



## STRATEGIC BUSINESS PLAN - ISO/TC 12 QUANTITIES AND UNITS

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### Executive summary

#### Main fields

In society, processes and products will acquire better interoperability, improved communication and can be more reliably traded, and ensured safe when tested with measurement expressed in terms of harmonised quantities, units and symbols. Quantities and mathematical operations, the particular focus of ISO/TC 12, are key concepts of all exact sciences and related applications, and constitute the language of physics, chemistry, engineering and mathematics and other sciences, having impact far beyond the commercial and industrial dimensions.

#### Environment of committee

The ISQ<sup>1</sup> is driven by increasing demands for unified measurement in many of the major societal areas of challenge. In addition to traditional areas, such as global trade manufacturing and trade, 21<sup>st</sup> Century challenges benefitting from harmonised quantities are sustainable energy production, environmental protection, and better health. In science, physical laws and the fundamental constants are invoked to relate different quantities and their units. In education, ISO/TC 12 standards can support pedagogic material addressing quantities and units across the disciplines and in primary, secondary and tertiary education. A serious and growing concern is the non-standardised notation in software designed to handle quantitative data in industrial, academic, and societal contexts.

#### Benefits expected from work of ISO/TC 12

Mutual understanding is gained from standardised quantities and units between different fields of activity, e.g., between mechanical engineering and electrical engineering, and between nations with different languages and different alphabets. This benefit is not only of economic nature but also includes the improvement of communication with respect to cultural, scientific, and political matters. Standardised quantities and units are essential for fairness in conformity assessment.

#### Objectives and priorities of ISO/TC 12

ISO/TC 12 Quantities and units is a committee charged (since 1947) with the standardization of units and symbols for quantities and units (and mathematical symbols) used within different fields of science and technology.

At the same time as producing its own standards, ISO/TC TC12 assists in

- (i) reviewing the use of quantities and units in other ISO standards and similar documents;
- (ii) encouraging input from third parties to influence its own standards development.

Recent trends which may stimulate new work items for ISO/TC12 include (i) data in more qualitative situations where humans (as customers, patients etc) are the centre of focus; (ii) coding in modern data collection with specialised indexing language for informatics. One example is where ISO/TC 12 is at present working closely with the health informatics community, including ISO/TC 215, where quantities & units are in focus, including both issues.

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<sup>1</sup> International System of Quantities (ISQ)

## 1 Introduction

### 1.1 ISO technical committees and business planning

The extension of formal business planning to ISO Technical Committees (ISO/TCs) is an important measure which forms part of a major review of business. The aim is to align the ISO work programme with expressed business environment needs and trends and to allow ISO/TCs to prioritize among different projects, to identify the benefits expected from the availability of International Standards, and to ensure adequate resources for projects throughout their development.

ISO/TC 12 *Quantities and units* has a unique role among the standards technical committees, reflecting the generic character of its scope, as summarised in the Executive Summary. Apart from producing its own standards, ISO/TC 12:

- assists in reviewing use of quantities and units in other ISO standards and similar documents;
- encourages input from third parties to influence its own standards development.

ISO/TC 12 has primary responsibility for the International System of Quantities (ISQ), providing standardization of units and symbols for quantities and units (and mathematical symbols) used within different fields of science and technology. The ISQ in turn provides a base for the International System of Units (SI), so that ISO/TC 12 complements the work of the CGPM<sup>2</sup>.

### 1.2 International standardization and the role of ISO

The foremost aim of international standardization is to facilitate the exchange of goods and services through the elimination of technical barriers to trade.

Three bodies are responsible for the planning, development and adoption of International Standards: [ISO](#) (International Organization for Standardization) is responsible for all sectors excluding Electrotechnical, which is the responsibility of [IEC](#) (International Electrotechnical Committee), and most of the Telecommunications Technologies, which are largely the responsibility of [ITU](#) (International Telecommunication Union).

