, more metrology organisations started collaborating across Europe.

In 1994, The Western European Calibration Cooperation merged with the Western European Laboratory Accreditation Cooperation to form the European Cooperation for Accreditation of Laboratories (EAL). In 1997 EAL merged with the European Accreditation of Certification to become today's European Cooperation for Accreditation (EA).

Legal metrology organisations also began to see the value of collaboration. In 1990, the Western European Legal Metrology Cooperation (WELMEC) has been established. This organisation did not undergo any merger and is still operating under the same acronym. But 'Western' has been deleted from its name, so it is now known as 'European Cooperation in Legal Metrology' – reflecting the opening for central and eastern Europe countries.

is today seen as a very valuable partner, promoter and supporter of metrology research and projects.

Very soon after it established in 1974, the WEMC brought together Europe's top metrology experts and formed a working group on calibration services. The group quickly took on a life of

its own, as cross-border trade and calibration became more important to national economies. The group initially reported to WEMC but in 1976 it developed its own entity and was named Western European Calibration Cooperation (WECC). In 1989 it became independent by signing its own Memorandum of Understanding.

EUROMET 1988–1999 – the Early Years

In 1986, the British Department of Trade and Industry initiated the further development of metrological cooperation in the spirit of the European Union. A tripartite working group composed of the NMIs in the UK, Germany and France (NPL, PTB and BNM) investigated the possibility of more intensive collaboration and formal structure. They came up with the name 'EUROMET', European Cooperation in Measurement Standards.

In September 1987, the legally non-binding Memorandum of Understanding establishing EUROMET was signed in Madrid by all EU and European Free Trade Association states except Iceland but including the European Commission.

In 1989 the EC mandated EUROMET to undertake a study of metrological traceability in Europe with the aim of identifying measures to come to a more effective collaboration among NMIs in providing traceability. The study report, based on a questionnaire and the EUROMET network of experts, specified a set of recommendations which helped to launch future actions with EC support.

The new EUROMET collaboration in measurement standards immediately generated an overwhelming interest and enthusiasm in all metrology fields and project types. In the begin-

ning, 160 projects were proposed demonstrating the urgent need for cross-border metrology exchange and cooperation in Europe. These projects were related to the core activities of RMOs: traceability provision, comparison of measurement standards, cooperation in research and development as well as consultations. After some feasibility checks, 75 projects were agreed. Every year more projects were proposed and agreed on. This increase was largely caused by the growing demand for comparisons of national standards.

EUROMET's collaboration during the first 12 years was very successful; not only because of the number of completed projects, but also by the important exchange of knowledge and mutual respect in each other's competences and capabilities.

However, at the same time, competition between NMIs began to increase; triggering many metrology advances in Europe. But undoubtedly, the intensive project collaboration benefitted all of EUROMET's member NMIs. Different countries began to see the value of collaboration.

The number of signatories of the EUROMET Memorandum of Understanding increased from 18 in 1987 to 25 in 1999, mainly due to the NMIs joining from central and eastern Europe.

The CIPM MRA Implementation – a Major Challenge for EUROMET 2000–2006

In October 1999, the Mutual Recognition Arrangement of the International Committee for Weights and Measures (CIPM MRA) was signed. This is the framework through which

National Metrology Institutes demonstrate the international equivalence of their measurement standards and recognise each other's Calibration and Measurement Capabilities (CMCs). A de-

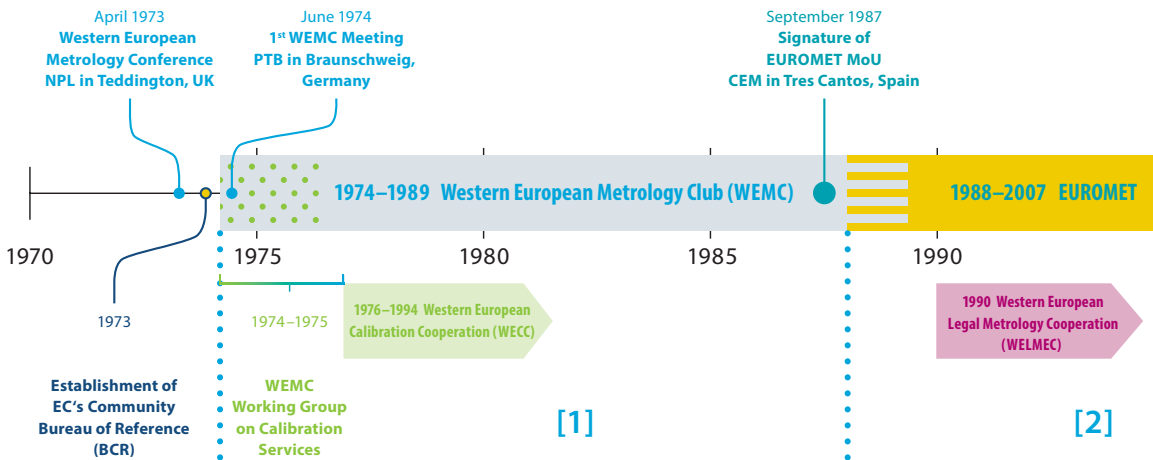
tailed explanation on the CIPM MRA will be given later in this publication. In 2000, EUROMET began implementing the recently signed CIPM MRA. Fortunately, this new task was taken on board with similar enthusiasm as the EUROMET projects 12 years before. Special projects were started to support the implementation of the CIPM MRA resulting in the publication of two new EUROMET guides including review criteria and procedures for EUROMET Calibration and Measurement Capabilities and NMI quality systems. A related activity was the establishment of a quality management forum for discussion and review of quality management systems

(QMS) at NMIs. The quality management forum was facilitated and funded by the EC project 'Initiation'. Furthermore, the coordination of regional key comparisons complementing the CIPM key comparisons to underpin the CMCs was another specific task allocated by the CIPM MRA to EUROMET and other RMOs. Although quite slow at the beginning, the Regional Metrology Organisations now play an important role in implementing the procedures of the CIPM MRA. The RMOs are responsible for carrying out comparisons within their regions to support mutual confidence in the validity of the Calibration and Measurement Capabilities of their member NMIs.

The MERA Study – a Trigger for Fundamental Changes at the Beginning of the 21st Century

After 2000, European NMIs became faced with the dilemma of having to respond to growing demands for metrology services by their stakeholders, including wider ranges and lower uncertainties, while their budgets remained stable at best. In addition, emerging sectors like nanotechnology, food safety and chemistry began requesting traceable measurements. Experts began to ask how should the metrology landscape develop in Europe in order to cope with these growing demands. This question

was addressed by the EUROMET study entitled MERA 'Metrology in the European Research Area'. Several scenarios were analysed as part of this study, including even the option of a single centralised metrology institute in Europe. The MERA study signalled a development which would fundamentally change EUROMET forever. Within a few years, it evolved from having informal cooperation, to a professional organisation; managing research programmes worth several hundred million euro each. Its members began



Timeline of European metrology collaboration showing four distinct periods, [1] WEMC, [2] EUROMET, [3] CIPM MRA oriented EUROMET and [4] EURAMET

Two of the key conclusions of MERA, the first strategy exercise of EUROMET:

1. Local delivery of metrology services is highly valued by the stakeholders. A system of national metrology centres with a more effective cooperation and more efficient use of the resources, reducing unnecessary redundancies would be the choice.
2. The most urgent and at the same time promising area to start coordinating activities among European NMIs is research and development.

to desire more formal and legally binding cooperation. At this time, its visibility among stakeholders and policy makers also increased significantly.

The study was followed by the iMERA project entitled 'Implementing Metrology in the European Research Area'. The main objectives of

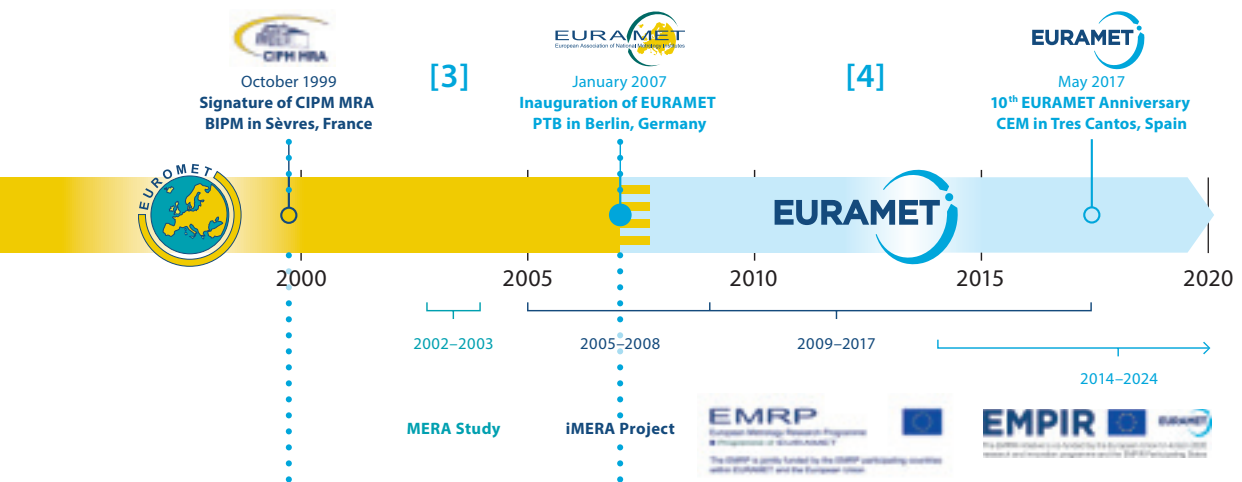
this project were: to develop rules for carrying out joint metrology research programmes; to develop the legal and organisational structures of the future entity, enabling both the traditional RMO activities and the implementation of joint programmes; and to secure funding for joint research activities.

An analysis was carried out to try and establish the most appropriate form of the new legal entity. A registered association under German law was chosen. Based on the structure of the existing EUROMET, new requirements, structure, byelaws and rules for the new legal entity were developed. On 11 January 2007, EURAMET was finally inaugurated at a ceremony in Berlin. All former EUROMET members joined the new organisation and 26 of the 34 EUROMET members signed the byelaws at the inauguration as founding members. The remaining members joined EURAMET soon afterwards. Michael Kühne from PTB was elected as the first Chairperson.

EURAMET and the Joint Metrology Research Programmes 2007–2024

Once EURAMET was established, the first joint European research programme for metrology co-funded by the European Union was launched. It was called iMERA-Plus and its aim was to align and enhance national programmes. A total of

21 collaborative projects were launched in four targeted programmes, each project chosen for the quality of science and potential to make a significant contribution to its field. With a budget of 64.8 million euro, the iMERA-Plus projects



produced a wide range of significant impacts in metrology, industry and other fields of research, as well as contributing to the redefinition of a number of SI Units. It proved the capability of EURAMET to execute this type of programme. In 2009, a larger European Metrology Research Programme (EMRP) was launched, with a budget of 400 million euro. The purpose of the EMRP was to enable Europe to respond in an integrated way to the growing demands for cutting-edge metrology as a tool for innovation, scientific research and support for policy particularly in emerging technological areas, by accelerating the development of new measurement capabilities. In the modern world, comparability of measurements and interoperability is crucial. In 2014, a third research programme, the European Metrology Programme for Innovation and Research (EMPIR) was launched. This 600-million euro research programme is expected to run for a decade. Over this period, the focus of the activities of EURAMET and its members naturally shifted towards the joint research programmes.

