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National Metrology Systems

The framework for States to participate in the globalization of trade and services that depend on measurement-based requirements

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Critical national and international goals such as economic growth, innovation, energy and the environment, good health, food security and fairness of consumer transactions in the marketplace depend on accurate and trusted measurements of physical, chemical and biological quantities. It is important that a country has an efficient and appropriately funded metrological infrastructure because none of these quantities can be correctly and consistently measured without it. The science of measurement and its application is known as metrology; metrology includes all theoretical and practical aspects of measurement, whatever the measurement accuracy and field of application.

States which participate successfully in the global marketplace, and which have a thriving and diverse national economy that supports their businesses and consumers, have a formalized national metrology system (NMS).

A national metrology system comprises the:

- **organizations (public and private)**
- **policies**
- **appropriate legal and regulatory framework, and**
- **practices**

needed to support and enhance the metrology activities undertaken within their country or economy.

The benefits of a national metrology system are that:

Governments can be confident that the measurements made throughout their economy are 'right', and that they gain access to the technical and legal framework, which constitutes a trusted and solid foundation for wider agreements related to international trade, commerce and regulatory affairs. The interdependent world economy requires an open, transparent, and comprehensive scheme that demonstrates equivalence between technical and legal requirements of measurement capability, regulated instrumentation, and prepackaged products.

Business, industry and manufacturers have the possibility to produce goods and services of ever higher quality and added value, and can be assured that products and services involving metrologically traceable measurements will gain acceptance in national and international markets. They can be assured that manufactured parts imported from foreign suppliers will meet national standards and be of dependable quality, reducing duplication of measurements. Measurement science enables and drives industrial innovation in advanced production and instrumentation. Parties searching for measurement solutions can choose the optimal source, based on delivery time, cost and level of uncertainty, regardless of whether the source is inside or outside the country.

Regulators can be confident of conformity assessment outcomes by utilizing the scientific and legal metrology systems and furthermore, by recognizing the associated international agreements and standards avoid creating technical barriers to trade. This is a sound approach at all stages, for example, with regard to policy advice, conformity assessment and verification. They can rely on the knowledge within their national metrology system when implementing regulations. Decisions will be based on reliable and objective results.

Citizens interests are protected; they are directly and indirectly the beneficiaries of metrology in many ways, including public health, safety, protection of the environment and the consumer, the levying of taxes and duties as well as fair trade. They can be confident that purchases of measured items in the marketplace (for example, a litre of petrol or milligram of medicine) will be fair, safe and have the expected quality. They can be confident that laws intended to protect them or impose a sanction (such as infringements of the blood alcohol level of machine operators) will be enforced fairly.

The role of the government in a national metrology system

The role is to provide society with the necessary means to establish confidence in measurement results. Countries provide these protections through their legal systems, so they need a legal framework that covers how measurements and measuring instruments are to be treated in a legally acceptable manner. This requires governments to undertake a number of activities to promote metrology, to develop appropriate infrastructures, to support research and development in metrology, and to protect both individuals and companies against possible measurement-related fraud. The importance of metrology for social and economic development calls for a comprehensive and coherent policy on metrology for which laws must take account of all the issues concerning consumers, enterprises, education, health, safety and security of the population.

International aspects of national metrology systems

Many aspects of measurement are global in nature, so the legal framework of the NMS should take account of this interconnectedness. International mutual recognition of the measurement capabilities of a country is critical to the removal of technical barriers to trade and, therefore, to participation in multilateral trade agreements such as those of the World Trade Organization. As part of their national metrology system, countries are strongly encouraged to take part in both the key international (OIML, BIPM, ILAC, ISO) and regional organizations, and the mutual recognition agreements or arrangements which they provide. The institutional and legal framework in a country needs to facilitate participation in these organizations, and dedicated resources need to be provided for that participation.