ISO is a legal association, the members of which are the National Standards Bodies (NSBs) of some 164 countries (organizations representing social and economic interests at the international level), supported by a Central Secretariat based in Geneva, Switzerland.

The principal deliverable of ISO is the [International Standard](#).

An International Standard embodies the essential principles of global openness and transparency, consensus and technical coherence. These are safeguarded through its development in an ISO Technical Committee (ISO/TC), representative of all interested parties, supported by a public comment phase (the ISO Technical Enquiry). ISO and its [Technical Committees](#) are also able to offer the ISO Technical Specification (ISO/TS), the ISO Public Available Specification (ISO/PAS) and the ISO Technical Report (ISO/TR) as solutions to market needs. These ISO products represent lower levels of consensus and have therefore not the same status as an International Standard.

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<sup>2</sup> CGPM: Conférence Générale des Poids et Mesures

ISO offers also the International Workshop Agreement (IWA) as a deliverable which aims to bridge the gap between the activities of consortia and the formal process of standardization represented by ISO and its national members. An important distinction is that the IWA is developed by ISO workshops and fora, comprising only participants with direct interest, and so it is not accorded the status of an International Standard.

## **2 Business Environment of the ISO/TC**

### **2.1 Description of the Business Environment**

#### **2.1.1 General**

Within the broad remit of ISO/TC 12, impacting both fundamental science and societal issues, the following political, economic, technical, regulatory, legal and social dynamics describe the business environment of the industry sector, products, materials, disciplines or practices related to the scope of this ISO/TC, and they may significantly influence how the relevant standards development processes are conducted and the content of the resulting standards.

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#### **2.1.2 State of art in field addressed by the scope of ISO/TC 12**

Standardisation of the units and symbols for any quantity, that is, a property of a phenomenon, body, or substance, where the property has a magnitude that can be expressed as a number and a reference, has impact ranging from fundamental science to society at large.

An internationally agreed system of quantities (ISQ), with well-defined symbols for quantities and units; symbols for chemical elements; and the set of mathematical signs and symbols used to describe relations between quantities, will act as a bridge across all linguistic barriers regardless the alphabet used in different languages.

In society, processes and products will acquire better interoperability, improved communication and can be more reliably traded, and ensured safe when tested with measurement expressed in terms of harmonised units and symbols. The ISQ is driven by increasing demands for unified measurement in many of the major societal areas of challenge, such as sustainable energy production, environmental protection and better health.

In science, physical laws and the fundamental constants are invoked to relate different quantities and their units. The ISQ is enabled by advances in fundamental science and technology, be it a new unit based on Nobel-prize winning research or refined measurement on the nanoscale, for instance.

#### **2.1.3 Global trade**

Society has since ancient times always required reliable measurements that give the same answer wherever they are made. Support for fair trade, which needs harmonised expression of the results of measurement, stimulated the World's first international convention – for the metre – in 1875. The use of non-standardized quantities and units is a serious barrier to trade. Different estimates of the value of goods might be made by the seller and buyer if there are differences in measurement & testing in determining the quantity, quality, safety, robustness etc of product. Both measurement uncertainty and metrological traceability might be estimated differently by the seller and the buyer.

#### 2.1.4 Global manufacturing

Modern manufacturing and process industries are extending the range and accuracy of manufacture and increasingly require measurement systems which can handle the transition from off-line, single parameter measurement to on-line, multivariate real-time monitoring. Incidents, both minor and major (such as the Mars Lander 1999), continue to occur when units are mistakenly mixed, reflecting the extra effort required when interpreting specifications using conversion factors with non-standardized units.

#### 2.1.5 Other areas of concern and grand challenge

Quality assurance in environmental protection and in medicine requires harmonisation of quantities and units not only in physics but also chemistry and biology. There is increased focus, in person-centred care, quality of life and customer satisfaction, on qualitative measurements, typically involving the human senses, perception, in psychology, but also enabled by advances in information technology, such neural networks and machine learning. The quality assurance of metrological data in more qualitative situations, where humans (as customers, patients etc) are the centre of focus, is still in its infancy<sup>3</sup>.

