Bureau International des Poids et Mesures

“Metrology at the service of the economy, society and citizens”

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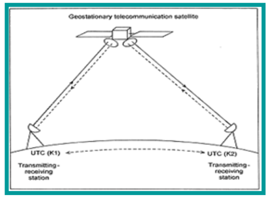
Director, BIPM

IPQ

26th Sept 2013

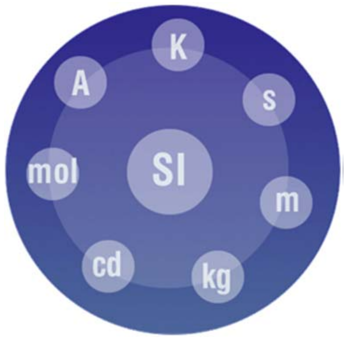
Bureau International des Poids et Mesures

- Established in 1875 by the Metre Convention
- Based in Paris and financed by 55 Member States and 37 Associate States/Economies.



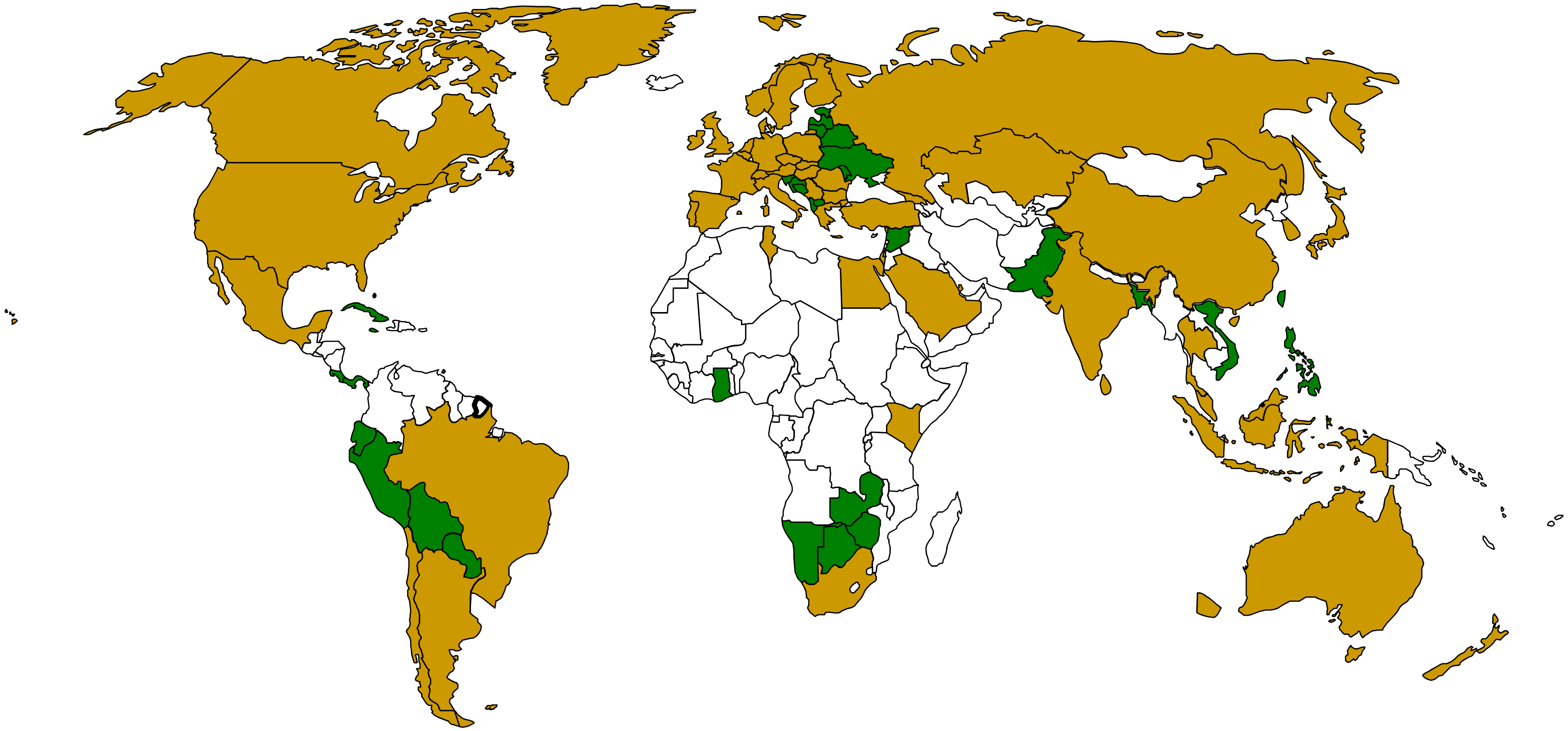
- **Our mission is to ensure and promote the global comparability of measurements.**
- This is achieved both through technical activities in its laboratories and through international coordination.

- operate laboratories in: mass, time, electricity, ionizing radiation, and chemistry.
- an international staff of around 75 with budget of approximately 12 million euros (for 2012).