Assessing metrology needs that support national priorities

One of the first tasks of a government in establishing the NMS is to develop a national metrology policy. Developing a national metrology policy begins with assessing the specific needs and priorities of the country as they relate to the economic sectors, technological infrastructure, scientific capability, population size and geography; and then mapping those priorities against already existing metrological capabilities. Such analysis should also consider how the economy is likely to develop in the future. It is important to identify the scope of the legal metrology regulations on those areas that the government considers necessary to protect. This should include an economic analysis of the resources required for implementing and operating the NMS. Consideration should be given to the specific institutions and legal and regulatory framework proposed in the NMS. The evaluation of the status and goals should utilize national expert bodies and/or international experts.

Policy implementation options for governments

In addition to determining the needs and goals of the NMS, it is important to consider practical implementation aspects in order for the NMS to be a benefit to the state. Broadly, these will include the form of the institutions where metrology activity will occur, how the institutions coordinate activities among themselves, what regulatory and enforcement options will be implemented, and how the NMS will be funded.

Legislation for metrology

Once the status of metrology has been assessed and the decision taken to develop a national metrology system, a "law on metrology" should be written and passed. Annex B of the BIPM and OIML joint publication - *"National metrology systems - Developing the institutional and legislative framework" (OIML D 1:2020)* sets out a possible model law, which provides preferred logical structure and minimum elements to include. This model law was developed based on the experience of many countries in developing their NMS. The elements should be tailored from the model law, taking into account the legislative drafting practice and cultural needs of the country, whilst maintaining their simplicity and clarity. Elements which governments need to consider include:

1. obligation by the law of what is mandatory and what is forbidden
2. enforcement practices
3. necessary sanctions
4. notifications
5. status of public bodies participating in the infrastructure.

Responding to a changing world

The economies and societies, which national metrology systems support, are constantly changing and developing. Some recent changes, and future developments that will affect metrology systems include: continued introduction of digitalization in all areas; redefinition of the SI and the increased availability of intrinsic standards and self-calibrating instruments; the proliferation of sensors and the "internet of things"; introduction of new technologies, such as electric vehicles and GPS-based distance measurement, that will require new measurement traceability and verification methods. If metrology systems are to be responsive to these changes, it is important that flexibility be built into them, in terms of policy development, institutional structures, legislative arrangements, personnel training, and engagement with the public and society.

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The role of government in a National Metrology System

National Metrology System (NMS) overview

A national metrology system comprises:

1. **the institutions, both public and private, that carry out the metrology activities**
2. **the policies to be carried out by those institutions, brought together in a national metrology policy**
3. **the appropriate legal and regulatory framework that establishes the institutions and policies**
4. **the practices needed to support and enhance the metrology activities.**

It is important to first understand what constitutes metrology activities for which the NMS must cater. Metrology activities fall into the areas of scientific metrology, industrial metrology, and legal metrology.

Metrology activities

- **Scientific and industrial activities include:** maintenance and dissemination of national measurement standards and of certified reference materials; conducting research into new methods of measurement; calibration of instruments and provision of reference materials; contract testing and analytical services; and training in metrology. In practice, most legal metrology activities are underpinned by scientific and industrial metrology, and the needs of legal metrology help to set the activities of scientific and industrial metrology.
- **Policy-making activities in legal metrology include:** setting the national policy on the structure and funding of public metrology institutions, both scientific and legal; setting the role of metrology within the National Quality Infrastructure; determining the national policy for areas to be regulated and how that regulation should be accomplished; setting the policy on engagement with international and regional metrology bodies; setting the policy on public funding related to metrological controls and documentary standards for measuring instruments subject to legal or regulatory controls and prepackaged products; and setting the policy on public funding of research into improvements in measuring techniques.
- **Other legal metrology activities include:** advice on legislation and the standards it refers to; the various activities of type approval (registration, testing and evaluation, conformity of measuring instruments); carrying out pre-market conformity assessment of measuring instruments; verification, in-service inspection, and post-market surveillance of regulated instruments; and inspections of prepackaged products.