Although, the traditional activities of EURAMET, in particular those relating to the CIPM MRA, were continued and in some cases intensified and the growing need for knowledge transfer and capacity building was recognised. The intention was that all members should benefit from the research programmes, including those focussed on customer services and those with limited research activities. Therefore, capacity building was strengthened and became a key activity for the programmes; the required infrastructure was developed and funding provided. The permanent structures of EURAMET facilitated working in all fields in a more systematic, professional and sustainable way. Despite the great success of the joint research programmes, more cooperation and coordination is still needed among European NMIs. In order to address this challenge, in 2016, a study on coordination in metrology was launched to analyse the current position and the opportunities and readiness of EURAMET members to move towards an even more coordinated European metrology infrastructure.

Statements from EUROMET and EURAMET Chairpersons

EURAMET asked the previous chairs, "What was the most outstanding challenge or achievement during your chairmanship?" Here are their answers:



"Prior to EUROMET there were informal meetings from time to time between the heads of metrological organisations in Western European countries. These informal meetings led to the establishment of EUROMET, the goal of which was to bring together scientists and others in formal collaborative programmes for research in metrology across Europe. A secondary goal was to enhance the traceability of measurements across the various countries."

Paul Dean
NPL (United Kingdom)
1988–1990

"The transition of the chairmanship from Paul Dean to me did not mean any change of EUROMET policy. Both of us had closely worked together in establishing European organisations since the early days of WEMC. Realising the alignment of their political aims with the aims of EUROMET the Commission of the European Community supported EUROMET. Among others a study of metrological traceability of primary standards was set up as a precondition for defining working groups for special fields. Following the metrological structures in Western Europe, the former Eastern European countries organised their national cooperation in COOMET as a further expansion of international metrology cooperation."

Dieter Kind
PTB (Germany)
1990–1994





Kim Carneiro
DFM (Denmark)
1994–1998

“During 1994 to 1998, together with the secretary and the executive committee, I addressed three major challenges:

- Modern management, strategic and formal: I took over from the club-like ruling of the former WEMC and ending by sending the files electronically to my successor;
- The technical chairs in particular went through great pains to help Eastern European NMIs to upgrade their metrology to a level that satisfied the Acquis Communautaire, whereby their path to EU-membership was significantly eased. This was much appreciated by the EC.
- Several mutually beneficial collaborations, including EURAMET-membership of the Institute for Reference Materials and Measurements of the EC.”



“The main challenges I faced and overcame, were related to the participation in the expansion of the classification of the services for the recently signed CIPM MRA. I also established the first EUROMET logo and introduced the idea of fees for members to support a more professional secretariat. Additionally, I proposed that EUROMET could become a legal entity which was implemented a few years later.”

Luc Erard
LNE (France)
1998–2000

“By far the most demanding challenge was setting up and timely putting into operation the procedures necessary to accomplish the new tasks assigned to EUROMET by the recently launched CIPM MRA; in particular the coordination of RMO key comparisons, the review of NMI Quality Systems and the review of NMI Calibration and Measurement Capabilities.”

Wolfgang Schwitz
METAS (Switzerland)
2000–2002



“A key challenge was the consolidation of the CIPM MRA processes within EUROMET and its promotion to industry, and regulators. Aligned to this was developing and building on the relationship between EUROMET and European Accreditation, particularly regarding the separation of NMI and National Accreditation Bodies activities and recognition of the CIPM MRA.

A major achievement was establishing a budget to fund the running of the secretariat through the levying of a membership fee. Establishing a budget enabled EUROMET to resource publicity and marketing activities in addition to undertaking development work on the EUROMET website.”



Paul Hetherington
NSAI NML (Ireland)
2002–2004



In his time as Chair, Seton successfully worked towards the establishment of EURAMET as a legal entity and the structures for the implementation of joint European research programmes. His contributions to European metrology are gratefully acknowledged. Seton passed away much too early in 2015 at the age of 70.

Seton Bennett
NPL (United Kingdom)
2004–2006

“As the last chair of EUROMET the greatest challenge was to change the organisation into a legal entity that allowed all members to stay on-board. This was accomplished with the creation of EURAMET as a registered association under German law. As the first chair of EURAMET the challenge then was to create the appropriate structures and tools for the operation of a multi-million euro research programme and to convince the European Commission, the European Parliament and the participating member states of EURAMET’s competence and integrity to successfully run it.”

Michael Kühne
PTB (Germany)
2006–2009



“The main achievements during my chairmanship were the signing of the EMRP General Agreement in 2009 and a couple of Memoranda of Understanding and collaboration agreements relating to Metrology and Conformity Assessment (with CEN-CENELEC and WELMEC, both in 2010). Furthermore, I emphasised that metrologists from both large and small NMIs should be treated equally.”

Leslie Pendrill
SP (Sweden)
2009–2012



Kamal Hossain
NPL (United Kingdom)
2012–2015



“My three years as chair passed quickly. The overarching work of developing a new 2020 Strategy for the association and its implementation meant several strands of work focussing on stakeholder engagement, research, communications, partnership building, and fostering an inclusive environment for all our members and associates, as well as providing leadership in the RMO community. Whilst we executed the European Metrology Research Programme, we also developed and established an even larger new research programme worth 600 million euro to create major impact for European economy and society. Such achievements were exciting and were the results of the effort of many people and excellent teamwork.”

“The period of my chairmanship is marked by strengthening EURAMET’s management structure by transforming the secretariat in a unit led by the General Secretary with extended management responsibilities and competences. Furthermore, I am focussing on the study on the status of the coordination in European metrology, the discussions on a joint metrology strategy and future steps towards a truly coordinated metrology in Europe with joint infrastructure and coordinated services where appropriate, and the definition of the role EURAMET will play in this development.” (Editor’s note: the term was on-going while the publication was written)

Beat Jeckelmann
METAS (Switzerland)
2015–2018





2. The Journey from EUROMET to EURAMET

2. The Journey from EUROMET to EURAMET

In 2002 and 2003 EUROMET conducted an EU supported review on 'Metrology for the European Research Area' (MERA) looking at options to improve the cooperation among the European NMIs. To address the challenges in metrology, a coordinated effort of all NMIs would be required, with financial support through the European Metrology Research Programme. It quickly became clear that the club-like structure would not be sufficient. To receive and spend funds EUROMET needed to become a legal entity. So, the key issues that were addressed in the follow-up project 'Implementing Metrology in the European Research Area' (iMERA) were how to change EUROMET into a legal entity and to develop the necessary structures and tools to execute such a joint programme. A key requirement of the new structure was that it should be open both to NMIs that wanted to

participate in the joint research structures, as well as to those NMIs that choose not to do so. Another requirement was that all NMIs, presently members of EUROMET, should be able to become members of the new organisation. Many NMIs are part of their respective government infrastructures; it was essential that the obligations caused by the membership were acceptable to their governments. Therefore, in the iMERA project the legal entity question played an important role. In addition, the structure of the new organisation needed to be developed. The guiding principles for the operation of a legal entity were agreed at the 20th EUROMET General Assembly in Vienna, Austria, on 31 May 2006. EUROMET committed itself to democratic principles: Decisions are made or controlled by elected representatives or bodies with elected members. In the iMERA project possible legal structures



Europe's metrology community who gathered on 11 January 2007 for the creation of EURAMET at PTB in Berlin, Germany
Courtesy of PTB

Guiding principles of EURAMET:

- EUROMET and later EURAMET committed itself to democratic principles.
- Decisions are made or controlled by elected representatives or bodies with elected members.
- The General Assembly is the highest body for all decisions but can delegate tasks to Technical Committees.
- The strategy of the organisation is developed by the Board of Directors and implemented after approval by the General Assembly.
- The composition of the Board of Directors should reflect the diversity of the members in respect of geography, level of metrological development, and metrological impact in Europe.
- In the management of the EMRP, the General Assembly and the Board of Directors act on the basis of binding recommendations from the EMRP Committee.

were reviewed, including for example European Economic Interest Grouping (EEIG), Societas Europaea (SE), or the Association of Public Utility according to German law. These structures were evaluated regarding legal personality, founding modalities, membership, organisational constitution and liability.

The conclusion was that an Association of Public Utility under German law could be suitable both to the operation of metrology research

programmes and for the other purposes of EUROMET.

It was further decided to name the new organisation EURAMET to have a clear distinction from the previous EUROMET but close enough to be recognised as its successor. On 11 January 2007 EURAMET was officially established in Berlin, Germany. Now the organisation was ready for the practical implementation of the metrology research programmes.



Michael Kühne (standing), last EUROMET and first EURAMET Chairperson, chaired the plenary session at EURAMET's inauguration
Courtesy of PTB

2020 Strategy – Vision, Mission and Objectives

Besides the various contributions from all the highly-committed people within the European metrology community, EURAMET was very well aware of the fact that a sound strategical plan would be essential if the whole undertaking was to be successful. It was vital to define long-term goals and focus the limited resources on the most important tasks.

One of EURAMET's main strengths is its diversity, but this diversity makes it important to define common goals and a common plan for the organisation. EURAMET's leaders were acutely aware of the importance of ensuring each individual in the association knew what to do and why. In 2012 EURAMET developed its first overall strategy including vision, mission and objectives. The '2020 Strategy' came about following

different discussions and workshops, including the Board of Directors. As well as input from its members, EURAMET also took into consideration the goals and objectives of the European Union, particularly in terms of research and innovation. EURAMET's strategy is aimed at helping member nations and Europe to meet future needs related to innovation, growth and societal well-being, through the provision and development of quality assured and traceable measurement. The overall goal was to raise the profile of European metrology and make it more internationally competitive. Again it was the pooling of metrological resources across boundaries which was seen as essential but this time in the changing context of global challenges in areas such as health, environment and energy.



**3. Collaboration in Research – Developing
the Mechanism**

3. Collaboration in Research – Developing the Mechanism

As the new millennium dawned, the European National Metrology Institutes were faced with a number of growing challenges that became known as the *'European metrology dilemma'*. Even in the larger NMIs, demands for new measurement capabilities outstripped the national resources available to develop them. It also outstripped any realistic expectation of resources going forward. There was a voracious need for measurements of increased precision over ever wider ranges, and this need was coming from all directions.