Member States and Associates

Metre Convention
54 Member States & 37 Associates of the CGPM



Member participating in the CIPM MRA
Associate participating in the CIPM MRA

CIPM- MRA
91 NMIs and 145 Designated Institutes from
51 Member States & 36 Associates of the CGPM
& 4 international organizations

The International System of Units (SI)

Prefixes

Table 5. SI prefixes

Factor	Name	Symbol	Factor	Name	Symbol
10^{1}	deca	da	10^{-1}	deci	d
10^{2}	hecto	h	10^{-2}	centi	c
10^{3}	kilo	k	10^{-3}	milli	m
10^{6}	mega	M	10^{-6}	micro	µ
10^{9}	giga	G	10^{-9}	nano	n
10^{12}	tera	T	10^{-12}	pico	p
10^{15}	peta	P	10^{-15}	femto	f
10^{18}	exa	E	10^{-18}	atto	a
10^{21}	zetta	Z	10^{-21}	zepto	z
10^{24}	yotta	Y	10^{-24}	yocto	y

Derived units

Table 3. Coherent derived units in the SI with special names and symbols

	SI coherent derived unit [a]			
Derived quantity	Name	Symbol	Expressed in terms of other SI units	Expressed in terms of SI base units
plane angle	radian [b]	rad	1 [b]	m/m
solid angle	steradian [b]	sr [c]	1 [b]	m^2/m^2
frequency	hertz [d]	Hz		s^{-1}
force	newton	N		$m\ kg\ s^{-2}$
pressure, stress	pascal	Pa	N/m^2	$m^{-1}\ kg\ s^{-2}$
energy, work, amount of heat	joule	J	N m	$m^2\ kg\ s^{-2}$
power, radiant flux	watt	W	J/s	$m^2\ kg\ s^{-3}$
electric charge, amount of electricity	coulomb	C		s A
electric potential difference, electromotive force	volt	V	W/A	$m^2\ kg\ s^{-3}\ A^{-1}$
capacitance	farad	F	C/V	$m^{-2}\ kg^{-1}\ s^4\ A^2$
electric resistance	ohm	Ω	V/A	$m^2\ kg\ s^{-3}\ A^{-2}$
electric conductance	siemens	S	A/V	$m^{-2}\ kg^{-1}\ s^3\ A^2$
magnetic flux	weber	Wb	V s	$m^2\ kg\ s^{-2}\ A^{-1}$
magnetic flux density	tesla	T	Wb/m^2	$kg\ s^{-2}\ A^{-1}$
inductance	henry	H	Wb/A	$m^2\ kg\ s^{-2}\ A^{-2}$
Celsius temperature	degree Celsius [e]	°C		K
luminous flux	lumen	lm	cd sr [c]	cd
illuminance	lux	lx	lm/m^2	$m^{-2}\ cd$
activity referred to a radionuclide [f]	becquerel [d]	Bq		s^{-1}
absorbed dose, specific energy (imparted), kerma	gray	Gy	J/kg	$m^2\ s^{-2}$
dose equivalent, ambient dose equivalent, directional dose equivalent, personal dose equivalent	sievert [g]	Sv	J/kg	$m^2\ s^{-2}$
catalytic activity	katal	kat		$s^{-1}\ mol$