Institutions within the National Metrology System

At the core of an NMS there should be an authority in the government (here referred to as the *Central Government Authority* or CGA) that is unambiguously in charge of the national metrology policy and coordinating the actions of other parts of the government related to metrological issues. The CGA is usually the budget holder responsible for the government support provided to those parts of the NMS that are publicly funded. This authority should be responsible for much of the policy-making activities stated earlier, as well as coordinating metrology activities that are relevant to other parts of the government. A *National Metrology Institute* (NMI) is important for the scientific aspects of metrology; it has the responsibility of developing and maintaining national measurement standards and disseminating the SI units. NMIs serve as the national focus on measurement science, providing leadership in nation wide and world-wide cooperation relating to metrology. The NMI engages in the regional and international metrology systems. The world-wide metrology community ensures that measurements are accurate, stable, comparable, and coherent. It is also necessary for national authorities or institutes to carry out *legal metrology activities*. This is often the responsibility of the NMI, but in other jurisdictions the activities may be distributed among several institutes or authorities specializing in different fields, with appropriate coordination. Many legal metrology activities (such as prepackage inspections or instrument validation) require implementation at a local level. Some metrological services, such calibrations within industry or accreditation of testing laboratories, are more appropriately implemented by the private sector.

National metrology policy

The CGA should be responsible for developing a national metrology policy. This development should begin with a report on the status of metrology in the country, which is then submitted to the highest level of government that will be making the decision on the authorization of the NMS. This report should include an economic analysis of the resources required for implementing and operating the proposed NMS. The evaluation of the status and goals should utilize national expert bodies and/or international experts. Consideration should be given to the specific institutions and legal and regulatory framework envisioned in the NMS; there exist many examples of States which have successful national measurement systems whose framework can be used as a guide.

Legal and regulatory framework

Laws and legal requirements interact with metrology in two distinct ways: first, by providing the framework within which metrology in a country or economy operates, and second, through regulations relating to trade, health, safety and environmental protection, which set measurement-based requirements and requirements for measuring instruments used for such purposes. National measurement standards are a key part of the national metrological infrastructure, and a system of national measurement standards should be set up to maintain and disseminate legal units in order to meet a country's needs. These standards should either be a primary realization of the SI, or metrologically traceable through calibration under the CIPM MRA to the primary realization maintained by another country. In broad terms, metrological traceability to the SI is required for the application of any laws and regulations prescribing requirements on measurements, measuring instruments, or on prepackages.

A country's national metrology system is a key part of its National Quality Infrastructure. This requires that the national metrology system should work in close collaboration with the national institutes responsible for accreditation, standardization and conformity assessment.

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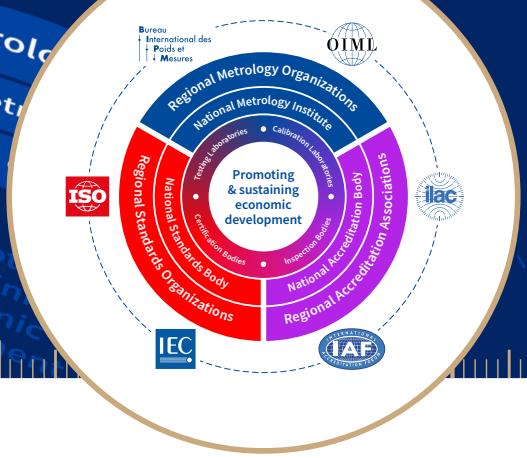

International aspects of National Metrology Systems

The need for international recognition and compatibility between national and international metrological requirements.

International mutual recognition of a country's measurement capability is critical to the removal of technical barriers to trade, and to participation in multilateral trade agreements such as those of the World Trade Organization. Harmonizing national requirements and technical regulations with international documentary standards creates a pathway for participating in the world economy. It is important to note that successful engagement with the international community requires dedicated resources to undertake both the technical activities associated with demonstration of technical competence, and to enable experts to participate in the international forums. It is important that the institutional and legal framework in a country facilitates participation in international organizations. The central government must take the lead in coordinating international issues. National Metrology Institutes (NMIs) and legal metrology authorities should be enabled and encouraged to enter into international and regional agreements and take part in the activities of those international organizations that form those agreements. It should not be forgotten that engaging internationally with peers provides excellent opportunities to benchmark and improve metrological skills.