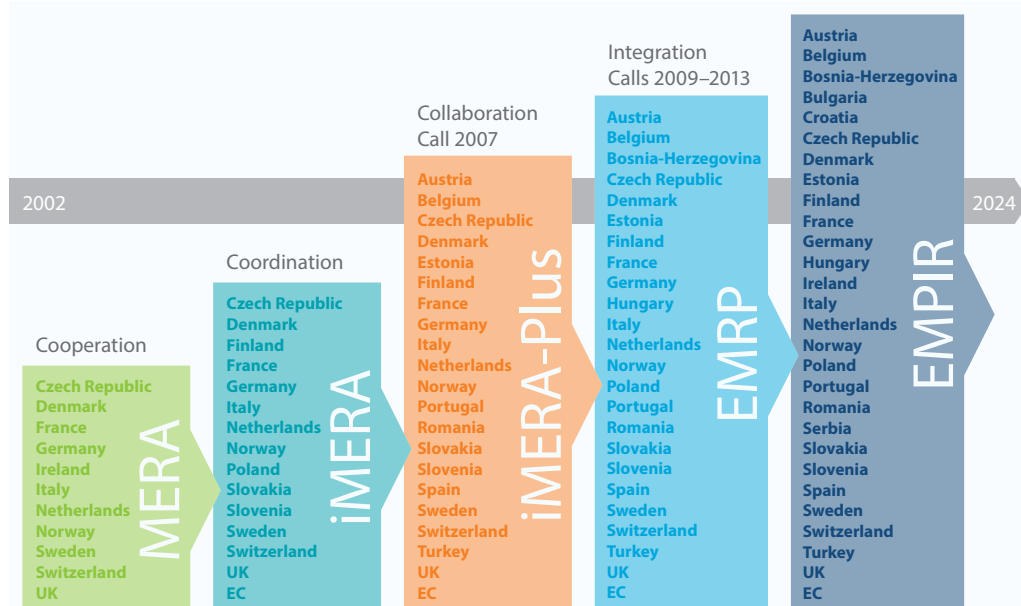
Better measurement was increasingly recognised as a key enabling mechanism for innovation, helping not only with research but also on bridging the gap between laboratory prototype and marketplace expectations. Emerging areas such as biotechnology and nanotechnology crucially depended on advanced traceable SI measurements to create reliable products and services and to demonstrate their regulatory compliance. At the same time, traditional industrial stakeholders also recognised that better measurements helped increase functionality and reliability, and reduce waste in the production process. In short, better metrology helped cut costs and increase value, exactly what manufacturers needed to remain competitive in an increasingly globalised world. Additionally, areas such as clinical chemistry, not in themselves new, were now requiring accuracy that depended on precision measurements just at a time when the possibilities were opening up due to advances in measurement science. Consequently, this community also began to see the value of a sound metrological approach and looked for

support from the NMI community. Chemical metrology began to take off and many NMIs set up dedicated departments. Yet resources in the European NMIs were limited and even the larger NMIs felt under pressure. There was also no sign that government budgets would come to the rescue, so a more creative solution was needed. It became increasingly clear that the European nations must somehow get more impact out of their unconnected and uncoordinated investments in national measurement systems. In late 2001 and through 2002 the desire for a wide-ranging study to see what was feasible at European level was explored within EUROMET's Committee for Interdisciplinary Metrology. Discussions caused some unease. Everyone was aware that moving towards some sort of, at that time unknown, coordinated solution meant giving up at least some element of national control of the agenda, and smaller NMIs were concerned about their very existence. However, in the end, everybody came to the same conclusion. The European NMIs had to work together, collaborate and collectively Europe had to up its game. With common purpose agreed, EUROMET launched a successful bid into the European Framework Programme. This would allow for a collaborative study that formed the basis of the eventual European Metrology Research Programme. This 15-months study, 'Metrology in the European Research Area' (MERA) was successfully evaluated and launched in September 2002 and received around 450 000 euro of EU funding. The study was divided into ten work packages, including preparatory data, collection and analysis, two workshops and consultation with

stakeholders at European and national level, with a specific work package looking at the particular challenges faced by NMIs in the newly associated states. MERA, set within the political context of constructing the European Research Area, laid the foundations for all the following actions, iMERA, iMERA-Plus, EMRP and EMPiR. Although the most modest of the suite of EU projects, in some ways, it was also the most ambitious. The study took a 'clean sheet' approach and looked not only at research but also in service delivery and shared facilities, this means at all aspects of European metrology. The NMIs within EUROMET already had a good track record of collaborating in the scientific comparisons that are the bedrock of metrology. This foundation gave some confidence: the NMI directors knew each other and trusted each other. However, no one was under any illusion that the things being considered represented a vastly ambitious step that would change the metrology landscape in Europe forever. The task ahead seemed daunting. Working together previously had been on a small project-by-project basis and depended on objectives, resources and budgets aligning by coincidence. Commitments had been on a

'best effort' basis, and many projects faltered for these reasons. Not everyone thought things could be changed.

It was understood from the beginning that to make real progress it was not sufficient to have a partnership solely of NMI directors. The government officials behind the NMIs had no international exposure and no knowledge of each other, yet for the changes being contemplated their support would be crucial. Building a community that included as many of the government officials as possible, as formal project partners, proved pivotal to success. MERA involved just eleven EUROMET countries. However, this was sufficient at this stage as these included the leading NMIs. The modest size of the partnership increased flexibility and speed of execution, and as the consultations and workshops involved all EUROMET members nothing was lost. MERA concluded that significantly increased collaboration in research and development should be the cornerstone of any solution to the European metrology dilemma. It identified the key issues to be addressed, confirming that a new paradigm for NMI collaboration was indeed warranted.



Schematic showing the expanding participation in European metrology research programmes Courtesy of EURAMET

It is interesting to reflect that whilst research collaboration has progressed beyond what could be envisaged at that time, some of the other

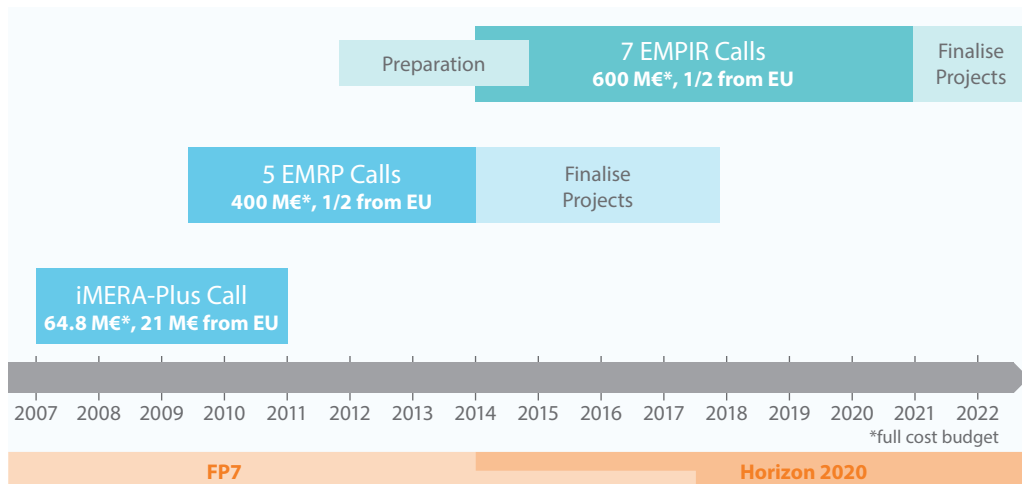
aspects explored back in 2002 and 2003 remain challenges for EURAMET today as they move beyond EMPIR. There is still more to do.

Collaboration with the European Union

The EU Lisbon Strategy was launched in 2000. Its aim was to make Europe the most competitive knowledge economy in the world. With it, the concept of joint programming of national policies for research in areas that have a global impact, had been articulated. In practice, little progress had been made. Janez Potočnik became European Commissioner for Science and Research in 2004 and his arrival was extremely timely for EUROMET’s ambitions. He championed the concept of an integrated *European Research Area* as a way of accelerating progress towards the goals of the Lisbon Strategy across the science and research portfolio.

EUROMET quickly understood that the concepts being discussed in the MERA study complemented high level European political objectives. Although far from simple, EUROMET adopted a policy of developing a programme that offered as far as possible a ‘win-win’ situation not only for its diverse membership, but also the European Union, which was keen to see concrete examples of integrated national programmes. Following on from MERA and iMERA, EUROMET ensured that

its aims were articulated in the language that the EU and national governments, could understand. Metrology was not the most exciting initiative from a political point of view. So a policy was developed in which the metrology community became the European Commission’s most reliable partner in delivering a real working example of joint programming within the European Research Area. Through the many years and different metrology programme projects, EUROMET and later EURAMET prided itself on always honouring its commitments. It was unique amongst the many initiatives in that it met every single deadline set by the European Commission. In such a way, a close working relationship was developed with the EC services. Indeed, in later years informally the Commission looked to the EURAMET example as they developed their own mechanisms for major joint programmes. Major initiatives involving many countries by definition tend to be complex and success often hinges on what, at one moment in time seems to be just a minor detail; yet it is impossible to address all details with the same level of atten-



Timeline of EURAMET’s metrology research programmes
Courtesy of EURAMET

tion. However, a lot can be done to help manage such complexity. Two key examples from the EMRP initiative were the '*Guiding Principles*' and the '*Cornerstones*'.

The Guiding Principles are best expressed as an expansion of the EUROMET vision. Just three pages long; it spelt out the aims and the fundamental principles to be honoured. It was laid out in such a way that all those involved in the initiative could understand and sign up to. This then enabled a much smaller and more focused team to work on the detail. The core group was made up of Andy Henson, who at that time was leader and Programme Manager of the MERA, iMERA, iMERA-Plus and EMRP initiatives; Luc Erard, who later became chair of the EMRP Committee (the Committee of representatives of those countries participating in the EMRP), and Michael Kühne, who at the time of the key negotiations was chairperson of EUROMET. This team developed the details of the proposed programme structure and implementation without having to revert at every point to the wider group for endorsement.

The second document, the Cornerstones was developed as the basis of a formal mandate, specifically for the negotiations with the EC. The Cornerstones addressed each of the basic elements that would be covered by such a negotiation, again laid out in clear terms over a few short pages. Thus, with negotiating terms pre-agreed, the core team had the flexibility to negotiate with the EC meaningfully and in good faith, with room for manoeuvre without having to revert back to the membership at every stage. There were major challenges, but all were tackled in manageable steps following the adage "How do you eat an elephant? One bite at a time". Indeed, one of the key skills necessary to keep more than 20 NMIs and their ministries pulling in the same direction is distilling the sheer complexity of the undertaking into understandable key elements.

The approach worked, both with the members and with the EC. Against the odds, metrology became a headline major programming initiative for the EU, and the major success it is today.