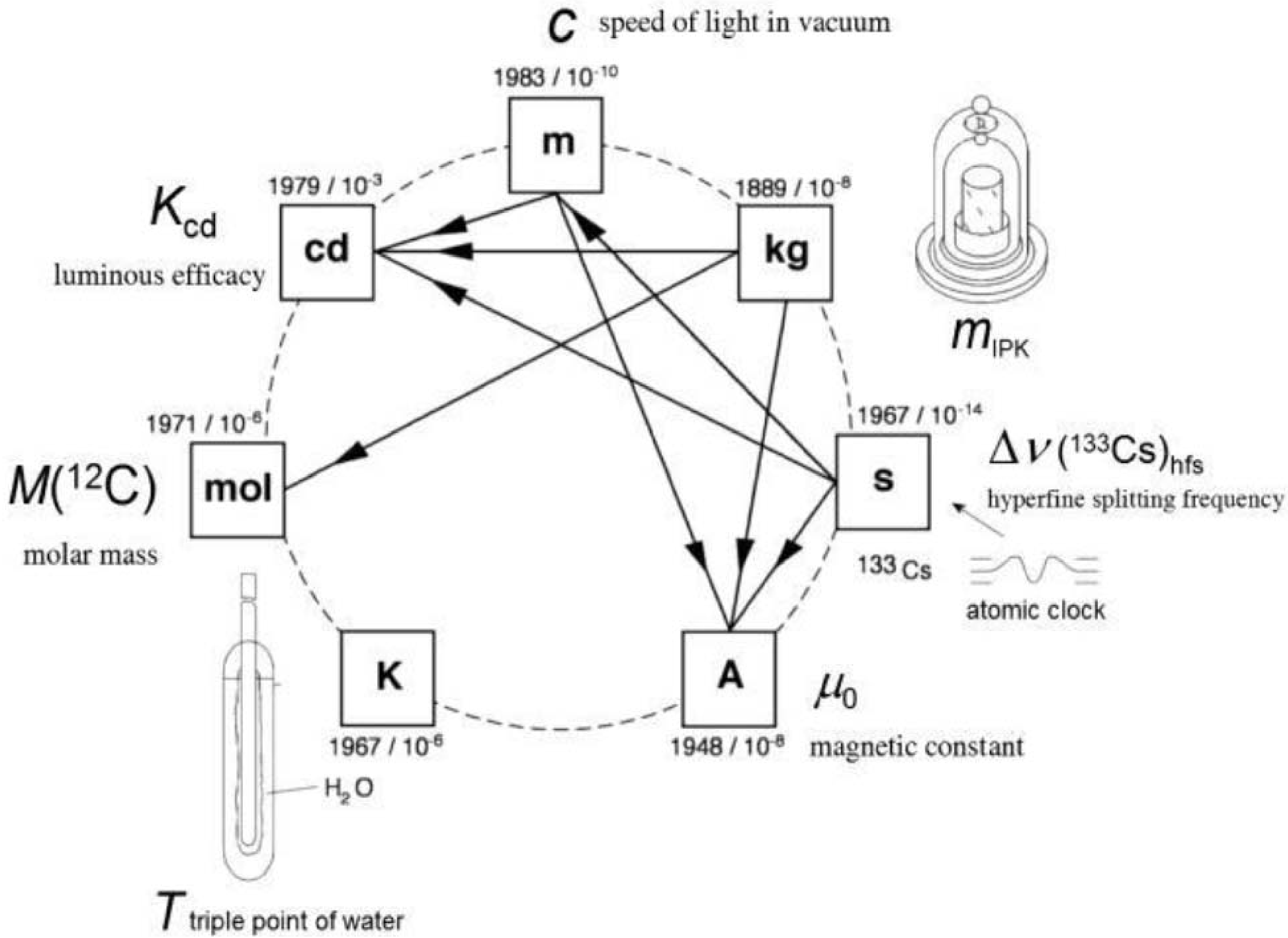
Base units

Table 1. SI base units

Base quantity		SI base unit	
Name	Symbol	Name	Symbol
length	*l, x, r*, etc.	metre	m
mass	*m*	kilogram	kg
time, duration	*t*	second	s
electric current	*I, i*	ampere	A
thermodynamic temperature	*T*	kelvin	K
amount of substance	*n*	mole	mol
luminous intensity	I_v	candela	cd

The 8th edition of the SI Brochure is available from the BIPM website.

The International System of Units (SI)



The objectives of Metrology

Metrology is the "science and practice of measurement", its objectives are

Measurements that are stable

- Long-term trends can be used for decision making

Measurements that are comparable

- Results from different laboratories can be brought together

Measurements that are coherent

- Results for different compounds and from different methods can be brought together

To meet the needs of the economy, society and citizens

The objectives of Metrology

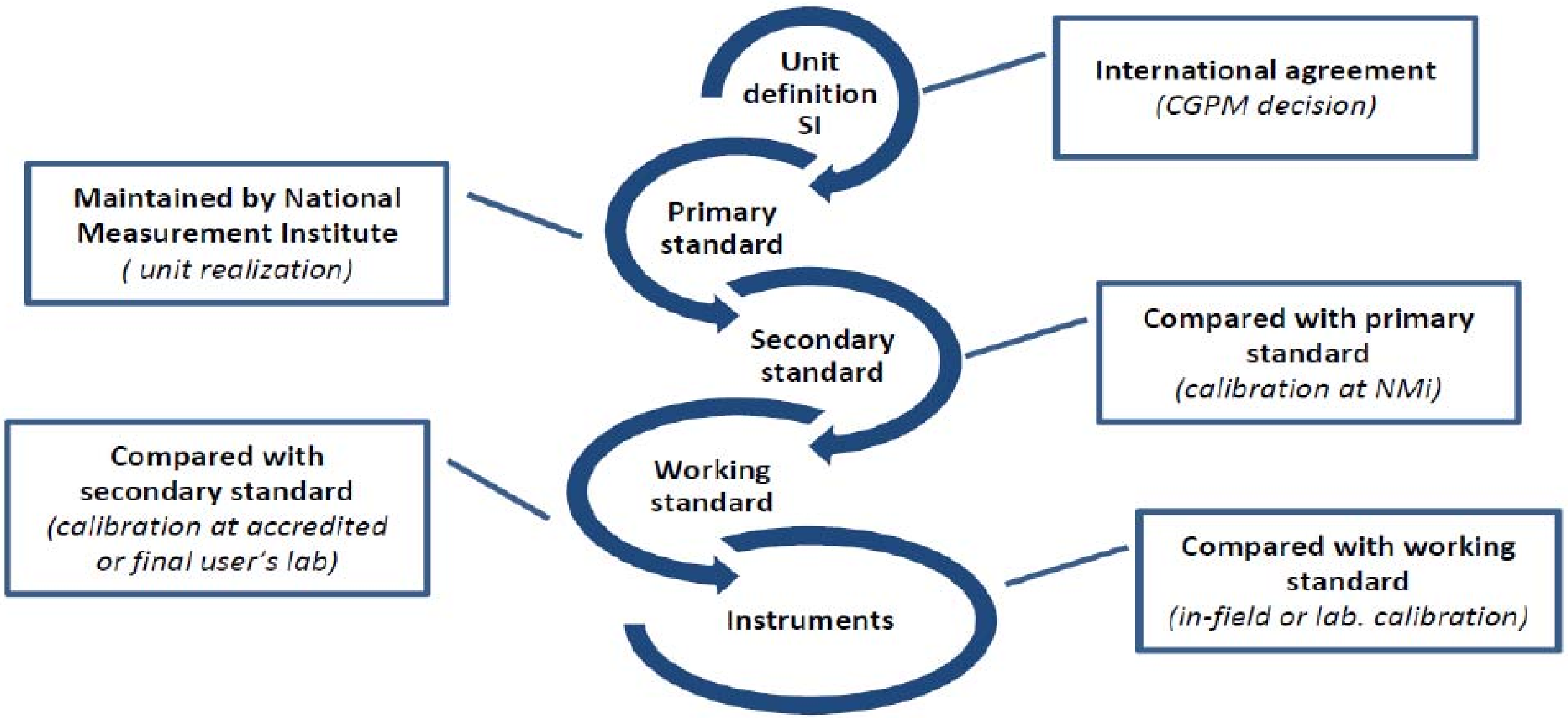
The objectives of metrology are achieved through providing the framework for traceable measurements.