International metrology organizations

The Metre Convention and scientific metrology: The Metre Convention is the international treaty, signed by representatives of seventeen nations in Paris in 1875, that forms the basis for international agreement on units of measurement. It established a permanent organizational structure for member governments to act in common accord on all matters relating to units of measurement. It founded the International Bureau of Weights and Measures (BIPM), the scientifically expert intergovernmental organization whose mission is to work with NMIs of Member States and Associates of the General Conference on Weights and Measures (CGPM), the RMOs and strategic partners to advance the global comparability of measurements. Currently, more than 100 countries participate in the activities of the BIPM. Participation in the activities of the BIPM helps to:

- demonstrate the international equivalence of national measurement standards and the calibration and measurement certificates issued by the NMI (and other institutes designated to hold national standards)
- exchange knowledge, information, and experience at the international level
- contribute to global decision-making concerning metrological developments.

The CIPM Mutual Recognition Arrangement (CIPM MRA) is the framework through which NMIs demonstrate the international equivalence of measurement standards and accept the calibration and measurement certificates they issue.

The OIML Convention and legal metrology: The OIML Convention, signed in 1955, established the International Organization of Legal Metrology (OIML) and provides the constitution of that organization. The OIML is an intergovernmental treaty organization whose membership includes Member States that participate actively in technical aspects and Corresponding Members that join as observers. The OIML promotes the global harmonization of legal metrology laws and procedures and provides its members with guidance on their national legislation, including the principle that measurements used for trade and regulatory purposes should be made using measurement standards that are legally traceable to the SI. The principal activities of the OIML are the writing of technical standards and the promotion of the acceptance of type evaluation test reports in order to avoid duplication of approval testing.

The OIML Certification System (OIML-CS) is a system for issuing, registering and using OIML Certificates and their associated type evaluation and test reports for types of measuring instruments. The aim of the OIML-CS is to facilitate and harmonize the work of national and regional bodies that are responsible for type evaluation and approval of measuring instruments that are subject to metrological control.

Regional Metrology Organizations

Regional bodies play an important role in the way that all quality infrastructure organizations operate. *Regional Metrology Organizations* (RMOs) are regional associations of NMIs. Within the BIPM context, RMOs work to improve regional metrological capability by sharing expertise and exchanging technical services among members. They have a wide range of activities, including participation in the CIPM MRA. Their participation is critical in carrying out measurement comparisons that demonstrate metrological capabilities and documenting the calibration and measurement capabilities in the BIPM key comparison database (KCDB). Within the OIML, *Regional Legal Metrology Organizations* (RLMOs) are groupings of legal metrology authorities who participate in the development of legal metrological infrastructure and promote free and open trade through the harmonization and removal of technical and administrative barriers to trade. Their activities achieve greater harmony of measurement and testing within their region and build mutual confidence among their members through improved communication in the region.

Other important international quality infrastructure organizations

Quality infrastructure components of standardization and accreditation also have international organizations that work to harmonize practices world-wide and disseminate metrological traceability from the NMI to industry. Because of the metrological elements in these other parts of the quality infrastructure, it is important to be aware of the key international organizations responsible for standardization and accreditation, and to integrate them into the NMS as appropriate. These organizations include:

- **International Organization for Standardization (ISO)** – publishes a range of international standards that apply to the manufacture and testing of various products, and the provision of services.
- **International Electrotechnical Commission (IEC)** – publishes international standards for all electrical, electronic and related technologies.
- **International Laboratory Accreditation Cooperation (ILAC)** – ensures international acceptance of accreditation of calibration laboratories, conformity assessment bodies including, testing laboratories, medical testing laboratories and inspection bodies, proficiency testing providers and reference material producers.
- **International Accreditation Forum (IAF)** – provides international acceptance in conformity assessment in the fields of management systems, products, services, personnel and other similar programmes of conformity assessment.

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Assessing metrology needs that support national priorities

The purpose of an NMS is to support measurement related activity across a country's economy. One of the first tasks of a government in establishing its NMS is to develop a national metrology policy. Establishing a national metrology policy begins with assessing the priorities of the country and specific needs as they relate to the economic sectors, technological infrastructure, population size, and geography, mapping those priorities against metrological needs and whether there are existing metrology capabilities, and finally, establishing (or shaping, if it exists) the national metrology system to meet these needs.