#### 2.1.6 Quantities & units in education

Modern standards often adopt a more pedagogic style than the old-fashioned step-by-step instructions of former days and are thus more suited to support educational material across the disciplines and at several levels of primary, secondary and tertiary education which all need to address quantities and units.

#### 2.1.7 Research and development

The value of a quantity is generally expressed as the product of a number and a unit. Units of measurement act as the 'words' of metrological communication and are chosen so that they are readily available to all; are constant throughout time and space; and are easy to realize with high accuracy. The International System of Units (referred to as the SI system) is based on and, in turn, supports continual and long-term research in fundamental science and technology.

When coherent units are used, equations between the numerical values of quantities take exactly the same form as the equations between the quantities themselves. For example, the unit of volume is the cubic metre, which is directly derived from the unit of length, the metre. The relations between quantities of different kinds and their units are well-defined where relations between different quantities are known, for instance, through physical laws.

In research and development more widely, at the universities or in industry, each measurement of quantities made – and there are many – will require one or more units to express the result. As science and technology advances, there is a continuous need for new quantities with corresponding units.

#### 2.1.8 Regulatory bodies

Legislation, regulations and directives in many areas of contemporary concern are implemented through a system of conformity assessment which:

- provides confidence for the consumer that requirements placed on products and services are met;
- provides the producer and supplier with useful tools to ensure product quality; and
- is often essential for reasons of public interest, public health, safety & security, protection of the environment and the consumer and of fair trading.

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<sup>3</sup> L R Pendrill 2014, "[El ser humano como instrumento de medida](#)" / "[Man as a Measurement Instrument](#)", *e-medida* and *NCSLI Measure J. Meas. Sci.*, **9**, 24 – 35 (Dec 2014)

An objective base for decision-making in conformity assessment is provided by quality-assured measurement, with traceability to international standards and with quoted uncertainty.

Conformity assessment procedures, written standards and/or directives might refer to measurement in various ways, with sometimes unrealistic measurement requirements. Measurement uncertainty also increases the risk of in-correct decisions of compliance, especially where a test result is close to a product specification limit. Unfortunately, there are still no internationally harmonised rules for handling these uncertainty-related risks.

### **2.1.9 Other relevant international, regional or national standards or voluntary initiatives**

The SI covers the base units (metre, kilogram, second, kelvin, candela, ampere, mole) and the derived units, as adopted by the General Conference on Weights and Measures, CGPM, which is the highest international organization in the field of units. A worldwide network of regional and national metrology organisations is charged with maintaining, developing, and disseminating national standards (etalons) and metrological traceability to the SI. The CGPM receives advice from its Consultative Committee for Units (CCU), of which ISO is a member represented by ISO/TC 12. In its standards, ISO/TC 12 implements the decisions adopted by the CGPM. ISO/TC 12 experts participate in the work of the Joint Committee of Guides in Metrology, with two working groups addressing a vocabulary in metrology and the expression of measurement uncertainty.

Other technical committees in ISO and other standards bodies develop standards in their respective areas of expertise. For consistency, the use of quantities and units in those standards should be reviewed while new standards in ISO/TC 12 should reflect trends in the other standards fields. See further in clause 4.

### **2.1.10 Concerns and perceptions of relevant stakeholders**

Relevant stakeholders are — directly or indirectly — practically all industries in the world, governments, and consumers.

The end consumers of activities in society are the private households. They buy food and beverages in units of kilograms and litres. They are buying grid electricity in kilowatt-hours, gas for heating in cubic metres and gasoline for the car in litres. The list of such examples could be made very long.