"Traceability" - the property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty

From the International Vocabulary of Basic and General Terms in Metrology; VIM, 3rd edition, JCGM 200:2008

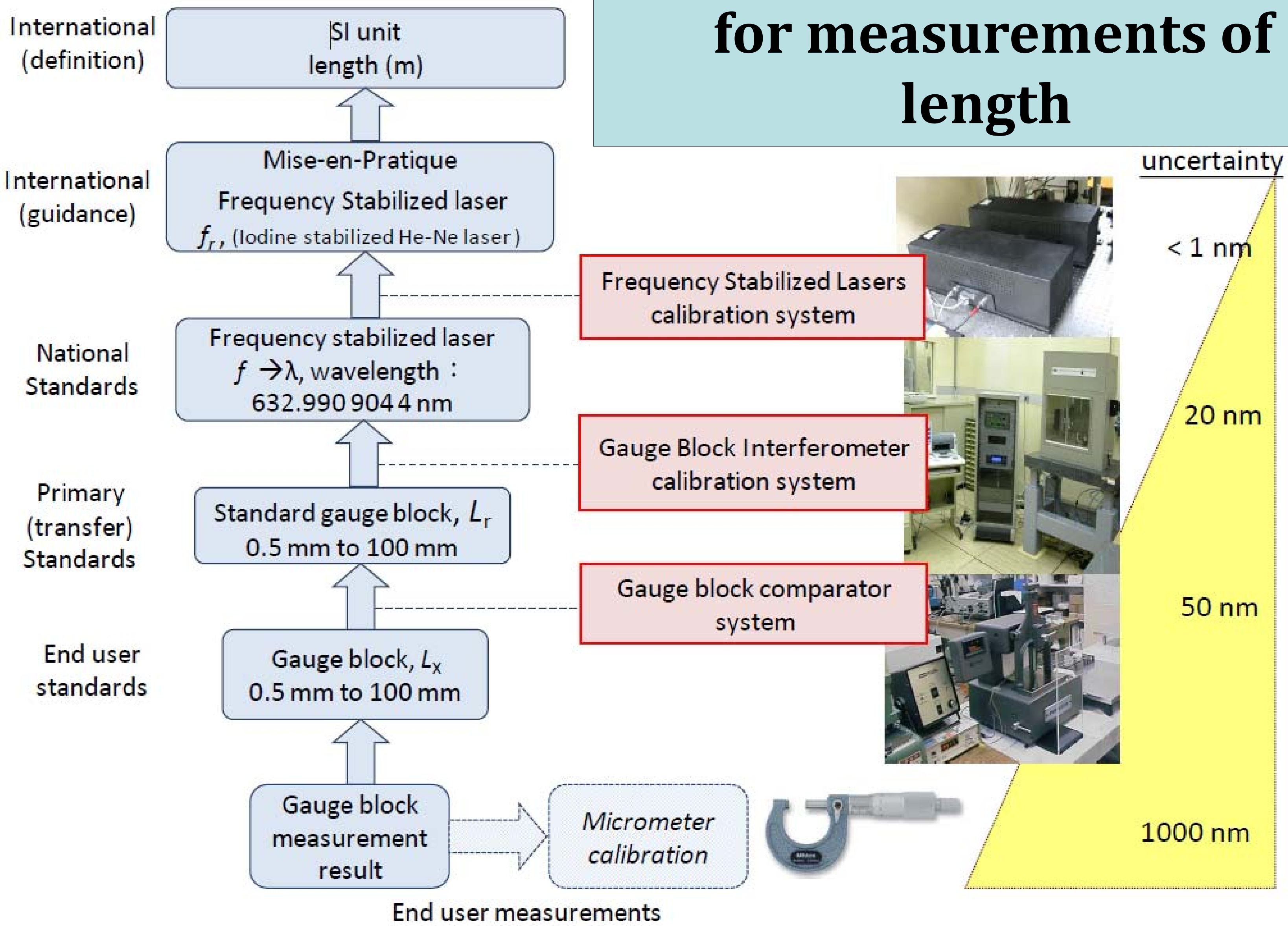
Note: traceability is the property of the result of a measurement, not of an instrument or calibration report or laboratory