Assessing metrology needs related to sectoral priorities

The starting point for drawing up a national metrology policy should be an understanding of which sectors are the most important to the country's economy, both currently and in the future. The assessment of the country's priorities and specific needs gives a clear understanding of the context in which to focus metrology activities. In determining these priorities, governments may wish to take account of the following factors:

- Many economic sectors are very dependent on metrology for their ability to demonstrate the quantity of a sellable product, allowing them to compete in export markets. In particular, bulk agricultural products and extractive industries (for example minerals or energy products) need a solid weighing infrastructure to demonstrate quantity.
- Industrial products, including components that will be exported or imported, require world-class industrial metrology to be competitive. The metrology needs for industrial production are likely to be broader than a just a weighing infrastructure, and could include length, temperature and pressure metrology, as well as material and chemical metrology. High-quality semiconductor components require accurate dimensional metrology.
- If goods are pre-packaged prior to export, this requires a legal framework for verifying the amount of contents according to international standards.
- Security, environmental and health sectors often require radiation metrology in addition to more traditional physical and chemical metrology.
- Food and agricultural products are often obliged to meet demanding quality requirements (to determine value, safety or nutritional content) in export markets.
- Perceptions of consumer protection can be important for the tourism industry.
- The country's regulatory sector will likely require metrology support (safety, health, environment, consumer protection etc.).

Mapping the priority sectors against the existing national metrology system

Different areas of metrology are relevant to different sectors of industry, commerce, scientific research and innovation. Even in large economies it is not possible to support every possible need, so priorities must be set, and choices made. Once the priority sectors have been identified, the assessment should focus on parts of the national quality infrastructure which are most important to those sectors. This requires examination of availability of internationally harmonized documentary standards (including mandatory standards in the form of regulations), and availability of accredited calibration laboratories and conformity assessment bodies linked with ILAC, as well as the availability of national institutions (these can be both public and private) that carry out metrology activities.

It is recommended that assessment includes:

- Defining which measurements are mainly concerned with legal metrology and which are concerned with scientific and industrial metrology.
- Further multilayered assessment of needs in metrology activities (what metrological services are needed, level of measurement, required measurement range and measurement uncertainty).
- Assessment of national metrology capabilities already existing in the country (private, semi-public and public laboratories, staff required, technical and financial resources etc.).

Shaping and establishing the national metrology system

The result of mapping the priority sectors against the existing capability (if any) gives appropriate knowledge for creation of the law on metrology; this should include the framework in which metrology in a country operates and regulatory aspects of metrology. Having undertaken the assessment, a country will be in the position to describe its NMS, including the law on metrology and physical institutions that carry out metrology in the country.

Where to go for expertise?

Policy-making is by definition the exclusive role of governments, although it will usually be desirable to develop policies in consultation with the other bodies and companies that provide metrology services and with the users of the metrology system. It is recommended to seek advice from regional organizations. International organizations that specialize in scientific and legal metrology (BIPM and OIML), scientific universities, as well as UNIDO and the World Bank Group are excellent resources when determining best practices in establishing an NMS.

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Policy implementation options for governments

When governments make strategic decisions on the shape and size of a national metrology system, there are several different areas to consider. The assessment of the national metrology needs and national priorities (often called strategic planning) should be completed before considering the other important policy implementation aspects of the national metrology system. These implementation aspects are broadly designated as: institutional options; coordination options; regulation and enforcement policy options; and funding options.

Institutional options

A key institutional decision is the form in which the National Metrology Institute (NMI) will take, as the NMI will often become the focus of implementing the NMS. The three common forms of an NMI are:

1. **A public institute owning and running its own laboratories**
2. **A public agency coordinating public or private institutes**
3. **A private institute operating under the authority of the government (with safeguards to assure impartiality and objectivity).**

A second institutional decision is whether NMI-type functions in some specialized areas of metrology (for example chemical metrology) should be the responsibility of separate specialized institutes.

