Toward a measurand taxonomy for interoperable measurement data

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Measurement-Information Infrastructure

Section 1

Introduction

Today's Topics

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1. Introduction
2. Motivation and Strategy

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3. Tools and Process

Today's Topics

Current Project Contributors

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- NCSL International 141 MII and Automation Committee

Acronyms

- API—application programming interface
- BIPM—International Bureau of Weights and Measures
- CMC—calibration and measurement capability
- DCC—(PTB's) digital calibration certificate
- DCR—(PTB's) digital calibration request
- FAIR—findable, accessible, interoperable, reusable
- KCDB—key comparison database
- M-Layer—metrology information layer to support measurement systems
- NCSLI—NCSL International
- NMI—national metrology institute
- PID—persistent identifier
- PR—photometry-radiometry
- SoA—scope of accreditation

MII (measurement information infrastructure)

set of normative standards that unambiguously define data structures, taxonomies, service protocols and security for locating, communicating and sharing measurement information

Section 2

Motivation and Strategy

Motivation

- We want interoperability for machine-actionable measurement data.
  - Time and labor savings
  - Automatic data validation and verification
  - New productivity, services, data value and insight
  - Digital documents such as DCCs won't realize their potential otherwise.
- This requires standardized metrology metadata.
- One of least standardized data elements: measurand descriptions
  - Various DCC projects currently seek a measurand identifier.
  - Wanted: unique measurand PIDs

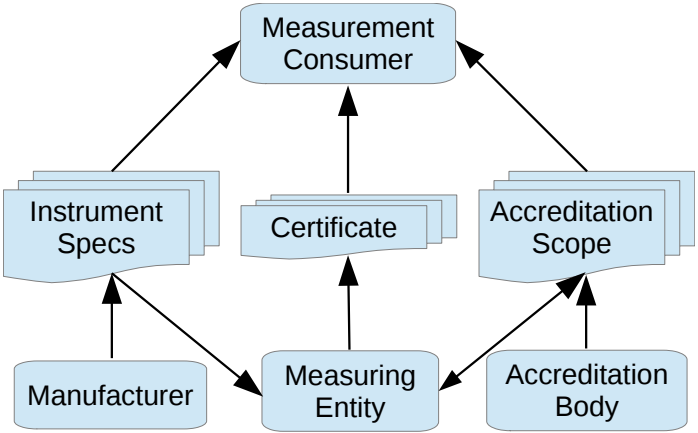
MII Proposal for Measurand Metadata

1. Standardize a measurand taxonomy.
2. Link taxons to KCDB CMC IDs.
3. Tag digital document data and service offerings with the taxons as metadata.

Spec: `Source.Voltage.DC`

SoA: `Measure.Voltage.DC`

Cert: `Source.Voltage.DC`



Solution: abstract taxon definitions customized for any context

Source.Coefficient.Voltage.Luminance

Definition: `https://cie.co.at/eilvterm/17-25-061`, `https://cie.co.at/eilvterm/17-21-050`

- **Required Parameters (instantiated with ranges)**
  - Luminance
  - SourceType {CIEA, CIED65, ..., Tungsten, TungstenDiffuser, Halogen, ...}
    - Alternatively perhaps: Temperature.Color.Correlated, e.g. CCT = 2856 K for Tungsten
  - Angle.Solid
- **Optional Parameters (instantiated with ranges)**
  - LuminanceResponsivity
  - Voltage[.Output]

Draft Taxons

Previous strategy:

- Identified and drafted taxons targeting the most common CMCs (Pareto style).
- Drew from a dataset containing 250,000 CMCs from SoAs.