The traceability "chain"



Slide courtesy
Dr S Davidson, NPL, UK

A traceability chain for measurements of length



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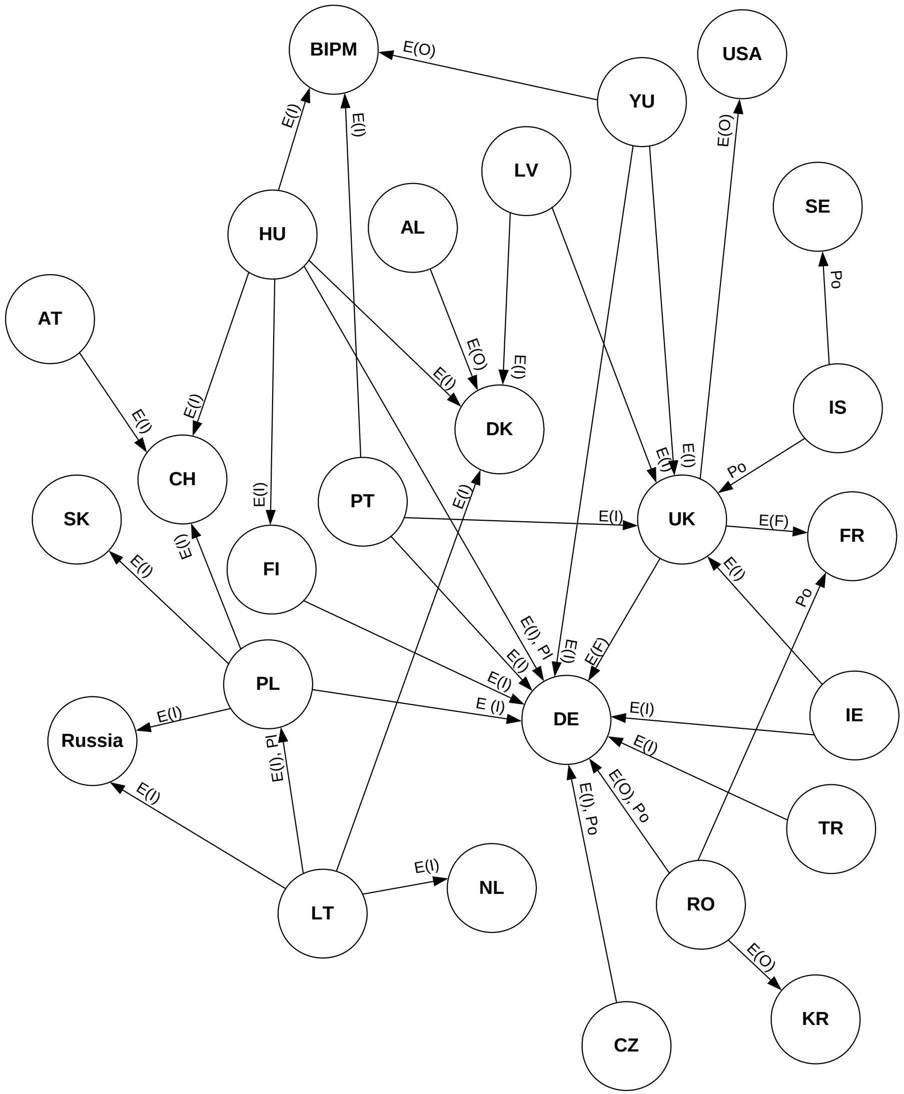
The traceability chain links standards in different countries

The example of **Length**



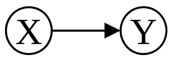
E(F): Existing (formal)

E(O): Existing (other)

E(I): Existing (informal)