Governments are often buyers and users of big and complicated technical systems. Examples are military aircrafts, battle ships, tanks, missiles, cannons, and guns for the armed forces.

Roads, railways and trains, harbours, airports, air traffic controls for the transport infrastructure are other examples. Again, we have a list of examples that could be made very long.

Industry does not only represent production; most industries are also consumers of semi-finished products from other industries. This flow of products, specified in different units, represent an enormous amount of money. The trade of these products would be very difficult without the tool of standardized quantities and units.

Schools and universities are major customers using quantities and units in their teaching. The same applies for universities and other scientific institutes in their research and development.

Recent trends in the need for standardisation of quantities and units as expressed by stakeholders and which may stimulate new work items for ISO/TC 12 include the following:

Modern data collection increasingly integrates data from multiple systems, both in laboratory set-ups as well as Internet search engines. Non-standardised notation in software designed to handle quantitative data in industrial, academic and societal contexts, is a serious and growing concern. Without standardisation, there can be a lack of consistency – both in terms of metadata and document formats<sup>4</sup>. The uniform expression of both measurement quantities and units in these

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<sup>4</sup> B Harlen 2013 “The data dilemma”, *Scientific Computing World*, pp 9 – 12, June/July 2013, [www.scientific-computing.com](http://www.scientific-computing.com),

data sets can be improved through agreed standard approaches for instance in XML<sup>5</sup>; a metrology information infrastructure<sup>6</sup>; and with specialised indexing language as documents are entered into repositories<sup>7</sup>. ISO/TC 12 is at present working closely with the health informatics community, including ISO/TC 215, *Health informatics*, where quantities & units are in focus, including issues such as the handling of counts and ordinal data.

## 2.2 Quantitative Indicators of the Business Environment

It is very difficult to summarise the total market for standardised quantities and units, owing to its vastness and importance in many areas.

However, below is an attempt to give a list of quantitative indicators describes the business environment in order to provide adequate information to support actions of ISO/TC 12.

Quantities constitute the language of exact science and technology. If only the market for basic textbooks in physics, chemistry, and technology is considered and it is estimated that one chapter out of say 20 chapters deals explicitly with quantities and units (and the other chapters implicitly) it is found that at least 5 % of this textbook market can be referred to the field of quantities and units. This modest estimate in itself implies billions and billions of US dollars each year. Then consider the time teachers in science and technology at high schools and universities spend on the subject quantities and units. Quantities are not a separate topic, but teaching, research and applications are totally dependent on a clear understanding of quantities and their representations. A modest estimate is that the fraction (including mathematics) is at least about the same order of magnitude as in textbooks, i.e. 5 %, probably more. This implies even higher economic resources than for textbooks.

In industry, standardised representation of quantities has a similar vast impact. Every stage of industrial production – from design to finished product – relies heavily on harmonised quantities. Consumers of industrial products also need standardisation of quantities to be able to have maximum benefit and sustainability. In industry, the time fraction spent on quantities and units is probably less than in education – let us say only 1 %, again certainly an underestimate – but the total economic turnover is far much bigger in industry than in teaching natural science and technology. Hence industrial activities in this field represents several trillion US dollars each year. If the alternative is considered that there did not exist any International Standards for quantities and units, the costs for national and international trade would further increase with at least one or two powers of ten. An estimate, giving the same order of magnitude, has also been made by the National Institute for Standards and Technology (NIST) in USA.

The standards of ISO/TC 12 are adopted as national standards in most countries of the world. There are two important exceptions where non-SI units are still used. In naval navigation and civil aviation, the units nautical mile and knot are used for distance and speed, respectively. Altitudes are given in the unit foot, which has neither a simple relation to the nautical mile nor to the metre.