EURAMET's Metrology Research Programmes in a Nutshell

Between 2005 and 2015, the European Union and the majority of European member states agreed to finance metrology research

programmes to the tune of more than one billion euro, through iMERA, iMERA-Plus, EMRP and EMPIR.

iMERA – implementing MERA

In 2005 representatives from 14 countries plus the European Commission, comprising EUROMET members and ministries, launched a three-year project, called iMERA. This project, worth four million euro, enabled the NMI community to understand, plan and trial closer collaboration, and to develop the conditions and design the structures to enable the NMIs to conduct coordinated and collaborative metrological research in areas of strategic importance. The key achievements of the project were:

- The establishment of EURAMET as a not-for-profit legal entity
- Developing the guiding principles of the European Metrology Research Programme and addressing challenges in health, energy, environment and new technologies for nano-sciences and security
- Delivering 10 joint research projects to test the cooperation

iMERA-Plus

In 2006 there was another opportunity for EU funded initiatives. The Seventh Framework Programme for Research and Technological Development was designed to respond to Europe's employment needs, competitiveness and quality of life. The iMERA-Plus project was aimed at aligning and enhancing national programmes with EC support.

Resources from the publicly funded metrology laboratories from 19 European countries, plus the Commission's measurement institute (IRMM), were committed within a single call for metrology research projects. In total 64.8 million euro were brought together, with the EC providing 21 million euro of funding. A total of 21 collaborative projects were launched in four targeted programmes. The selected collaborative joint research projects covered four areas: SI and fundamental metrology, health, length, and electricity and magnetism.

EMRP – the European Metrology Research Programme

EMRP was launched in 2009 as a programme under Article 169 of the European Treaty.

EURAMET published five calls over the lifetime of the EMRP (2009–2017) covering the areas energy, industry, environment, health, new technologies and SI Units. In total 119 projects were funded. In addition, the programme supported three types of researcher grants, which supplemented the research in the projects: Researcher Excellence Grants, Researcher Mobility Grants and Early-Stage Researcher Mobility Grants for a total of 306 participants.

EMPIR – the European Metrology Programme for Innovation and Research

EMPIR was successfully launched in 2014. The 'I' in the name indicated the raised profile towards innovation.

The key difference between EMPIR and EMRP is that EMPIR has an increased focus on innovation activities to target the needs of industry and is aimed at a more efficient exploitation of the research outputs and at a more coherent development of the European metrology landscape. The pre-normative programme part is underpinned by a joint platform of CEN and CENELEC, two of the three officially recognised European standardisation organisations, and EURAMET. The transfer of research outputs to industry and other stakeholders is supported by projects called 'Support for Impact'. Capacity building is driven by the targeted programme 'Research Potential Projects'. It aims to develop research capabilities of emerging NMIs and DIs in cooperation with established institutes.

There was a smooth transition from EMRP to EMPIR. The programmes co-existed over a period of more than three years. This co-existence did not cause significant problems, although the underlying rules for implementation of the EU framework programmes are significantly different.

How does EURAMET Manage the Research Programmes?

The development of the European joint research programmes from iMERA to EMPIR was characterised by a parallel development of agenda and instruments. Far from being static, EURAMET has committed to enhancing the joint research programmes for almost 20 years, from 2005 to 2024. This continuous improvement is driven by new challenges and stakeholder needs.

The key project for the development of the instruments and rules was iMERA. It included the research agenda – which led to the work plan of both iMERA-Plus and EMRP, the establishment of EURAMET as a legal entity, and the consultation with the ministries responsible for national metrology research programmes. New bodies were needed, such as the EMRP Committee for making decisions on the implementation, the Management Support Unit and the Research Council.

Only part of EURAMET's membership makes a financial commitment to the research programmes but the whole membership takes responsibility for how they are implemented and ensures that all members benefit from the outcomes.

The General Assembly and its executive part, the Board of Directors, are responsible for implementing and delivering the overarching strategy. In addition, EURAMET is advised by an independent Research Council, made up of distinguished senior experts and representatives from key stakeholder organisations. The central bodies for the practical programme implementation are the EMPIR Committee and the Management Support Unit, which is a part of the Secretariat. Each participating state is represented in the EMPIR Committee by one representative from the respective NMI. The voting acknowledges the large differences in the national commitments to the programme as well as the right of small contributors for an adequate representation. The call cycle of EMRP and EMPIR is unique. EURAMET issues annual calls for 'Potential

Research Topics' in a set of sub-programmes called targeted programmes. The call scopes are derived from the strategic research agenda, that was established on extensive road mapping and consultations among the Technical Committees and dedicated Task Groups on themes like energy, environment and health. EMPIR subcommittees analyse each of the 'Potential Research Topics' and propose 'Selected Research Topics' to the EMPIR Committee. Once a decision has been made, the specifications for the 'Selected Research Topics' are published and a call for joint research project proposals, based on the 'Selected Research Topics' is launched.

The review process of the European metrology research programmes is also unique as it is conducted in the form of a review conference, at which proposers have the opportunity to explain their proposal to the referees in an open discussion. The referees agree on a ranked list of the proposals and the EMPIR Committee then decides where to draw the line on that list indicating which proposals will be funded within the available budget. After passing an ethics review and contract negotiations, the projects can start. The EMPIR Committee has chosen to launch calls every three years for specific targeted programmes such as energy or environment. This allows for long-term approaches to be addressed in a series of subsequent three-years projects. Calls for targeted programmes that don't require subsequent projects, such as pre-normative projects, are issued annually.

In summary, EURAMET has established a robust and suitable governance structure that allows for the implementation of European research programmes. EURAMET has demonstrated this capability in a series of joint programmes, supported by the EU and more than 1 billion euro in funding. With that history, EURAMET is well placed to implement possible new research initiatives following EMPIR.

A Strategic Research Agenda for Metrology in Europe

After the start of the European Metrology Programme for Innovation and Research, EURAMET published the 'Strategic Research Agenda for Metrology in Europe' in 2015. This document was developed to provide a high level strategic view of the measurement capability requirements for the following five to ten years. These were more than those likely to be delivered by EURAMET's research programmes but also included those required by the wider research community involved in measurement-related programmes on a national, regional and international level.

EURAMET's research strategy calls for the European metrology community to develop and maintain capacity that meet current and future demands, support the development of advancing technologies, and develop scientific and technical research ability in areas of strategic national and regional importance. It seeks to create and maintain a cost-effective, balanced and integrated European metrology infrastructure and research capability; one that provides

support to all European nations and enables Europe to remain competitive.

The strategy highlights the need for EURAMET to continue developing a growing and sustainable metrology infrastructure, working ever more closely with stakeholders. It has increased emphasis on addressing the grand challenges facing Europe where there is a need for even greater cross-disciplinary research. This will require increased openness and collaboration with stakeholders including academia, research and technology organisations and industry that can provide capability that traditionally has not been found within the National Metrology Institutes and Designated Institutes community.

The Strategic Research Agenda supports the realisation of a common vision which is to ensure Europe has a world-leading metrology capability, based on robust and high-quality science and an effective network-based infrastructure to meet the rapidly-advancing needs of end users, to achieve significant societal and economic impact in Europe.

A close-up photograph of a hand holding a dark, smooth, rounded stone. Below it, two more similar stones are stacked. A circular blue overlay is centered over the stones, containing white text. The background is dark and out of focus.

**4. Collaboration in Research – Contributions
to Europe's Grand Challenges**

4. Collaboration in Research – Contributions to Europe's Grand Challenges

EURAMET's research programmes, EMRP and EMPIR, help make Europe a more prosperous and sustainable continent by developing the measurement infrastructure of the future; ensuring it meets society's needs. Below are some examples of how these research projects have helped address society's big challenges in health, environment, energy and industrial innovation.

Health

Accurate measurement in the medical sector supports precise diagnosis, safe and effective treatment and the thorough assessment of new medical techniques. This not only contributes to improved public health but supports an important European industry.

In global health terms, infectious diseases present an even greater challenge. They account for over 20% of human deaths globally and 25% of all illness. Finding accurate and rapid methods to diagnose and manage infectious diseases is critical to protecting public health. Infectious pathogens can be present in patients' samples at very low levels and accurate and consistent assessment methods are needed to identify and quantify pathogens. Molecular methods such as digital PCR, a method used to amplify a focused segment of DNA, and nucleic acid sequencing can improve the identification and quantification of pathogens in clinics worldwide and may become the primary metrological methods at national and international level. Traceability to international systems of measurement is in

its infancy in biology and EMRP research has developed methods with high accuracy, taking us closer to the goal of SI traceability. The higher-order methods will support the development of reference materials used to assure the quality of analyses made in end-user laboratories and so support robust and effective identification and monitoring of infectious diseases.

EMRP research extended the use of accurate measurements to healthcare treatments where traceability did not exist. Ultrasound, commonly used for ailments such as kidney stones, soft tissue injuries and cataracts, can be used at high energy levels as a cancer treatment in place of radiotherapy. High Intensity Focused Ultrasound (HIFU) targets tumours with a focused, high-energy dose with the potential for less unwanted damage to surrounding tissue than X-ray based radiotherapy. But without a method to determine the dose given, a personalised treatment plan cannot be created. Under- or over-treatment can occur, leading to ineffective treatment of the cancer or inadvertent damage of the wider

tissue. EMRP research is creating the dose standards and modelling techniques that will help health practitioners develop effective treatment plans and improve patient quality of life. NMI experts are working with HIFU equipment manufacturers to accurately validate the performance of equipment and components and demonstrate compliance with the relevant International Electrotechnical Commission (IEC) standard.

The medical implants industry, manufacturing life-saving stents, pacemakers, replacement joints etc., helps to extend or improve lives and is worth over 200 billion euro annually. To be successful, devices must be able to work with the body; yet the rate of infections and device failures due to incompatibility is still too high. Novel materials, surfaces and antibacterial and drug-releasing coatings can improve the biocompatibility of implants, reducing infections and complications. These require accurate assessment of the chemistry on the implant surface to support product development and quality assurance during manufacture. EMRP research



advanced the traceability of the highest-order measurement techniques, complex, expensive and slow methods conducted in a vacuum and assessed and improved practical methods for the manufacturing environment. As a result, devices are now being manufactured that include innovative coatings that resist bacterial contamination and surface grafted biomolecules and materials that release drugs slowly to prevent tissue rejection.

Environment

Accurate measurement is important in our understanding and management of the environment. By knowing how we are changing the environment we can mitigate it. European metrology research is addressing environmental challenges at both global and local levels – supporting our fundamental understanding of climate change and enabling reliable and practical assessments of air and water quality.

Working with the academic, meteorology and space communities, European NMIs ensure that measurements of the internationally defined Essential Climate Variables are available to climate scientists and policy makers. EMRP research has made significant progress towards the goal of an ‘NMI in space’ that will calibrate and validate climate data from earth observation satellites. The metrology community is working

closely with the European Space Agency (ESA) and climate scientists to develop and test high-level measurement instruments for the space environment.

Down on earth, EMRP has helped develop a calibration device for local temperature, pressure and humidity sensors used around the world for monitoring climate change. This device, called EDIE, was installed on the island of Svalbard, located between Norway and the North Pole. EDIE can provide traceability for local sensors, removing the need to transport instruments to distant calibration laboratories. Accuracy of ground sensors is crucial not only to the understanding of environmental change in specific areas but also to the validation of satellite-based monitoring, without which our space-based global monitoring systems would be unreliable. Improving



Ocean wave – measurement research
supports environmental data quality
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our local environment requires accurate and practical tools to determine air and water quality and ensure compliance with national and international regulations. Roadside air pollution in the form of nitrogen dioxide (NO₂) is not only a public health hazard but damages biodiversity and contributes to climate change. EMRP research has supported the development of innovative instruments to assess these pollutants to make sure existing regulation is met and tighter regulations can be introduced in the future.