Pl: Planned

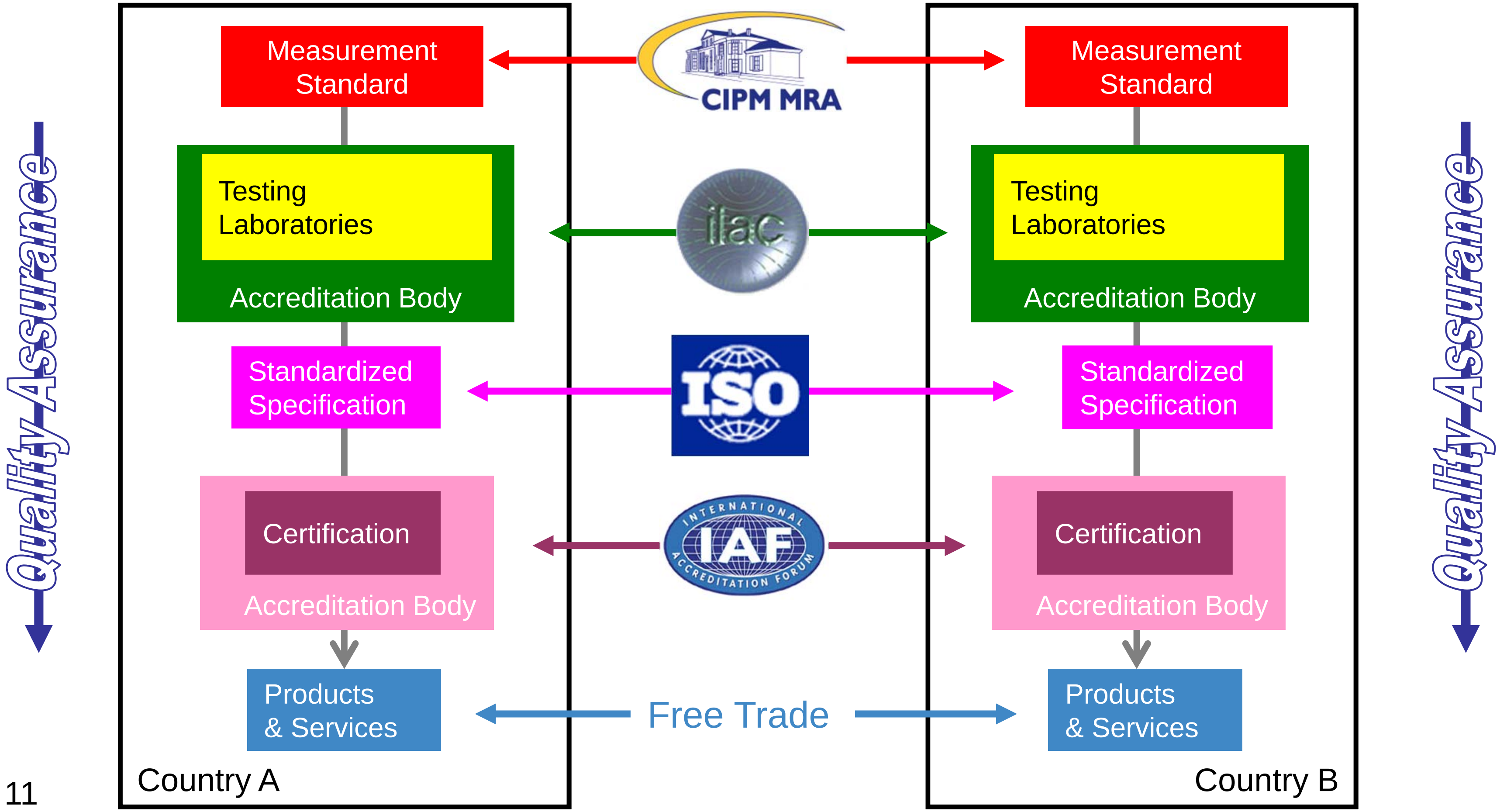
Po: Possible



X takes traceability from Y

the economy, society and citizens need

Measurement standards are provided through an internationally recognized framework through which suppliers of products can demonstrate compliance with specification.



International Organizations that coordinate aspects of international metrology

BIPM

- It is responsible for the establishment of the International System of Units, the SI
- Maintains a number of international measurement standards
- Helps coordinate metrology research at the highest levels
- Helps ensure the international equivalence of measurements and their traceability to the SI
- Provides the means for the international recognition of the national metrology programs worldwide.

OIML

Helps **harmonize the national regulations** concerned with metrology

Helps develop **mutual information** on metrology

Helps develop **international systems of certification** of instruments and of measurands

Helps develop **international recognition** of regulatory certificates related to metrology

ILAC

Coordinates the **international accreditation of laboratories**

Coordinates the activities of the regional cooperation accreditation bodies (**RCABs**)

Helps develop the **international recognition** of tests, measurement standards and reference materials covered by accreditation.

The CIPM Mutual Recognition Arrangement

In 1999, and **in support of world trade**, the CIPM established a **Mutual Recognition Arrangement** (CIPM MRA) of national measurement standards and of calibration and measurement certificates issued by NMIs.

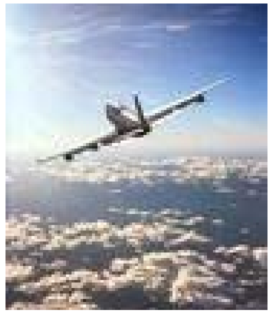
The aim of the MRA is to provide the technical basis for the **worldwide acceptance** of national measurement standards and calibration and measurement certificates from NMIs.

Currently, there are 74 NMIs and 122 DIs participating in the CIPM MRA from:

- 47 Member States of the BIPM,
- 2 International Organizations (IAEA and IRMM), and
- 25 States or economies that are Associates of the CGPM.

The cost of technical barriers to trade

- lack of compliance with standards reduces trade:
  - developed and G22 countries lose between 1% and 15%
  - developing and LDCs lose between 10% and 40%.
- 70% of the burden on developing countries' manufactured exports comes from trade barriers erected by other countries
- The EU single market reduced trade costs of the pre-expansion EU by 2.5% by using "harmonised" standards
- New Zealand exporters pay 5% to 8% of exports to overcome TBTs



An example – trade from India to Mexico in 2004

Pohang Steel and Iron Company (POSCO)

Claim

- Mexican manufacturer of automobile parts demanded the proof of reliability of POSCO steel.
- Indian buyer of POSCO steel required the certification from BIS(Bureau of India Standard).