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<sup>4</sup> B Harlen 2013 “The data dilemma”, *Scientific Computing World*, pp 9 – 12, June/July 2013, [www.scientific-computing.com](http://www.scientific-computing.com),

<sup>5</sup> OASIS UnitsML TC, “Defining an XML-based specification to enable the unambiguous representation of units of measure”, [https://www.oasis-open.org/committees/tc\\_home.php?wg\\_abbrev=unitsml](https://www.oasis-open.org/committees/tc_home.php?wg_abbrev=unitsml)

<sup>6</sup> M Kuster 2013 “Toward a Metrology Information Infrastructure: Standardize and Automate”, *Metrologist*, January 2013, pp 14 – 7, [www.ncsli.org](http://www.ncsli.org)

<sup>7</sup> S D Clarke 2013, “Overcoming the logistics of language barriers”, *ISO Focus*, pp 43 – 4, April 2013, [www.niso.org/schemas/iso25964/](http://www.niso.org/schemas/iso25964/)

By tradition human blood pressure in medicine is measured in the unit millimetre of mercury, symbol mmHg.

Finally, it should be pointed out that the overall importance of quantities and units follows from the fact that it is prescribed in the ISO/IEC Directives that all International Standards shall use quantities and units as given in the International Standard ISO 80000 and IEC 80000, *Quantities and units*.

### **3 Benefits expected from the work of the ISO/TC**

#### **3.1 Global benefits**

##### **3.1.1 General**

The main benefit is the mutual understanding between different fields of activity, e.g. between mechanical engineering, electrical engineering, civil engineering and chemical engineering, and between nations with different languages and different alphabets. This benefit is not only of economic nature but includes also the improvement of communication with respect to cultural, scientific and political matters.

In all fields of activity and in all countries the SI is nowadays recognized and well understood.

As time goes by new products will appear on the market. They will successively be adapted to metric sizes all over the globe.

The standards from ISO/TC 12 supports the sustainable Development Goals 4, *Quality education* and 9, *Industry, innovation, and infrastructure*.

##### **3.1.2 Global trade**

An independent review<sup>8</sup> points out the potential for considerable economic impact: “Reduction of non-tariff barriers to trade can be expected to result in as much as a 10% net benefit. One-tenth of a percent increase in trade values (a conservative estimate of the impact of better measurement) would translate into an increase in value of over \$4 billion US, amongst the 28 nations presented here (in the metrological Mutual Recognition Agreement).”

##### **3.1.3 Global manufacturing**

Enhanced product quality and more efficient production (including less waste) – from design to marketing – are benefits of using harmonized quantities and units. The competitiveness of global manufacturing industry, where composite products are increasingly put together from parts made in different regions of the World, has since the 20<sup>th</sup> Century relied on a global uniformity expression of the measurement.

#### **3.2 Other areas of concern and grand challenge**

In the 21<sup>st</sup> Century, the standardisation of measurement is equally relevant to the concerns of modern society, such as sustainable energy production or health care, to name a few. Patient health can be in danger if quantities and units are used imprecisely in diagnosis and treatment, for example. Harmonised treatment of quantities and units will facilitate the route to market for innovative products and services of all kinds.

#### **3.3 Regulatory bodies**

The metering of many kinds of goods and commodities has a sufficiently large economic impact in society, including trade, that this is regulated since many decades in legal metrology. Other examples are speed limits on roads, limits for exposition of ionizing radiation in nuclear power

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<sup>8</sup>KPMG Report, 2002. [Potential Economic Impact of the CIPM Mutual Recognition Arrangement](http://www.bipm.org/en/cipm-mra/economic.html), 125 pp., <http://www.bipm.org/en/cipm-mra/economic.html>

plants, electric tensions in electric grids, and amount of emissions of carbon dioxide. The specifications of all such systems subject to regulation are made in terms of quantities and units.