Although a single public national institute is the more traditional form, the choice of the form of the NMI largely depends on the existing structures and institutions that are in place, the priority fields of metrology, the national policy, and the legislative traditions of the country and resources available. It is crucial that the institutes have the legal capacity to enter into international agreements or arrangements on mutual acceptance and mutual recognition. It is highly recommended to develop synergies between scientific and legal metrology activities, in particular the study of technical requirements for new regulations, type testing, and type approval. This can be done by combining scientific and legal metrology in the same institute, or by establishing close cooperation between the institutes in charge of these two fields.

It is necessary to be clear on how the various metrology bodies interact with national standards bodies and national accreditation bodies due to the importance of metrology within the wider quality infrastructure. Accounting for the structural organization within the country, as it relates to regulation and enforcement, is essential in determining the relationship between national legal metrology and local legal metrology, and where responsibilities lie. In practice, the role of public administration in the implementation of metrology policy depends on the existing infrastructure and competencies in the country. If metrology tasks are delegated to the private sector, the government must ensure that public interests are protected, activities are performed in a transparent manner, there is no conflict of interest, and no company is given an unfair competitive advantage.

Coordination options

Effective arrangements for cooperation and coordination of metrology activities are required, given the broad range of metrology activities that must be undertaken. One successful approach for the coordination of metrology activities is for all issues of national metrology policy to be managed by a single central government authority (CGA) of the country. These issues range from studying needs, formulating the national policy, coordinating the actions of various ministries, developing and implementing legal metrology regulations, participating in the international metrology system, supervising the national bodies, and providing information to the public. It is usually desirable to set up a national oversight committee to address the national policy, to which the central authority reports. Coordination among legal metrology authorities is important to ensure uniform application of law, especially when there are several legal metrology authorities (such as in different regions of the country). It is also important to involve the very large number of stakeholders who rely on the national metrology system in some formal manner to capture their input, in order to respond appropriately to national trends and needs.

Regulatory and enforcement options

Once the decision has been made as to what shall be covered by legal metrology, one of the first decisions for governments is how international standards such as OIML Recommendations are to be incorporated or referenced in their legal system. Methods include verbatim text, inclusion of identical requirements (but not verbatim text), inclusion of compatible requirements, and reference to specific editions (or the most current edition) of a standard. The approach adopted in a country will depend on its broader legal traditions and may even vary between different areas of legal metrology. Another key decision will be which tools to use in regulation and enforcement. These will also range from pre-market verification or surveillance, market surveillance in the distribution chain or in the marketplace, and risk-based inspections. Enforcement of non-compliance could range from education and training, administrative measures and warnings, enforceable undertakings such as fines or stop-work injunctions, to criminal prosecution and publicity. In most cases, the enforcement response should be proportional to the severity of the offence and the likelihood of recurrence.

Funding options

The two areas where important policy decisions are required are the funding of the NMI and the funding of the legal metrology infrastructure. The mission of the NMI includes tasks of general importance spread over the long term, such as development of measurement standards and scientific research into advancing the state of the art of metrology, and services rendered to clients, most notably the dissemination of metrological traceability. Long-term goals require funding from the government on a sustainable basis. This funding must cover the cost of developing laboratories, purchasing equipment and instruments, maintaining that equipment, hiring technical staff, and performing the technical work to gain international acceptance of the standards. For NMI services, the most common funding model is to charge for the cost of delivering calibration and test services to the client requesting the service, whilst underpinning costs such as developing and maintaining national standards which are publicly funded. That is to say clients pay for the services that directly benefit them, but not the costs related to the wider public good. However, there is a risk that the NMI becomes dependent on the income from a service. Decisions on establishing a service, and maintaining it for the future, should be based on technical importance to the NMS rather than short term budgetary concerns.

The legal metrology infrastructure requires national support for the metrological control systems for measuring instruments, prepackaged products, transactions based on measurement, and measurement practices. It will often be appropriate for businesses to meet the direct costs of some legal metrology activities, through fees and charges. This may apply for applications requiring type approval or where the business derives benefits of assurance. In all cases, fees should be transparent and should reflect the actual cost of the legal metrology activity. Appropriate national funding will be needed in the development stage of integrating International Recommendations with the national legal metrology system, and the ongoing engagement with the international metrology community. The CGA is usually the budget holder responsible for the government support provided to those parts of the NMS that are publicly funded.

