

Draft of the Grand Vision

Transforming the International System of Units for a Digital World

CIPM Task Group on the "Digital-SI"

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The International Committee for Weights and Measures (CIPM) (which directs all metrological work the parties to the Metre Convention decide to carry out in common) now takes the lead to transform the SI into the digital world via its Task Group on the "Digital SI" (TG "Digital-SI"). The primary mission of the Task Group encompasses:

- To develop and establish a world-wide agreed, uniform, unambiguous, authoritative and dependable data exchange framework based on the International System of Units (SI) described in the current SI Brochure.
- To propose suitable actions towards making the SI Brochure machine readable.
- To coordinate this effort with all relevant stakeholders by exploring and/or establishing suitable liaisons.

An international team of experts in digitalization related to metrology was formed in November 2019 to support the necessary work of the Task Group on a high technical level. As a first action, a grand vision guided by FAIR (findable, accessible, interoperable, and reusable) principles for the SI in a digital world and a roadmap towards the grand vision were drawn up by the expert group.

Task Group and the expert group are now seeking input on the initial concept for the SI in a digital world together with organizations from the quality infrastructure and INetQI as well as from industry and research. An international virtual workshop will be held from 22 to 26 February 2021 gathering leading experts and practitioners from relevant stakeholder organizations. The workshop will be the starting point for joint presentation, discussion and development of common needs for the SI in a digital world and accompanying future services, tools and data products from CIPM and BIPM.

Grand vision of the SI Digital Framework

International System of Units (SI), provided by the BIPM SI Brochure, provides a coherent foundation for the representation and exchange of measurement data, enabling interoperability and reproducibility in all scientific and technological domains. The long-term aim of the TG "Digital SI" initiative is to establish a framework that meets FAIR principles (respecting business and privacy constraints) and allows all aspects of the international measurement system – measurement results, uncertainties, traceability and provenance – to be accessed and interpreted digitally, enabling machine-to-machine communication and

analysis. With this respect, the SI - existing for more than one century - might be considered an exemplar of interoperability principles for data. The envisioned framework encompasses foundational (core) models for SI based data representation, digital services and tools, and data stewardship and management activities, providing SI data and information that is transparent to (authorized) users and machines.

The framework will allow more information to be represented digitally, not only measurement results, but also the system being measured, how the measurements were made, and the workflow (data, models, software) associated with establishing the measurement results. The framework will increase the level of machine readability from basic capabilities to full machine-actionable knowledge representation. This machine-actionable information will allow the provenance, traceability and fitness-for-purpose of datasets to be assessed by users and machines and enable the application of knowledge reasoning, machine learning and artificial intelligence tools to be applied to create new knowledge.

It is envisaged that a sustainable framework for the SI in a digital world (SI Digital Framework) supporting provenance will be composed of various data, services and tools aligned with the FAIR principles. In the nearer term, it will cover:

- Interoperable data and metadata models for quantities and SI units
- Digital representation of (the knowledge encoded in) key reference documents: the SI Brochure, the International Vocabulary of Metrology (VIM), the Guide of the Expression of Uncertainty in Measurement (GUM)
- Establish high quality, open access points to all relevant data, services and tools where their qualities are regularly controlled and verified, including the Key Comparison Database (CMC lists), JCTLM database
- Adoption of digital calibration certificates as key for traceability in metrological data

In the longer term:

- Digital representation of measurement procedures, measurement workflows, analysis methods, provenance and traceability chains, that allows machines to access and act upon this information with little or no human intervention.
- Especially digital representation of key comparison and interlaboratory comparison
- Embed the SI Digital Framework in cyber-physical systems, e.g. sensor networks, Internet of Things environments, autonomous systems, and establish traceability at point of measurement.

The development of the SI Digital Framework will benefit from the following activities:

- National Metrology Institutes (NMIs), the RMOs and the CIPM/BIPM engaging with the science community initiatives for FAIR data through active participation and collaboration on the national, the regional (e.g. EURAMET with the European Open Science Cloud) and international level (e.g. the Research Data Alliance (RDA), CODATA, GO FAIR, the Allotrope Foundation, or the ISC), respectively.
- The NMIs and the CIPM/BIPM establishing mechanisms and incentives for long-term support, investments and continuous development of SI Digital Framework data, services and tools in the NMIs and the BIPM, and international data quality

infrastructure, with formally established data stewardship roles, responsibilities and activities.

In summary, the SI Digital Framework is coordinated by CIPM and consists of three layers:

1. **SI core representation, defined by CIPM:** Metadata models and exchange format implementations for basic data elements comprising values, units and uncertainty of a quantity based on the BIPM SI Brochure.
2. **Services, implemented by the NMIs, BIPM and related organizations:** Open data formats and software tools and services that build upon the SI core representation. Such services enable data to be ready for analysis, improve data quality and reliability, facilitate life-cycle analysis, communicate that data is fit for purpose, and improve data transparency.
3. **Applications, developed and deployed in the broader metrology community and in research disciplines that rely upon the SI:** Tools and services can be utilized in domain-specific applications, including sophisticated analysis and AI/ML methods, and, through layering on the SI core representation, assure reliability and traceability.

