# *APMP DEC Future Proofing Task Force*

## Workshop on: "SI units: Practical realizations and how to assure measurement traceability"

## 15th, 17th and 20th September 2021, 6am-8am UTC

APMP's Developing Economies' Committee (DEC) is responsible for initiating and coordinating work programs to address the needs of APMP member Developing Economy NMIs (DENs), working together with other APMP bodies/Committees as appropriate. In delivering on the DEC Strategic Plan 2021-23, the DEC Future Proofing Task Force is charged with supporting DENs to adapt, adopt and engage in new technologies in order to

- Improve their ability to address customers' needs using new technologies applied to metrology services;
- Increase societal benefits through access and use of advances in metrology;
- Increase their ability to support their stakeholders through access to external capabilities (including traceability to the re-defined SI) and services that are fit-for-purpose in the changing external environment of technological and industrial innovation.

**Workshop aims and target group:**
The DEC Future Proofing Task Force is organising this Workshop to assist APMP's DENs in:

1. Gaining a comprehensive overview of practical realizations of the International System of Units (SI) and how to establish measurement traceability to the SI.
2. Using the knowledge they gain from the workshop to help their economy achieve traceability to the revised SI.

While the Workshop is open to all APMP member institutes (and free-of-charge), staff from DENs with roles relevant to the topics being covered are especially encouraged to attend.

**Application process:** Please register using this link: https://forms.gle/poGeJWQzXdiMrAwb8
Registrations will close on **5th of September 2021.**

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**Background:**
The International System of Units (SI) has been used around the world as the preferred system of unitsunderpinning science, technology, industry and trade, since it was established in 1960 by a resolution at the 11th meeting of the Conférence Générale des Poids et Mesures (CGPM). At the 26th CGPM in 2018, Member States of the Metre Treaty endorsed Resolution 1 "On the revision of the International System of Units".

As a result, since May 2019 the definitions of the SI units are now established in terms of a set of seven defining constants. The complete system of units can be derived from the fixed values of these defining constants, expressed in the units of the SI. These seven defining constants are the most fundamental feature of the definitions of the entire system of units. These particular constants were chosen after having been identified as being the best choice, taking into account the previous definitions of the SI based on seven base units and progress in science.

The International System of Units, the SI, is the system of units in which:

- the unperturbed ground state hyperfine transition frequency of the caesium 133 atom, $\Delta\nu_{Cs}$, is 9 192 631 770 Hz,
- the speed of light in vacuum, $c$, is 299 792 458 m/s,
- the Planck constant, $h$, is $6.626\,070\,15 \times 10^{-34}$ J s,
- the elementary charge, $e$, is $1.602\,176\,634 \times 10^{-19}$ C,
- the Boltzmann constant, $k$, is $1.380\,649 \times 10^{-23}$ J/K,
- the Avogadro constant, $N_A$, is $6.022\,140\,76 \times 10^{23}$ $mol^{-1}$,
- the luminous efficacy of monochromatic radiation of frequency $540 \times 10^{12}$ Hz, $K_{cd}$, is 683 lm/W,

where the hertz, joule, coulomb, lumen, and watt, with unit symbols Hz, J, C, lm, and W, respectively, are related to the units second, metre, kilogram, ampere, kelvin, mole, and candela, with unit symbols s, m, kg, A, K, mol, and cd, respectively, according to $Hz = s^{-1}$, $J = kg\ m^2\ s^{-2}$, $C = A\ s$, $lm = cd\ m^2\ m^{-2} = cd\ sr$, and $W = kg\ m^2\ s^{-3}$.

The definitions of the SI units, as decided by the CGPM, represent the highest reference level for measurement traceability to the SI. NMIs around the world establish the practical realizations of the definitions in order to allow for traceability of measurements to the SI. Instead of each definition specifying a particular condition or physical state, which sets a fundamental limit to the accuracy of the realization, a user is now free to choose any convenient equation of physics that links the defining constants to the quantity intended to be measured. This is a much more general way of defining the basic units of measurement. It is not limited by today's science or technology; future developments may lead to different ways of realizing units to a higher accuracy. When defined in this way, there is, in principle, no limit to the accuracy with which a unit might be realized. The exception remains the definition of the second, in which the original microwave transition of caesium must remain, for the time being, the basis of the definition.

The methods stated in the *Mises en Pratique* (MeP) are generally the highest-level experimental methods used for the realization of units using the equations of physics. They are called primary methods and they do not involve reference standards of the same quantity.

# WORKSHOP PROGRAMME

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| **Day 1** | 5.30 – 6.00 UTC | Registration |
| **15 September 2021** Practical realization and how to assure measurement traceability to the **Metre** | 6.00 – 6.05 UTC | Welcome and introduction |
| | 6.05 – 6.45 UTC | Practical realization and how to assure measurement traceability to the Metre |
| | 6.45 – 7.45 UTC | Updates from members : current status of the national measurement standard of length measurement (and metrological traceability to the metre) including preparation towards traceability to the revised SI |
| | 7.45 – 8.00 UTC | Q&A |
| **Day 2** | 5.30 – 6.00 UTC | Registration |
| **17 September 2021** Practical realization and how to assure measurement traceability to the **Kelvin** | 6.00 – 6.05 UTC | Welcome and introduction |
| | 6.05 – 6.45 UTC | Practical realization and how to assure measurement traceability to the Kelvin |
| | 6.45 – 7.45 UTC | Updates from members : current status of the national measurement standard of temperature measurement (and metrological traceability to the kelvin) including preparation towards traceability to the revised SI |
| | 7.45 – 8.00 UTC | Q&A |
| **Day 3** | 5.30 – 6.00 UTC | Registration |
| **20 September 2021** Practical realization and how to assure measurement traceability to the **kilogram** | 6.00 – 6.05 UTC | Welcome and introduction |
| | 6.05 – 6.45 UTC | Practical realization and how to assure measurement traceability to the kilogram |
| | 6.45 – 7.45 UTC | Updates from members : current status of the national measurement standard of mass measurement (and metrological traceability to the kilogram) including preparation towards traceability to the revised SI |
| | 7.45 – 8.00 UTC | Q&A |

**Invited speakers:**

1. Dr Cong Yin
   Length Quantum Primary Standards Laboratory, Division of Length and Precision Engineering
   National Institute of Metrology (NIM)
   China

2. Dr Inseok Yang
   APMP TCT Chair
   Principal Research Scientist
   Korea Research Institute of Standards and Science (KRISS)
   Korea

3. Dr Sheng-Jui CHEN
   APMP TCM Chair
   Principal researcher, Manager, Mechanical and Medical Metrology Research Laboratory
   Center for Measurement Standards, Industrial Technology Research Institute (CMS/ITRI)
   Chinese Taipei