Capacitance
Conductance
Conductivity
Current.AC
Current.AC.Noise.RMS
Current.AC.Sinewave
Current.AC.Sinewave.2Phase
Current.AC.Sinewave.3Phase
Current.AC.Squarewave
Current.AC.Trianglewave
Current.DC
Current.DC.Delta.Current.LoadEffect
Current.DC.Delta.Current.SourceEffect
Current.DC.OutputAndReadback
Density.Mass.Gas
Density.Mass.Liquid
Density.Mass.Solid
Energy.AC.Sinewave
Energy.AC.Sinewave.Simulated
Energy.AC.Sinewave.Simulated.2Phase
Energy.AC.Sinewave.Simulated.3Phase
Energy.DC
Energy.DC.Simulated
Force
Frequency
Frequency.AmplitudeModulation.Rate
Frequency.FrequencyModulation.Deviation
Frequency.FrequencyModulation.Rate
Frequency.PhaseModulation.Rate
Humidity.Absolute
Impedance
Inductance
Length
Length.Circumference
Length.Diameter
Length.Form.Flatness
Length.Form.Parallelism
Length.Form.Perpendicularity
Length.Form.Roughness
Length.Form.Roundness
Length.Form.Sphericity
Length.Form.Straightness.Axis
Length.Form.Straightness.Surface
Length.Radius
Mass.Apparent
Mass.Conventional
Mass.True
Phase.PhaseModulation
Phase.ReflectionFactor.RF
Phase.TransmissionFactor
PhaseNoise.SideBand
Power.AC.Sinewave
Power.AC.Sinewave.Simulated
Power.AC.Sinewave.Simulated.2Phase

Draft Taxons

Power.AC.Sinewave.Simulated.3Phase
Power.DC
Power.DC.Simulated
Power.RF.Sinewave
Pressure.Hydraulic.Static
Pressure.Pneumatic.Absolute.Static
Pressure.Pneumatic.Differential.Static
Pressure.Pneumatic.Gage.Static
Ratio.AmplitudeModulation
Ratio.AmplitudeModulation.Delta.Rate
Ratio.Density.Mass
Ratio.Distortion
Ratio.Distortion.AmplitudeModulation
Ratio.Distortion.FrequencyModulation
Ratio.Distortion.PhaseModulation
Ratio.DutyCycle
Ratio.FrequencyModulation.Delta.Rate
Ratio.Humidity.Relative
Ratio.Humidity.Specific
Ratio.PhaseModulation.Delta.Rate
Ratio.Power.ReflectionFactor.RF
Ratio.Power.RF.Sinewave.Delta.Frequency
Ratio.Power.RF.Sinewave.Delta.Power
Ratio.Power.RF.Sinewave.Harmonic
Ratio.Power.RF.Sinewave.Spur
Ratio.Power.TransmissionFactor
Ratio.PulseModulation.CWtoPulsedPower
Ratio.PulseModulation.OnOffPower
Ratio.Torque
Ratio.Voltage.AC.Ripple.OnDC
Ratio.Voltage.AC.Sinewave.Delta.Frequency
Ratio.Voltage.AC.Sinewave.Delta.Voltage
Resistance
Resistance.Insulation
Temperature
Temperature.Radiometric
Temperature.Simulated.PRT
Temperature.Simulated.RTD
Temperature.Simulated.Thermocouple
Time.Interval
Time.Period
Time.PulseWidth
Time.Transient
Time.Transition
Time.Transition.PulsedRF
Time.UTC
Torque
Torque.HydraulicPressure
Voltage.AC
Voltage.AC.NoisePeakToPeak
Voltage.AC.Ripple.OnDC
Voltage.AC.Sinewave
Voltage.AC.Sinewave.2Phase
Voltage.AC.Sinewave.3Phase
Voltage.AC.Squarewave
Voltage.AC.Trianglewave
Voltage.DC
Voltage.DC.Delta.Voltage.LoadEffect
Voltage.DC.Delta.Voltage.SourceEffect
Voltage.DC.OutputAndReadback
Voltage.DC.Segemented.Delta
Voltage.PeakToPeak
...

Current Project

BIPM would like the taxonomy linked to KCDB service categories.

- Start with one service category.
- Focus on taxon names first, though parameter sets influence the names
- Extend coverage across the KCDB.
- Extend coverage for additional measurand demand down the traceability chain
  - Derived NMI measurement services
  - Lower laboratories' accredited CMCs
  - Unaccredited CMCs

The MII taxonomy will point to the KCDB since it already exists but future digital documents and enterprise systems may point toward the taxonomy as a FAIR standardized metadata resource.