## 4 Representation and participation in the ISO/TC 12

### 4.1 Membership

#### Countries/ISO member bodies that are P and O members of the ISO committee

### 4.2 Analysis of the participation

Some 20 countries are P-members of ISO/TC 12 and some 30 are O-members. Many big countries, such as China, Egypt, France, Germany, India, Italy, Japan, the Russian Federation, Spain, UK, and USA are all P-members. The P-members represent more than 50 % of the world's population. The O-members represent about another 25 % of the world's population. It is essentially in Africa and South America that relatively few countries are members of ISO/TC 12. Furthermore ISO/TC 12 has liaison with 12 other ISO and IEC/TC:s, among those JTC 1, *Information technology*, IEC/TC 1, *Terminology* and with IEC/TC 25, *Quantities and units*.

ISO/TC 12 has an A-liaison with 17 International Organizations and a B-liaison with 2 International Organizations. In addition to the diverse groups in ISO for specific sectors and technologies, ISO/TC 12 interacts with the 'generic' standards groups for data management and interchange (ISO/IEC/JTC 1/SC 32), and statistics (ISO/TC 69, *Applications of statistical methods*). There is a 'division of labour' between handling the International Systems for Units (CGPM) and Quantities (ISO). Other compilations in this area include those made by IUPAC and IUPAP. The most important A-liaisons are with BIPM, and with the International Organization of Legal Metrology, OIML. Both these organizations are intergovernmental and hence have a legal status. BIPM was established by the Metre Convention, which was signed in 1875. CGPM, according to the Metre Convention, makes the final decisions about the SI.

## 5 Objectives of the ISO/TC and strategies for their achievement

### 5.1 Defined objectives of the ISO/TC

ISO/TC 12 *Quantities and units* is a committee established in 1947. Its scope is the standardization of units and symbols for quantities and units (and mathematical symbols) used within different fields of science and technology, giving, where necessary, definitions of these quantities and units. Standard conversion factors between the various units. Most countries in the world have adopted (essentially) ISO 80000 as their national standard or as national law.

Apart from producing its own standards, ISO/TC 12 assists in reviewing the use of quantities and units in other ISO standards and similar documents while, at the same time, encouraging input from third parties to influence its own standards development. A key objective is therefore to harmonize the International Standards from ISO and from other standards organisations on the basic subject Quantities and units. Many customers today use standards in this area, and there must be no contradictions in the basic standards when treating common topics.

## 5.2 Identified strategies to achieve the ISO/TC's defined objectives

The strategy is to establish joint working groups with other ISO/TCs and other international organizations to carry out the work to continuously update all parts of the International Standard ISO 80000 *Quantities and units*.

## 6 Factors affecting completion and implementation of the ISO/TC work programme

Today, all the experts in quantity calculus who drafted the ISQ over 60 years ago are retired or dead. These old specialists have rarely been replaced. Recruitment of younger experts prepared to dedicate work to the generic field of Quantities & units is quite difficult in today's, application- and market-driven society. Many experts in national member bodies are experts only in special fields of science or technology and hence are inclined to sub-optimize the system of quantities and units to fit only their own field of interest. This may cause unnecessary "No"-votes and delays. However, the SI is global and covers practically all fields of science and technology.

There is, for the time being, no problem to get active participation in the technical work from a sufficient number of P-members. To reduce the travel costs the work on the TC level is conducted by e-mail and by using the ISO Livelink between the plenary meetings. When necessary, the working group meets, if possible, in connection with other meetings, or virtually.

## 7 Structure, current projects and publications of the ISO/TC

### Information on ISO online

The link below is to TC 12 page on ISO's website:

[ISO TC 12 on ISO Online](#)

Click on the tabs and links on this page to find the following information:

- [About](#) (Secretariat, C, Chair, Date of creation, Scope, etc.)
- [Contact details](#)
- [Structure](#) (Working groups)
- [Liaisons](#)
- [Meetings](#)
- [Tools](#)
- [Work programme](#) (published standards and standards under development)

### Reference information

[Glossary of terms and abbreviations used in ISO/TC Business Plans](#)

[General information on the principles of ISO's technical work](#)