Solution

- POSCO's testing laboratory had been accredited by KOLAS.
- KOLAS is a member of APLAC and signatory to the ILAC MRA.
- POSCO has a traceability to KRISS participating in the CIPM MRA.
- POSCO's steel accepted without being retested in India and Mexico.

Benefit

- US$ 5 million saved
- US$ 70 000 Invested for calibration

An example – frozen shrimps from China to Europe

Limit on antibiotic residues
(chloramphenicol) in frozen shrimps
set by EU2377/90 at “zero”

China	Spain	Holland	Holland
	customs lab	customs lab	food inspection lab

- 11 containers of frozen shrimps valued at $1.1M destroyed
- EU recognised the problem of specifying “zero” and developed the concept of Minimum Required Performance Limits for detection of substances
- Measurements can help reduce barriers to trade.

The base units of the SI

3 definitions based on fundamental (or conventional) constants:

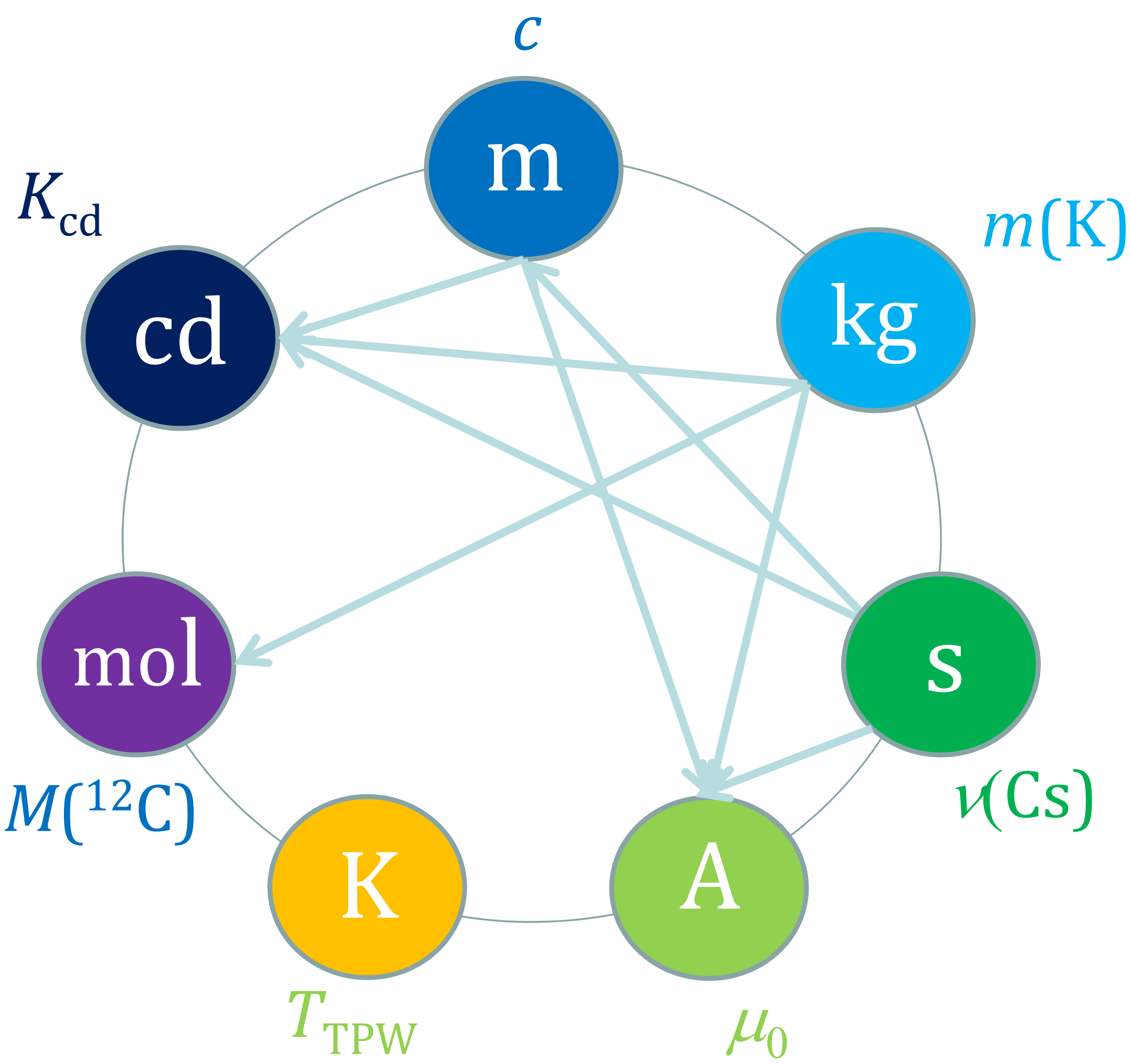
- **metre (*c*)**
- **ampere (μ_0)**
- **candela (K_{cd})**

3 definitions based on material properties:

- **second (^{133}Cs)**
- **kelvin (H_2O)**
- **mole (^{12}C)**

1 definition based on an artefact:

- **kilogram (IPK)**



The definition of the kilogram in the SI

The kilogram is the unit of mass - it is equal to the mass of the international prototype of the kilogram.