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Legislating for metrology

General considerations when developing a law on metrology

Developing legislation for metrology (the law on metrology) is a key goal of the "needs assessment", the determination of existing metrology resources and legal infrastructure, and the strategic planning discussed previously. The law on metrology, once passed and implemented, will codify the institutions and legal regulations, allowing the NMS to function and respond to the needs of the population, industry and scientific institutions of the country. The law on metrology should consider any other national laws of relevance, such the law on consumer protection, the law on accreditation, and the law on standardization.

Use of the BIPM-OIML joint publication:

"*National Metrology Systems - Developing the institutional and legislative framework (OIML D 1:2020)*" for guidance on specifics of the law on metrology

The *joint publication* should be utilized as a key reference to guide officials setting forth a law on metrology; it includes many more specific details than are summarized here. The document sets out the logically developed structure and the minimum elements which will usually be required in the form of a possible model law. At the outset, it is important to assess whether there is existing legislation within the country which contains some of the elements of the model law, or whether the full model law needs to be developed if a country is introducing a law on metrology for the first time. Annex B of the *joint publication* gives a model law for those countries with no existing national metrology system; this model law is structured in 28 articles which may be used directly within the law or reflected upon for developing similar but not verbatim text. Within each article, references are given to sections of the *joint publication* for possible draft text and background details on that article.

Annex A of the *joint publication* provides a "checklist" of important elements which should be considered when developing a legal framework for metrology. For countries which currently have some legal metrology laws, this checklist can be used to choose those elements that are lacking or are especially relevant based on the needs assessment determined earlier. The 36 elements of Annex A of the *joint publication* are all incorporated in the model law of Annex B. Many of these elements have been covered broadly in the inserts of this brochure.

As an example of how the elements of the checklist and the model law could work together, Element 11 of the *joint publication* discusses the concept of metrological traceability of measurement results, and states "Certified calibration results, test results and measurement results established by the national institutes in the scope of their designation should be metrologically traceable to the realization of the International System of Units (SI) and presented in compliance with the recommendations of the CGPM and OIML, and with relevant international standards". This concept is incorporated into the model law in Articles 12, 15 and 23, which relate to the importance of metrological traceability in terms of free trade (Art. 12), industrial metrology including calibration services (Art. 15), and international agreements (Art. 23).

Organization of metrological infrastructure

It is recommended that a law on metrology be developed is such a manner that it is considered “enabling legislation”, that is, it will address general and broader parameters that are not subject to frequent changes such as administration, offences, rule-setting powers and definitions. In other words, the law on metrology should be robust and should not require frequent amendments. Specific requirements for organizations, procedures and measuring instruments should be laid down in decrees, circulars or bylaws. Binding regulations should be issued by the responsible ministry or the metrology authority. These regulations should comply with the applicable OIML Recommendations, Resolutions of the General Conference on Weights and Measures - (CGPM) and ISO/IEC standards. Finally, voluntary standards should be incorporated on an international, regional or national basis as appropriate.

Legal units of measurement, legal metrology regulations, conformity assessment, surveillance and enforcement

The legal framework is required to specify which units of measurement are authorized to be used or made mandatory, and for which applications. It is necessary to specify when the use of units other than legal units is permitted. Regulations on measurements, on prepackages and on measuring instruments ought (when practical) to be compatible with OIML Recommendations and make use of OIML requirements. Conformity assessment procedures required by these regulations should, when practical, be compatible with the conformity assessment system set up by the OIML. A general surveillance framework must be exerted by the enforcement authorities to detect non-compliance with obligations and requirements.

It is necessary that the offences that arise from non-compliance with the obligations of the law on metrology are clearly listed, along with the corresponding penalties or enforcement mechanisms. Penalties should be proportional to the severity of the offences and be consistent across the various areas of regulation. This is particularly important when various levels of jurisdiction, or regions within the country, are responsible for the surveillance, testing or enforcement requirements.