The City of Zurich worked with METAS, Switzerland's NMI, to understand the level of NO₂ pollution from the city's roads by using a newly developed NO₂ permeation generator to calibrate the NO monitoring sensors. This has led to the development, in partnership with a gas calibration manufacturer, of a compact, commercial version of the METAS device. More reliable pollution monitoring supports the introduction of more effective public policies to protect the health of European citizens.

Energy

A robust metrology infrastructure is needed to create the technologies required to achieve Europe's energy goal of reducing greenhouse gas emissions by using of sustainable fuels and low carbon technologies. EMRP and EMPIR research is addressing the measurement needs of sustainable energy sources, low carbon technologies and improving the efficiency of electricity

Ultimately, the key to reducing roadside pollution is reduced vehicle emissions. The Euro series of standards has set progressively lower allowable emissions with each new edition since the introduction of the catalytic converter in 1992. These standards cover both gaseous pollutants and particulate matter and must be met before new engine designs can be used, so the correct measurement of engine emissions is crucial. EMRP has helped to establish the first direct traceability chain for condensation particulate counters, the instruments used to measure particulates at the low levels required by the regulation. New calibration facilities at NPL in the UK have enabled a leading manufacturer of these instruments, to provide measurement traceability to all the instruments it sells to engine manufacturers and emissions testing laboratories. The research is also addressing the issue of on-the-road testing of engines. NMI researchers at PTB in Germany worked with a world leader in portable measurement technology, to validate the performance of a new instrument for both mandatory periodic vehicle emissions testing and new engine type testing. In both examples emission measurements will be traceable to national standards, ensuring robust, comparable measurements of exhaust emissions to meet the latest Euro 6c standard that comes into force in 2017. By supporting the implementation of a key piece of the EU's air quality policy framework, this is an important step towards realising Europe's goal of improving health and environmental quality through cleaner air.

generation. Research outputs are already being adopted by industries throughout Europe.

Increased use of renewable energy sources is a key component of Europe's energy policy but their adoption requires a new approach to electricity generation and distribution. Smart grids have to balance a highly variable energy

supply with user demand in real-time to achieve sufficient power quality and grid stability to prevent blackouts. The European metrology community is ensuring that the appropriate measurement capabilities are in place to support them. A phasor measurement unit (PMU) is a device which measures the electrical waves on an electricity grid using a common time source for synchronisation. Time synchronisation allows synchronised real-time measurements of multiple remote measurement points on the grid. PMUs are expected to be the 'life-support monitor' for smart grids – installed throughout the grid to provide data for grid management. EMRP research is enabling PMUs to be developed that are traceable to national measurement standards and comply with relevant industry standards from the Institute of Electrical and Electronics Engineers (IEEE). This work, combined with complementary work from the NMI of the USA, has enabled a manufacturer to produce a unique PMU calibrator and another to develop a cost-effective high quality PMU. Together these provide grid operators with robust and reliable equipment to manage smart grids and accelerate their adoption in Europe.

Running in tandem with increased use of renewable energy sources is the need to increase the efficiency of traditional large power plants. Improved measurement techniques play an important role in managing power plant processes and EMRP research has addressed a range of essential measurement parameters. The research has enabled an instrumentation manufacturer to validate the performance of its innovative flowmeter. Using ultrasound to measure both flow and temperature accurately,

the instrument enables better optimisation of power plant operating processes. A trial on a nuclear plant run by an energy provider in Sweden demonstrated an efficiency saving of 2–3 per cent. Given Europe's dependence on traditional large-scale plants for the foreseeable future, there is real potential to scale up this technology and achieve significant energy savings.

Reducing energy consumption more widely using energy efficient or 'low carbon' products is the final part of the solution to reducing greenhouse gas emissions. Solid state lighting devices such as LEDs are highly energy efficient and, with lighting making up around one-fifth of global energy consumption, offer huge opportunities to reduce energy use. EMRP research on the electrical, optical and visual performances of LEDs contributed to a new Italian standard for illumination in road tunnels. Research conducted with a highway authority demonstrated that lower lighting levels could be used effectively and safely in tunnels. This will reduce the energy consumption and associated CO₂ emissions in Italy's 1500-kilometre road tunnel network by a further 33%.



Wind turbines in a crop field – measurement research supports a sustainable European energy system
iStock.com/imagean

Industrial Innovation

Metrology plays an important role in the competitiveness of Europe's manufacturing sectors. It supports efficient production of the products of today and the innovation needed to develop

the products of tomorrow. High quality commercial measurement instruments or devices are essential linking the highest-level measurement capabilities at NMIs and DIs and the shop

floor of manufacturing businesses. More than 450 companies, the majority instrument manufacturers, took part in EMRP research projects to access the best measurement capabilities and knowledge so far. Using this knowledge to develop and validate new products, these companies report over 450 million euro of sales in innovative products influenced by EMRP research; with 109 million euro of this directly attributed to EMRP research. This figure will increase as more of the EMRP and EMPIR research is completed and its outputs are adopted by

instrument manufacturers and, ultimately, by their customers in a broad range of industries.

EMRP and its successor programme EMPIR are supporting collaborative research by European NMIs and DIs over many years – from 2009 to the 2020s. The programmes are co-funded by the European Union and the participating states within EURAMET. The vast amount of research addressing societal challenges is ongoing and will, in the long term, lead to even greater benefits for European citizens.



4. Collaboration in Research – Contributions to Europe's Grand Challenges

Modern metalwork – measurement research supports industrial innovation and productivity
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**5. Collaboration to Ensure
Global Traceability**

5. Collaboration to Ensure Global Traceability

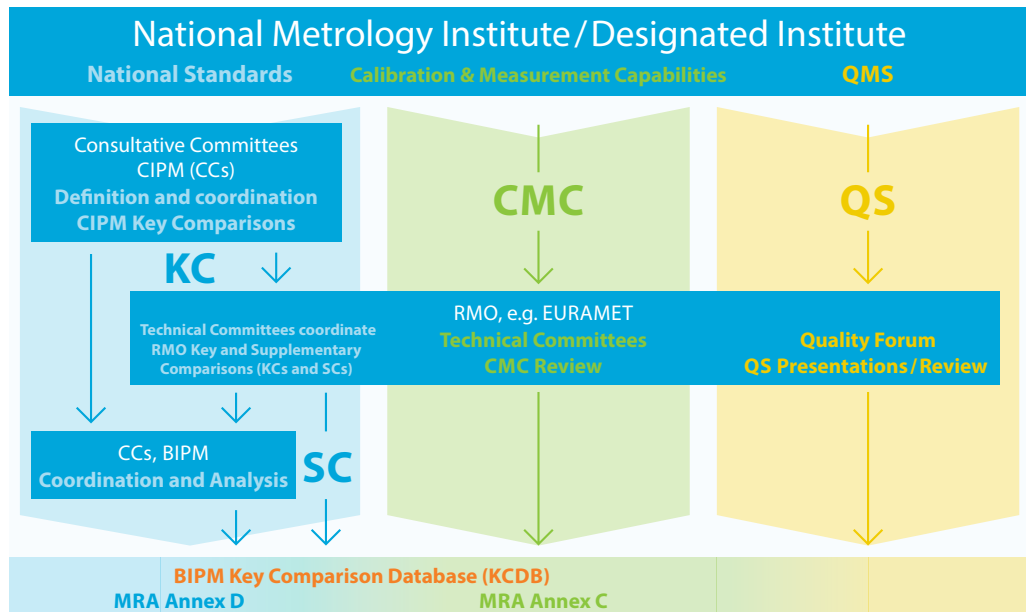
The international metrology laboratory BIPM was established in 1875 and this was followed by the foundation of National Metrology Institutes towards the end of the 19th century. Regional Metrological Organisations, like EURAMET, are much younger and did not emerge until the second half of the 20th century. Their specific role is to deal with metrological issues of their region. It is therefore a valid question why they are needed in addition to the BIPM and the NMIs and what is their role in global metrology.

How is Traceability in Measurements Established?

In the late 20th century, the development of RMOs was significantly influenced by increased economic interactions between neighbouring countries. This was particular true for many European countries which ultimately became members of the European Union. Demand for metrology services grew for a number of reasons such as advances in precision manufacturing, demand for energy efficient products and global

production of complex technical goods. All these developments created a strong need for improved metrology to assure product specifications. A key component in all quality management systems for manufactured goods is the requirement for traceable measurements. This means that the measurement tools used in the production process must be calibrated and that calibration must

5. Collaboration to Ensure Global Traceability



The process of the CIPM MRA
Courtesy of EURAMET

Goals of the CIPM MRA:

- Establish the degree of equivalence of national measurement standards
- Provide for mutual recognition of calibration and measurement certificates issued by NMIs
- Provide governments and other parties with a sound technical foundation for wider agreements

The CIPM MRA's objectives are achieved through international comparisons of measurements (key comparisons), supplementary international comparisons of measurements, quality management systems and demonstrations of competence by NMIs.

be traceable to the International System of Units. This is assured when the calibration of the measurement tools is performed at a NMI. However, the required number of calibrations would significantly exceed the capacity of any NMI. Therefore, NMIs will perform only those calibrations at the highest metrological level in the country. For all other calibrations, a hierarchy is introduced. The NMI, as the holder of the national measurement standards, performs a top-level calibration of a secondary standard. The secondary standards are then used in calibration laboratories to perform the calibration of the measurement standards used by industry. Often in industry one or more hierarchy levels are introduced down to the calibration of the measurement tool used on the shop floor.

To create the necessary confidence in that process the applicable international standards call for an independent third party review. In that process the calibration laboratories need to be accredited by accreditation bodies and the quality management system of the producers need certification that their systems comply with the applicable international standards. The certifiers themselves need accreditation by the accreditation bodies which themselves must undergo a third-party review by peers to be recognised. These developments had a strong influence on

the work of EUROMET. Traceability provision between NMIs became a core task and in parallel NMIs began to implement quality management systems. Some NMIs started to go for accreditation of their calibration capabilities through national accreditation bodies.

The recognition of measurement capabilities and quality systems of NMIs must be based on transparent, internationally agreed procedures, in order to support global trade. This idea was taken up by the International Committee for Weights and Measures in 1999. It drew up a Mutual Recognition Arrangement, the CIPM MRA, between NMIs all over the world.