- manufactured around 1880 and ratified in 1889
- represents the mass of 1 dm^3 of H_2O at its maximum density (4 °C)
- alloy of 90% Pt and 10% Ir
- cylindrical shape, *Ø* = *h* ~ 39 mm
- kept at the BIPM in ambient air

The kilogram is the last SI base unit defined by a material artefact.

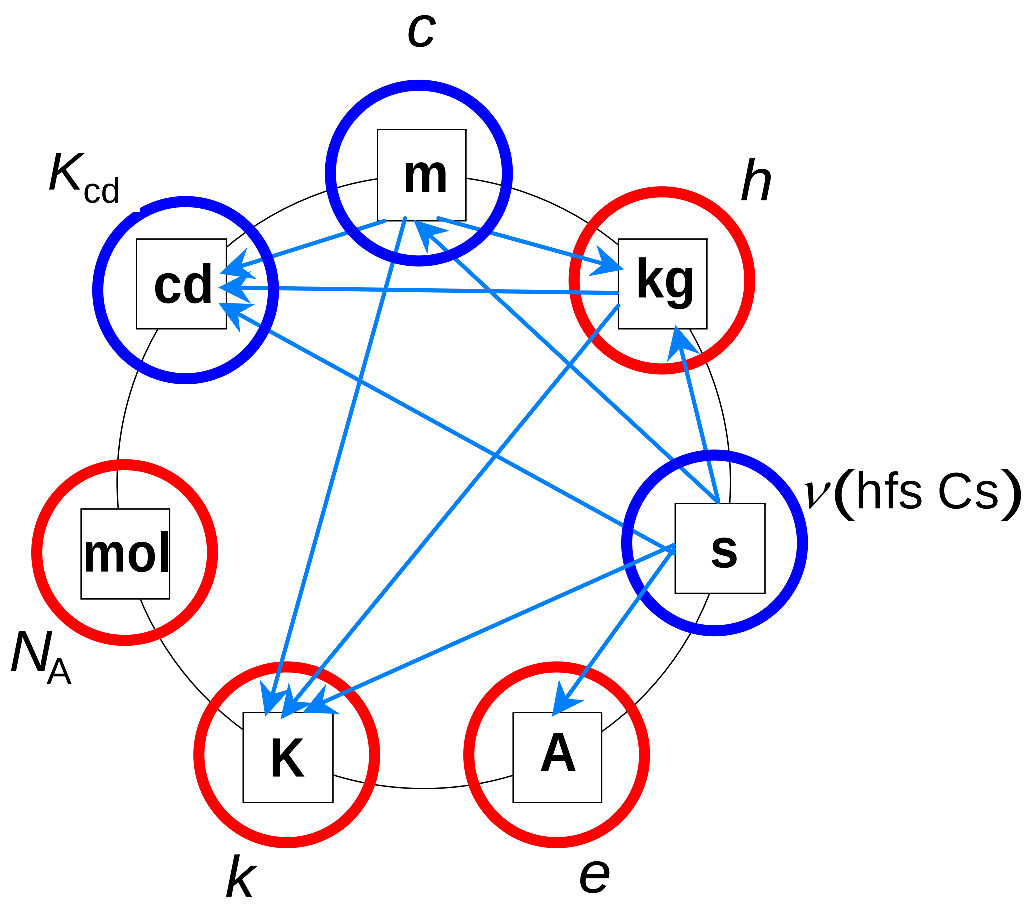
Proposal for a new SI, with 4 new definitions

Definitions based on fundamental (or conventional) constants:

- **metre (*c*)**
- **kilogram (*h*)**
- **ampere (*e*)**
- **candela (K_{cd})**
- **mole (N_A)**
- **kelvin (*k*)**

Definition based on material property:

- **second (^{133}Cs)**



(I. Mills et al., *Metrologia*, 2006, 43, 227-246)

Metrology for the 2020s - four trends

- Implementing the **new quantum SI**
- Measuring **beyond the boundaries**
- Exploiting the **internet of things**
- Working with **technological convergence**

Conclusion

- The economy, society and citizens depend on the national and international « quality infrastructure ».
- The « quality infrastructure » has several elements – all of which are essential.
- It depends on metrology to provide:
    - Measurements that are stable
    - Measurements that are comparable
    - Measurements that are coherent
- These are provided by chains of traceability based on the work of the National Metrology Institutes (NMIs).
- The NMIs are part of a regional and international measurement system supported by the work of the BIPM.

Bureau International des Poids et Mesures

Thank you for your attention

Dr Martin Milton

- BA Hons (First Class), Physics, Oxford University
- PhD, Physics, Southampton University
- MBA (Distinction), London Business School
- Honorary Professor, Department of Chemistry, University of York.
- Joined the National Physical Laboratory in 1981,
- Appointed as an NPL Fellow in 1998.
- Led the "Gas Metrology and Trace Analysis" Group
- Appointed to the International Bureau of Weights and Measures (BIPM) as Director Designate on 1st October 2012,
- Director of the BIPM since 1st January 2013.