Section 3

Tools and Process

Tools

- Open-source taxonomy editor at `https://github.com/CalLabSolutions/Metrology.NET_Public`
- Project hosted on GitHub at https://github.com/NCSLI-MII/
- A repository to integrate quantities, units, measurands, CMCs
  - Pull data from the M-Layer and KCDB APIs
  - Link taxons to M-Layer quantities (aspects) and units (scales)
  - Link taxons to KCDB CMCs and service categories
  - Monitor coverage, find orphans, expose gaps, facilitate development

Process

First trial: photometry branch of the PR area. Steps:

1. Pull all the relevant CMC-entry data.
2. Sort and filter on service, subservice, individual service, quantity and instrument.
3. Analyze the method, units, uncertainty, comments and parameter data.
4. Supplement the data from other sources—literature, standards, etc.—as required.
5. Draft a taxon set to represent the unique measurands and their parameters.

The information assembled at BIPM through CIPM and its Consultative Committees greatly facilitates taxon creation.

Drafting 14 taxons to cover the 341 CMCs took a photometry novice approximately 6 h.
Expert reviews encouraged!

Example KCDB CMC Data

KCDB Field(s)	**Data**
metrologyAreaLabel	PR
branchValue, serviceValue	Photometry
subServiceValue	Luminance responsivity
individualServiceValue	Luminance meter
quantityValue	Luminance responsivity
instrument	Luminance meter
instrumentMethod	Tungsten-based source
cmc	unit: $A/(cd/m^2)$, $V/(cd/m^2)$, $reading/(cd/m^2)$
traceabilitySource	MSL cryogenic radiometer
comments	Responsivity to other types of sources can also be calibrated.
internationalStandard	
parameters	Luminance: $27\,000\,cd\,m^{-2}$ to $33\,000\,cd\,m^{-2}$; Source Type: Illuminant A

Photometry Branch and Service Hierarchy

Sub Service	Individual Service	Quantity	Taxon(s)
Luminous intensity	Tungsten lamp	Luminous intensity	Measure.LuminousIntensity
Illuminance responsivity	Tungsten source	Illuminance responsivity	Measure.Coefficient.Voltage*.Illuminance
Luminous flux	Tungsten lamp	Luminous flux	Measure.LuminousFlux
|	LED	|	Measure.LuminousFlux
Illuminance	Tungsten lamp	Illuminance	Measure.Illuminance
Luminance	Tungsten-based source	Luminance	Measure.Luminance
			Source.Luminance
Luminance responsivity	Luminance meter	Luminance responsivity	Source.Coefficient.Voltage*.Luminance
Averaged luminous intensity	LED	Averaged luminous intensity	Measure.LuminousIntensity.LEDAveraged
Luminous exposure	General source	Luminous exposure	Measure.LuminousExposure
|	Flash photometer	Luminous exposure responsivity	Source.Coefficient.Voltage*.LuminousExposure
			Source.Coefficient.Charge.LuminousExposure

*These sub services also include . . . Coefficient.Current. . . taxon versions (omitted for space).

Example Results

Taxon	**kcdbCode**
...	...
Measure.Coefficient.Voltage.Illuminance Measure.Coefficient.Current.Illuminance	EURAMET-PR-TR-000006KM-2
Measure.Coefficient.Voltage.Luminance Measure.Coefficient.Current.Luminance	SIM-PR-MX-00000GER-1
Measure.LuminousExposure	APMP-PR-CN-00000K9V-1
Measure.LuminousIntensity	AFRIMETS-PR-ZA-000006FO-1
Measure.LuminousFlux	SIM-PR-BR-0000053M-2
Measure.Illuminance	COOMET-PR-RU-00000DMG-1
...	...

Currently covered: 351 of 25868 KCDB CMCs, $\approx$ 1.4 %

Next: EM measurement area (4609 CMCs), reporting results at the NCSLI 2024 Conference

Section 4

Conclusion

Recommendations

Establish and use a measurand taxonomy

- Unique measurand PIDs with unlimited human-readable aliases
- Fully qualifies measurands for interoperable digital documents
- (DCCs, instrument specs-DCRs, SoAs, . . .)

Collaboration

- Available for metrologists to augment, review and critique
- Current information
  - GitHub for configuration management (submission, review, approval): https://github.com/NCSLI-MII
  - Open-source taxonomy and SoA editors: https://github.com/CalLabSolutions/Metrology.NET_Public
  - Further info: http://miiknowledge.wikidot.com/

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And Thank You for your time!

Collaboration opportunities? Please bring your expertise!

Questions?