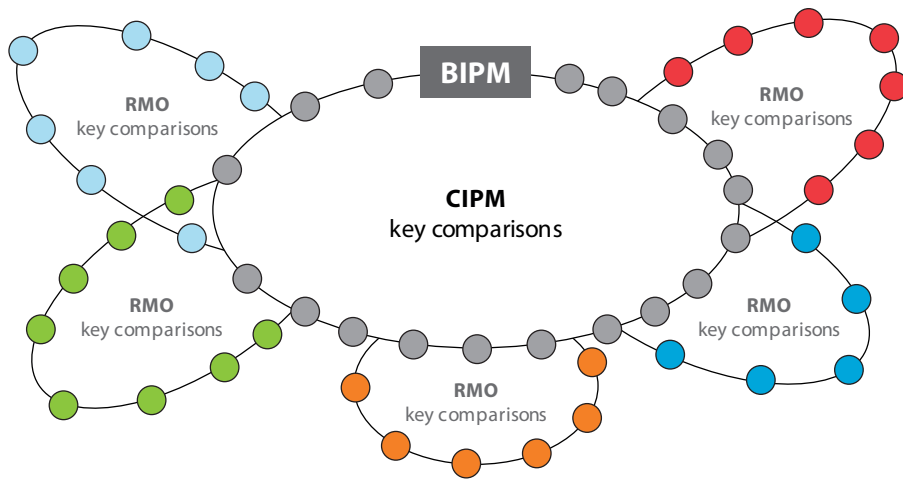
All Metre Convention member state NMIs can participate in the CIPM MRA. To enlarge the possible number of participating NMIs a new kind of membership at significant lower membership rates was established, the 'Associate to the CGPM'. Consequently, NMIs of countries that became associated could also participate in the CIPM MRA. The CIPM MRA has been signed by the representatives of 102 institutes and covers a further 156 institutes designated by the signatory bodies. To coordinate the implementation of the CIPM MRA, the Joint Committee of the Regional Metrology Organisations and the BIPM (JCRB) was created.

The outcome of the CIPM MRA processes are statements of the Calibration and Measurement Capabilities (CMCs) of each NMI. The CMCs are published in the key comparison database maintained by the BIPM.

In many countries the national metrology standards are not all kept in one institute. Some countries operate more than one NMI or a network of Designated Institutes which support the NMI. In these cases the additional institutes must be listed in the BIPM key comparison database; with a clear distinction, as to what area of metrology the institute is responsible for national measurement standards.

For a National Metrology Institute to have its Calibration and Measurement Capabilities recognised by other NMIs, it must have its quality management system reviewed and approved by its Regional Metrology Organisation. It must also participate in the appropriate measurement comparisons, and submit its CMCs, after approval by its RMO (intra-RMO review) to the BIPM which will send it out to inter-RMO review. If the other RMOs give a positive review, the CMCs are published in the key comparison database.

EURAMET and the other RMOs got new and concrete responsibilities with the establishment of the CIPM MRA. They became the key players in its practical implementation. This did not only result in a significant increase in activities; but it also gave the RMOs a formal role in the world metrology system. In this respect, the CIPM MRA can be considered as a milestone for the consolidation of the RMOs, and, in particular, for EURAMET.



Connecting the CIPM key comparison with the key comparisons of the Regional Metrology Organisations through common memberships
Courtesy of the BIPM

How is Mutual Trust in Calibrations and Measurements Achieved?

The Joint Committee of the RMOs and the BIPM (JCRB) was established to observe the practical execution of the CIPM MRA. The guidelines and procedures drafted by the JCRB are approved by the International Committee for Weights and Measures and then put in effect by the BIPM. The CIPM Consultative Committees have an important role in the CIPM MRA as they define the CIPM key comparisons. A CIPM key comparison creates a reference value which is later used to connect the results of this CIPM comparison with the results of regional key comparisons which are executed by the RMOs using an identical protocol as the CIPM key comparison. The procedure requires that at least one member of the

RMO has participated in the original CIPM key comparison to connect the RMO results to the Consultative Committee results.

This brings in the Technical Committees of EURAMET. Membership to a TC is open to all members of EURAMET and they cover different fields in metrology. Indeed, TCs are the backbone of the association and membership is an essential element of the cooperation between NMIs.

In the framework of the CIPM MRA, the Technical Committees execute the key comparisons defined by the Consultative Committees on a regional level. Participation is open to all NMIs of EURAMET which use the techniques under

The role of the 'Consultative Committees' of the CIPM

The CIPM Consultative Committees were established in the 1920s when metrology became so complex that the individual CIPM members could not cover all technical areas of metrology with the necessary detailed expertise any more. Membership to a Consultative Committee is limited to NMIs of member states to the BIPM that are recognised internationally as having the most expertise in the field. It is also limited to those who are active in research, have a record of recent publications in research journals of international repute and who have demonstrated competence by a record of participation in international comparisons. The Consultative Committees agree on the CIPM key comparisons and the protocols by which the comparisons must be executed. The purpose is to test the principal techniques in the field. CIPM key comparisons are open only to the laboratories with the highest technical competence, normally the member laboratories of the appropriate Consultative Committee.

investigation for the dissemination of the SI in their country. As the technical operation of NMIs in a Regional Metrology Organisation can vary significantly; it is often the case that not all NMIs will participate in a regional key comparison. To meet specific needs that are not covered by the key comparisons the RMO can establish 'supplementary comparisons'. In specific cases the participation in a key or supplementary comparison can be also opened for NMIs of other RMOs. All comparisons are registered in the key comparison database of the BIPM. Before a EURAMET NMI that has successfully participated in a RMO key or supplementary comparison can have its CMCs reviewed by the appropriate Technical Committee, it has to submit its quality management system to EURAMET for review and approval. For this task, all RMOs have set up special Technical Committees. In EURAMET, this is the Technical Committee for Quality (TC-Q). In order to fulfil the CIPM MRA requirements, the quality management system must comply with ISO standard ISO/IEC 17025 'General requirements for the competence of testing and calibration'. Once the quality management system is approved, a NMI can submit its CMC for review to the responsible Technical Committee. All CMCs that an NMI intends to declare must be covered by the approved quality management system and must have appropriate traceability

to the SI. Submitted CMCs must be backed by appropriate evidence. Acceptable evidence includes results of key and supplementary comparisons, documented results of past Consultative Committees, RMO or other comparisons, knowledge of technical activities by other NMIs or on-site peer-assessment reports.

With the approval of the submitted CMCs by the Technical Committee the intra-RMO review is completed. The CMCs are forwarded by EURAMET to the BIPM. The BIPM asks the other RMOs for a further review. This is called the inter-RMO review and must be performed by at least one other RMO. The intention is to assure that the same criteria are applied to the review worldwide. When the CMC has achieved inter-RMO approval it is published in the key comparison database.

From the first days of the CIPM MRA on EUROMET member NMIs and DIs were extremely active in organising and participating in comparisons and publishing CMCs. This becomes visible through the fact that EUROMET and later EURAMET members are accomplishing roughly half of all key figures of the CIPM MRA worldwide. As a result, EURAMET is strongly committed to contributing and further developing and improving the CIPM MRA via an active participation in the JCRB and other committees through its members.

EURAMET's Contribution to the Revision of the SI

The International System of Units is the present form of the metric system formally adopted by the 11th Conférence Générale des Poids et Mesures (CGPM), in 1960. Today, the SI includes two classes of units, the seven base units: the metre (m), the kilogram (kg), the second (s), the ampere (A), the kelvin (K), the candela (cd) and the mole (mol) and 22 derived units. It is used globally in more than 100 countries.

The present definitions of the base units have weaknesses, such as the dependence of the kilogram on an artefact that may change its properties, the definition of the kelvin based on the triple point of water that depends on sample purity, or the impractical definition of the ampere.

This has led the global metrology community to develop an approach that defines the SI Units by fixing the numerical values of seven constants – the defining constants. Provided the experimental data on the seven constants are satisfactory, the 26th CGPM in 2018 will accept a resolution to revise the SI. From the fixed values of these defining constants, expressed in the Units of the SI, the complete system of units can be derived. Particularly, four of the SI base units – the kilogram, the ampere, the kelvin and the mole – will be redefined in terms of constants; the new definitions will be based on fixed numerical values of the Planck constant h , the elementary charge e , the Boltzmann constant k , and the Avogadro constant N_A , respectively. Defining the SI Units in terms of the set of defining constants eliminates any artefact or material dependencies. Additionally, as new requirements from society and needs of increased accuracy arise, new and superior practical realisations may be developed. It is expected that the revision of the SI will be a major milestone for science and will be a trigger for innovation – as when the metre was redefined in 1983.

The revision of the SI is a fundamental change, which requires worldwide cooperation. National Metrology Institutes across the globe, as well as

the BIPM, have contributed significantly during the last decades. The metrology community's main objective is to transition from the current to the 'new SI' smoothly, without affecting the public's daily lives.

Several EURAMET members have played a fundamental role in improving the SI; from implementing experiments for the realisation of units, to obtaining data relevant for the determination of the Planck constant h , elementary charge e , Boltzmann constant k , and Avogadro constant N_A . At the same time, EURAMET has created the environment necessary for international co-operation with its European metrology research programmes EMRP and EMPIR. So far, 17 joint research projects, the first started in the iMERA-Plus phase in 2007, on the current and possible future SI redefinition have been funded. These contributions were and are key for the redefinition expected in 2018. All SI-related joint research projects within EMRP and EMPIR played a key role in bringing the European and international metrology community together to work on the redefinition of the SI and often acted as a focal point for the international activities.



With the revision of the SI a new logo will be implemented
Courtesy of the BIPM

Mass – the redefinition of the kilogram

The unit of mass, the kilogram, is presently the last unit in the SI based on an artefact, the mass of a platinum-iridium cylinder approved by the CGPM in 1889. It might be changing as it ages, due to environmental factors. Long-term stability cannot be guaranteed and other units depending on the kilogram have the same problems. Progress is being made towards a redefinition in terms of the Planck constant, realised via the watt balance and silicon sphere Avogadro experiments.

Joint research projects delivered various contributions to this approach:

- Methods and devices were produced to improve experiments at European NMIs and to support the development of future experiments;
- Methods to calculate the Planck constant were refined and improved, to increase the accuracy to which they can state the Planck constant and to ensure their results are consistent;
- To minimise uncertainties procedures and equipment were developed to transfer the mass standards between vacuum and non-vacuum conditions;
- Project results will be utilised by the Committee on Data for Science and Technology and the CIPM to help redefine the kilogram.

Temperature – the redefinition of the kelvin

Temperature is one of the most frequently measured physical quantities in science and industry. The unit of temperature, the kelvin, is currently defined by the temperature of the triple point of water. In the revised SI, the kelvin will be related to the Boltzmann constant which relates energy at the individual particle level with temperature. This will make the definition independent of any material substance, specific technique of realisation and temperature or temperature range.

Joint research projects generated methods and data being used to prepare the measurement community for the redefinition:


- Project partners have determined the Boltzmann constant independently using different experiments;
- Reliable progress in the improvement of the different methods was secured and all promising methods known worldwide were committed in one unique project (possible risks of one single method were mitigated);
- NMI capabilities were developed for making and disseminating high-temperature (> 1000 °C) and low-temperature measurements (< 1 K) directly linked to the definition;
- Lowest-uncertainty data ever achieved was generated for the International Temperature Scale of 1990 (ITS-90);
- Accuracy of regions of the ITS-90 scale was improved to optimise its realisation and alternative methods to disseminate the redefined kelvin were developed.