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Developing a metrology system for the future

Responding to a changing world

The economies and societies supported by national metrology systems are constantly changing and developing. Accordingly, metrology systems need to be able to adapt to the changing needs of the economy and society in which they operate. Technology change in particular presents new challenges for metrology systems, changing the products and processes which need to be measured and the ways in which businesses operate and societies are organized and protected. At the same time, technology change and market opportunities can provide new ways in which metrology systems can function, introducing new opportunities for operating more efficiently and effectively.

A recent example of a technology change to which metrology systems have had to respond comes from the transportation-for-hire industry, in which distance measurement (for determining ride fares) is transitioning from vehicle-based mechanical and electronic components (taximeters) to GPS and software-based distance systems. This has required both new traceability pathways, along with the regulatory enforcement of the changes and the development of public trust in their accuracy and fairness.

Implications for metrology policy and metrology systems

For metrology systems to be responsive to these changes (and others which cannot be predicted right now), it is important that flexibility is built into the arrangements that are introduced. Five main areas to consider are:

- **Policy development:** provision should be made for a regular review of both the national policy and the way in which different parts of the metrology system work together. If the system contains an advisory council or board, this could be a mechanism to conduct the review.
- **Institutional structures:** it is likely that the various institutions within the metrology system, both public and private, will need to change and adapt. It is important that issues such as funding and management structure should enable this to occur.
- **Legislative arrangements:** in most countries, it can be difficult to change top-level laws such as a law on metrology. The law on metrology should be short and general, with details set out in by laws and regulations that are easier to modify.
- **Personnel training and development:** technological changes and the introduction of new working methods will require all parts of the metrology community to develop new skills and competences. Training and continuing professional development are therefore vital for a robust metrology system.
- **Engagement with the public and society:** consumers and public groups have an important part to play in safeguarding their own interests. The law on metrology should facilitate voluntary networks and institutions playing an active role. For this to be effective, consumers need to be aware of both their rights and how to exercise those rights. Means must be available to report problems to regulatory/enforcement authorities, and the public needs to have confidence that action is taken by the authorities to correct problems.

Example of future developments: current challenges in digital transformation

Although the future is inherently difficult to predict, some future trends are already apparent:

- More and more transactions will be paperless, including the reduced use of hard currency.
- The redefinition of the SI is likely to lead to increased used of intrinsic standards and self calibrating instruments and sensors.
- The “internet of things” will lead to more complex measuring systems, with more and more sensors, data exchange, and interconnectivity of IT systems.
- Artificial intelligence will become an increasingly important feature in the software of measuring instruments.
- There will be continued introduction of digitization in all areas of business and society.

The digital transformation will affect many aspects of metrology and international scientific and quality infrastructure. Some aspects of this are already becoming apparent, such as a full digital representation of the SI, reliable foundations for digital data interchange and management, and the adoption of FAIR principles (Findable, Accessible, Interoperable, and Reusable) for digital metrological data. Successfully effecting and integrating into such a digital transformation, and ensuring that its benefits are fully realized, will require the active participation of the national metrology system.

For further information:

www.bipm.org

www.oiml.org

This insert has been developed from the BIPM and OIML joint publication:
National Metrology Systems - Developing the institutional and legislative framework.

For more complete information, please refer to this document and its references.
The document is available through the BIPM and OIML websites.

Glossary of acronyms

BIML	International Bureau of Legal Metrology
BIPM	International Bureau of Weights and Measures
CGA	Central Government Authority
CIPM	International Committee for Weights and Measures
CIPM MRA	CIPM Mutual Recognition Arrangement
FAIR	Findable, Accessible, Interoperable, and Reusable
GUM	Guide to the expression of uncertainty in measurement
IEC	International Electrotechnical Commission
ILAC	International Laboratory Accreditation Cooperation
ILAC MRA	ILAC Mutual Recognition Arrangement
ISO	International Organization for Standardization
JCGM	Joint Committee for Guides in Metrology
KCDB	BIPM Key Comparison Database
NMI	National Metrology Institute
NMS	National Metrology System
NQI	National Quality Infrastructure
OIML	International Organization of Legal Metrology
OIML-CS	OIML Certification System
QMS	Quality Management System
RMO	Regional Metrology Organization
RLMO	Regional Legal Metrology Organization
SI	International System of Units, also referred to as the metric system
VIM	International Vocabulary of Metrology

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