A

Electric current – the redefinition of the ampere

Electric current is the flow of electrons, each of which carries an identical charge. This charge is known as the elementary charge and is a fundamental constant of nature. The SI Unit of electric current – the ampere – can therefore be defined in terms of a fixed value for the elementary charge. To realise a new definition of the ampere the number of electrons that flow over time needs to be controlled.

Two joint research projects developed state-of-the-art Single Electron Transport (SET) devices. The first project used those SET pumps to calibrate current meters with an uncertainty 20 times better than available at that time. The second project combined the SET pumps with ultrasensitive single electron detectors to create highly-accurate quantum current sources for use as standards.



6. Collaboration in Sharing Knowledge and Building Capacity

6. Collaboration in Sharing Knowledge and Building Capacity

From the very beginning the diversity of EURAMET's members and associates has been a strength and a challenge for the organisation. The capabilities of National Metrology Institutes in EURAMET member states vary from country to country. Some NMIs have just four employees, or are newly established, while others have almost 2000 employees and have been in existence for over 100 years. Some NMIs put the focus on R&D while others are mainly service-oriented. EURAMET assists all members, especially new and emerging ones, in the development of their national metrology infrastructure and their integration within the European metrology network in a coherent, efficient and sustainable way. One of EURAMET's main goals is to ensure appropriate scientific knowledge and experience in the field of metrology is transferred amongst all EURAMET members across Europe. As a first step, a guidance document was developed describing what a national metrology infrastructure should look like and what EURAMET expects from its member NMIs (*EURAMET Guide No.1, EURAMET and the Operation of NMIs*). Over the years, in many member countries the role of Designated Institutes became more and more important for the national metrology infrastructure. Today, EURAMET has 37 NMIs as members and almost 80 DIs as associate members. These require special attention in the management of the organisation as well as a structured approach of knowledge transfer to meet EURAMET's ambitions to further develop an integrated European metrology network. During the days of EUROMET, it was mostly new and emerging NMIs that required metrological expertise.

Later, numerous new DIs were designated, which required knowledge transfer in new technological areas. This is the reason why EURAMET Guide No. 2, *Role of Designated Institutes within the CIPM MRA* was developed. This document was based on analysis of national metrology infrastructures in EURAMET member countries. The first systematic initiatives for knowledge transfer within EUROMET began in 2005 between the NMIs of south-east Europe. EURAMET quickly saw the benefits and decided to establish formal cooperation between all members. This led to the establishment of the Focus Group for 'Facilitating National Metrology Infrastructure Development' in 2008. The Focus Group became a joint EURAMET-WELMEC group, as many member institutes were also responsible for legal metrology. The Focus Group's objective was to promote and develop the metrology infrastructure in member countries by increasing cooperation and collaboration among EURAMET NMI members and raising awareness of metrology and quality infrastructure. The Focus Group devised action plans at its annual meetings, comprising activities in the following fields: training courses; comparisons; raising awareness and joint networking; peer visits on quality systems; coordination of metrology services and legal metrology. The action plans have always been very ambitious and their implementation very successful. Between 2008 and 2016, 44 collaborative projects were accomplished. Training courses were delivered in almost all technical areas. Additionally, further important topics were covered such as

the CIPM MRA, quality management systems, measurement uncertainty, legal metrology, good laboratory practice, communications and strategic management. As a direct result, at least four associate members became full EURAMET members. Many others got their first CMCs published in the key comparison database. This was without doubt one of the biggest successes of the Focus Group.

Special financial and expert support for the operation of the Focus Group was given by PTB's department for 'Technical Cooperation'. The budget for most of the participating NMIs was limited to the routine operation of the institute, therefore third party funding for training, consultancy and participation in regional and international activities was vital.

In 2015 the Focus Group was restructured as the

'Working Group for Capacity Building' directly connected to EURAMET's Board of Directors. This emphasises the strategical relevance of the issue and enables the group to continue its successful work.

EURAMET's knowledge transfer activities involve not only the working group but the whole association in supporting this important topic. Knowledge transfer is also one of the main tasks of the Technical Committees. An important example of the TC's work is the development of a series of calibration and technical guides to support knowledge transfer amongst members. These guides were developed to improve calibration harmonisation of measuring instruments and to enhance the equivalence and mutual recognition of calibration results obtained by laboratories performing calibrations.

Capacity Building and Knowledge Transfer within the Research Programmes

The European Metrology Research Programme was designed to support best practice research in metrology. Not surprisingly, one of the observations at its midterm evaluation in 2011 was that the EMRP is not having the desired effect in terms of capacity building in those countries with limited or no metrology research capabilities. Nonetheless, the capacity building activities which had been carried out independent of EMRP, were positively mentioned by the evalu-

ators. These activities were especially beneficial for EURAMET members, not focused on research and hence, not participating in EMRP. It was proposed that a follow-up programme of EMRP should include funding for capacity building. This was done in EMPIR with calls for 'Research Potential' joint research projects and 'Human and Institutional Capacity Building' activities such as training courses and researcher mobility grants. Research potential projects are aimed at developing the potential for metrology research and for the establishment of competitive metrology infrastructure in response to an existing need mostly in emerging EURAMET member countries or regions. These projects are directly financed by EMPIR. Human and institutional capacity building projects are aimed at the consolidation of the metrological core competence of all EURAMET members, and are not restricted to any country or region.

Within the researcher mobility grants, a less experienced researcher collaborates with a joint research project partner institution to undertake research additional but related



First meeting of the Focus Group for 'Facilitating National Metrology Infrastructure Development' in 2008 in Skopje, Macedonia
Courtesy of EURAMET

EURAMET training courses focusing on knowledge transfer and bringing together Europe's measurement community
Courtesy of EURAMET



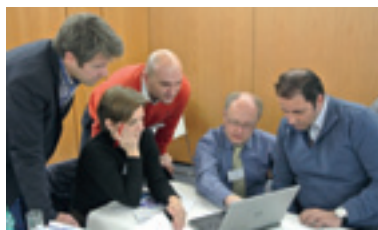
6. Collaboration in Sharing Knowledge and Building Capacity



Images from 'BIPM-EURAMET TC Leadership Course': Courtesy of the BIPM



Every year EURAMET conducts a number of training courses in various fields. The pictures show group working in training courses on strategic management, how to approach the media, TC leadership and a workshop for DIs



to the project. The duration of the grant is between one and 18 months. Researcher mobility grants benefit many parties, such as the researcher, the researcher's home institution, the hosting institution and the project within which the grant has been realised. The grants increase researchers' skills, inspire them

Preparing for the Future

It is vital for EURAMET to inspire active participation of all its members, with no restrictions or limitations. Within the new scope of EURAMET's capacity building tasks it also supports the full integration of smaller and emerging NMIs and DIs into EURAMET's activities and encourages closer collaboration between metrology institutes and national standardisation, accreditation and conformity assessment bodies at the national level. Further plans include identifying priorities at national, regional and European level, proposing appropriate research activities and research projects to develop research potential among less experienced EURAMET members. A new feature is to facilitate access to EU structural funds, direct bilateral and multilateral agreements and other funds.

to publish papers, increase links between two institutions and build researchers' networks, which is extremely valuable for future inter-institutional collaboration. Interest in researcher mobility grants has increased in recent years, enabling inter-institutional exchange of up to 20 researchers per year.

Since its beginning, EURAMET has always been extremely conscientious to enable knowledge transfer and support capacity building to bridge the gap between less developed and more established metrology institutes. From informal regional cooperation to the dedicated capacity building groups within EURAMET; a breakthrough came with the inclusion of research potential projects and researcher grants into EMPIR with targeted financial support. Additionally, all EURAMET Technical Committees have been and are actively involved in knowledge transfer and capacity building, including the newly established working group for Designated Institutes.



7. Collaboration in Serving our Customers

7. Collaboration in Serving our Customers

The landscape of Europe and of European metrology was very different back in 1987 when EUROMET was founded compared to how it is today. Many changes have taken place over this period, politically, economically and socially. We have seen greatly accelerated globalisation, rapid advances in technology and economic growth throughout Europe. The metrology infrastructure in Europe has also seen significant change over this 30-year period.

The uptake of quality standards by industry and the growing regulatory environment demanded the establishment of an appropriate quality and metrology infrastructure throughout Europe to underpin this industrial development.

For many countries in Europe this presented quite a challenge. While metrology may have been present in the country, it was in a rudimentary form focussing on a limited number of fields. In other cases, the metrology focus was primarily or solely on legal metrology and the protection of the consumer. It was obvious that some existing NMIs and developing NMIs needed to develop measurement and calibration services that would initially service their national industries and in-time provide the necessary

underpinning to the rapidly developing accredited test and calibration sector.

By the early 1990s industry and conformity assessment bodies needed efficient calibration and measurement services provided locally.

They also required access to technical expertise and knowledge. The metrology institutes of Europe had to respond to these demands. This was the main driver behind the establishment of EUROMET in 1987. From its foundation, a clear objective was to build a network that could assist in developing the European metrology infrastructure, particularly in relation to developing measuring and calibration services.

EUROMET set itself specific tasks, for example, to transfer expertise between members and to provide a framework for collaboration between members. This could have been difficult to achieve, but a number of positive factors made it possible:

- The spirit of openness between developed NMIs and the newer EUROMET members
- The setting aside of any commercial or competition concerns for the benefit of the wider metrology community
- Goodwill and willingness of the NMI experts to share their knowledge and experience and in most cases at no cost to the beneficiary NMI
- Availability of and access to EU funding to support the developing technical knowledge with measurement standards, equipment and buildings.

During the late 1980s and 1990s many young metrologists and their metrology institutes profited from their ability to visit leading NMIs. This way, they were developing their skills, obtaining critical advice and guidance thereby

EUROMET founding aims with regard to services:

- To develop a closer collaboration between members in the work on national measurement standards
- To optimise the utilisation of resources and services and emphasise the deployment of these towards perceived metrological needs

allowing them to put this into practice in their own NMIs.

It is believed that the availability of this open technical network helped to grow a sustainable national measurement infrastructure. It would have been infinitely more difficult to do this had EUROMET and later EURAMET not been established.

EURAMET within the CIPM MRA provided the framework for NMIs to participate in regional and global key comparisons and supplementary comparisons and to demonstrate their Calibration and Measurement Capabilities. This in turn allowed the NMIs to have their calibration services recognised and accepted by their customers.

NMI and DI Services Today and into the Future

The EURAMET NMIs are providing services to facilitate their industry and conformity assessment needs. Over 11500 Calibration and Measurement Capabilities from EURAMET NMIs and DIs are published on the BIPM key comparison database. EURAMET has managed more than 600 interlaboratory comparisons and almost 200 cooperative projects since 1987. EURAMET's NMIs and DIs operate in a competitive marketplace for their services. The development of the BIPM key comparison database means that companies seeking services can determine the NMIs that can provide the service they require and then decide on a suitable pro-


vider taking into account factors such as price, turnaround time, and measurement capabilities. The scope of services offered by EURAMET NMIs has broadened significantly in recent years. While initially focussing on traditional calibration and measurement areas, industry demand has seen NMI expertise being deployed in emerging measurement areas such as biotechnology, environment, nanotechnology and others. In addition, many NMIs now provide training, consultancy services and R&D support, in an effort to enhance industrial innovation. While the number of NMIs and DIs in Europe has increased significantly over the years it is



Production line – modern manufacturing requires reliable measurement services
iStock.com/chinaface

becoming more difficult for NMIs to keep pace with technical change in the market. Even the large NMIs can hardly offer the full spectrum of services that is required and consequently new models of service delivery need to be explored. These models may include an increased level of interdependence and European metrology networks for specific measurement areas, increased use of subcontracting and outsourcing of specific services to other NMIs or sharing of resources for NMIs in geographical proximity.

The metrology and calibration landscape has changed greatly in Europe over the past 30 years. Economic, industrial and political changes over this time have demanded a timely and appropriate response from Europe's NMIs. The existence of EUROMET and later EURAMET has ensured that Europe has a quality and metrology infrastructure that is not only fit-for-purpose today but has the necessary structures in place to tackle the challenges of tomorrow.



**8. The Future, from Collaboration
to Coordination**

8. The Future, from Collaboration to Coordination

Where do we come from?

Our members share a common mission to provide the measurement standards and technology that underpins the prosperity and competitiveness of their countries. In a globalised world, measurement standards have to be comparable and accepted everywhere. To achieve this, cooperation among National Metrology Institutes is essential. In Europe, the legislation and regulations driving the need for better measurements are not only developed at national level but also at EU level and this led the European NMIs to form EUROMET 30 years ago.

EUROMET started as an informal gathering of like-minded institutes which had similar interests and similar problems to solve. From the beginning, the collaboration was very transparent, open and driven by the conviction that the problems of the future can only be tackled in a collaborative approach. In the EUROMET period,

this work was performed without the incentive of external funding but it built confidence and a professional organisation capable of winning and implementing programmes co-funded by the European Union.

In January 2007, EURAMET was founded. Today, with 37 member institutes and many more associate members, the collaboration within EURAMET spans the whole continent. There is an impressive variety within the EURAMET membership in terms of the size and organisational structure of the institutes and they have a diverse range of activities.

Since its foundation, EURAMET has successfully implemented the European Metrology Research Programme and is now running its successor programme EMPIR. The two initiatives had a tremendous effect on metrology research in Europe: The annual value of the programmes is equivalent to half the combined national metrology research budgets. The collaboration between institutes has increased considerably, the quality of the research has improved, and large scale projects have been realised exceeding the possibilities of a single institute. This success in the collaborative R&D work is based on a good collaborative spirit among National Metrology Institutes and Designated Institutes for which the old EUROMET laid the foundation.

Besides the collaborative R&D work, EURAMET is today a very well established Regional Metrology Organisation, supporting its members in the realisation and dissemination of the International



Montage of planet Earth at night
iStock.com/Nastco

System of Units and in gaining global acceptance of their Calibration and Measurement Capabilities. All activities are supported by a

central secretariat with a team of highly dedicated professionals. Overall, EURAMET is very well positioned for the future.

Where do we want to go?

Metrology underpins nearly all aspects of modern life. Traditionally, systems for measurement science and measurement standards are the domain of the NMIs, in many countries supported by DIs, who primarily serve national needs and national stakeholders. In the past, NMIs had little incentive to raise responsibilities above the national level. However, in recent decades the complexity and scale of requirements for quality-assured measurements in industry, and those associated with grand societal challenges, have grown and the traditional, fragmented system found it difficult to respond. EURAMET's response aims to create an integrated European Metrology Research system with critical mass and active engagement at national, European and worldwide level. But the interests go well beyond research. Continuing in Europe with an uncoordinated network of metrology players would weaken the position of all NMIs in an increasingly globalised world. EURAMET believes that within the next decade, global

resources for metrology applications should be enhanced, and the contribution from Europe should match its projected share of the world economy and trade. There are important steps to take in the near future to move from today's still quite fragmented system to a fit-for-purpose and truly coordinated metrology infrastructure in Europe with appropriate use of joint infrastructures and coordinated services.

Further steps towards better integration:

- Coordinated planning and sharing of special research facilities to avoid unnecessary duplication
- Creating European metrology networks with competence in research: bundling de-centralised competence in a network of researchers and institutions working on a thematic focus

Coordinating Research

Within EMRP and EMPIR, the coordination of the research is mainly taking place at the project level. Future research programmes will develop a more strategic approach to integration of the national programmes. It is clear that such development needs to be based on continued support by the ministries and National Metrology Institutes. There are already good examples of the efficient combination of research resources

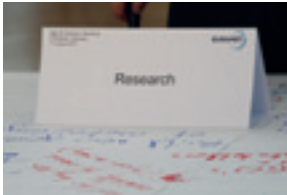
in different organisations. In future European metrology networks, metrology experts will be able to work and interact without limitation of national or organisational barriers. The great challenge is to involve all in such a development. Capacity building will continue to be a key activity for EURAMET, where the members are active in defining their role in the research coordination.

Coordinating Infrastructure

The units of the International System of Units are realised with primary methods and maintained by primary standards. These standards are the

highest level of accuracy. Some redundancy through realisations in different NMIs is necessary, but in general, not every NMI needs the

The 'EURAMET Directors' Workshop on Coordination in European Metrology' was held on 17 January 2017 at PTB in Berlin, Germany



EURAMET had carried out a study on the coordination in European metrology – aim of the workshop was to present the results of the study, to collect views, expectations and ambitions of NMI and DI management towards more coordination in European metrology and to prepare the grounds for the EURAMET strategy on coordination and a future metrology programme



Courtesy of EURAMET / Anne Trumpfheller

highest accuracy in every field. Secondary standards are often sufficient. Through traceability agreements among NMIs, secondary standards may be referenced to primary standards, often with little loss in accuracy. The potential for such arrangements is still huge in Europe and would help to considerably reduce the overall effort for

the realisation and maintenance of the SI. Especially in new fields of metrology like biochemistry, novel materials or nanotechnology, single institutes cannot cope with the challenge alone and new models for the realisation and operation of joint infrastructures will be particularly relevant.

Metrology and Regulation

If measurements, measurement methods and instruments are applied in the context of legal requirements, one usually speaks about legal metrology. On the international level, OIML is responsible for the harmonisation of the procedures applied in legal metrology. WELMEC is the organisation on the European level. The separation between scientific and legal metrology is not always clearly understood by outsiders or by states developing a metrology system. The boundary line between scientific and legal metrology cannot always be precisely drawn: Fields like food security, health, and protection of the environment are becoming more and more regulated. Reference methods and reference ma-

terials have to be developed to enable compliance with limit values set by the law. In addition, the technologies become more complex and often the classical concepts of legal metrology like conformity assessment and verification are not applicable. In the digital age, the concept of the localised instrument becomes obsolete and is replaced by systems with virtual instruments and cloud infrastructure for data storage. To keep pace with these developments, new concepts for legal metrology need to be developed. EURAMET will become more proactive in raising awareness and increasing its influence with policy makers, regulators, standards organisations and legal metrology authorities.

Quality Infrastructure

Quality infrastructure is the framework that establishes and implements standardisation, including conformity assessment services, metrology and accreditation. For this system to have its full effect, a close link between the actors is

necessary, and EURAMET will play an increasing role in ensuring that the European metrology system, standards developing organisations and accreditation bodies work together to develop a quality infrastructure fit for Europe's future.

EURAMET is developing towards an organisation which:

- Has a leading role in the coordination of the metrology infrastructure in Europe;
- Is recognised by the political authorities and stakeholders as one of the key players in the development of the quality infrastructure;
- Brings a clear added value for its members and
- Allows members to work together in a collaborative spirit and on an equal footing irrespective of the location, size and organisational structure of their institutes.

For further reading ...

EURAMET Website <https://www.euramet.org/>

About EURAMET <https://www.euramet.org/about-euramet/>

Newsletter <https://www.euramet.org/newsletters>

Calibration Guides and Technical Guides <https://www.euramet.org/calibration-guides>

Research & Innovation <https://www.euramet.org/research-innovation/>

Metrology for Health <https://www.euramet.org/health>

Metrology for Environment <https://www.euramet.org/environment>

Metrology for Energy <https://www.euramet.org/energy>

Metrology for Industry <https://www.euramet.org/industry>

Technical Committees <https://www.euramet.org/technical-committees/>

Knowledge Transfer and Capacity Building <https://www.euramet.org/knowledge-transfer/>

BIPM Website <http://www.bipm.org/en/about-us/>

BIPM Key comparison database <http://kcdb.bipm.org/>

If you have any questions or require further information, please contact EURAMET via e-mail secretariat@euramet.org



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Glossary

BIPM – Bureau International des Poids et Mesures; the International Bureau of Weights and Measures. The first international scientific institute founded in 1875, initially to maintain and disseminate the units of length and mass. The BIPM was placed under the direction of the International Committee for Weights and Measures which is under the authority of the General Conference on Weights and Measures.
CGPM – Conférence Générale des Poids et Mesures; the General Conference on Weights and Measures
CIPM – Comité International des Poids et Mesures; the International Committee for Weights and Measures
CIPM MRA – Mutual Recognition Arrangement set up by the CIPM in 1999; the concept of the CIPM MRA is explained in detail in chapter 5 'Collaboration to Ensure Global Traceability'.
CMCs – Calibration and Measurement Capabilities
DI – Designated Institute
EC – European Commission
EU – European Union
EMRP – EURAMET's European Metrology Research Programme (2009–2017); the EMRP is jointly funded by the 23 EMRP participating countries within EURAMET and the European Union.
EMPIR – EURAMET's European Metrology Programme for Innovation and Research (2014–2024); the EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the 27 EMPIR Participating States.

EURAMET – the European Association of National Metrology Institutes. EURAMET is the Regional Metrology Organisation of Europe and it coordinates the cooperation of National Metrology Institutes in fields such as research in metrology or traceability of measurements to the SI Units.

EUROMET – predecessor organisation of EURAMET

iMERA – the EUROMET project 'Implementing Metrology in the European Research Area' (2005–2008) was an initiative of 14 countries and the European Commission.
iMERA-Plus – EURAMET's first joint European research programme for metrology included 20 European countries and was co-funded by the European Union (2007–2011).

JCRB – Joint Committee of the Regional Metrology Organisations and the BIPM
NMI – National Metrology Institute
MERA – a EUROMET study entitled 'Planning the European Research Area in metrology' (2002–2003); the study involved 11 European countries and was funded by the European Community
OIML – Organisation Internationale de Métrologie Légale; the International Organisation for Legal Metrology
QMS – Quality Management System
RMO – Regional Metrology Organisation
SI – International System of Units
TC – Technical Committee
WELMEC – European Cooperation in Legal Metrology
WEMC – Western European Metrology Club

