Metrology's Digital Transformation

Mark Kuster, Independent Researcher, Consultant

Panelists
Greg Cenker, Indysoft
Collin Delker, Sandia National Laboratories
James Fedchak, NIST
Michael Schwartz, Cal Lab Solutions

NCSLI 141 MII and Automation Committee

Measurement-Information Infrastructure

Section 1

Introduction

Today's Topics

Learning Objectives

By participating in the session, attendees will learn to

- understand what digital transformation means,
- recount the latest worldwide digital-metrology progress, and
- infer implications for the metrology industry.

Agenda

- Panelists will briefly present their organization's DX perspectives, goals, progress
  - Greg Cenker, Indysoft
  - James Fedchak, NIST
  - Michael Schwartz, Cal Lab Solutions
  - Collin Delker, Sandia National Laboratories (alternate)
  - Mark Kuster, NCSL International 141 MII and Automation Committee
- Audience questions and discussion

Section 2

Global DX Background

Acronyms & Buzzwords

- DX—digital transformation
- IQI—international quality infrastructure
- DCC—digital calibration certificate (PTB)
- FAIR—findable, accessible, interoperable and reusable
- MII—measurement information infrastructure, NCSLI's DX initiative
- SoA—scope of accreditation
- M-Layer—metrology information layer to support measurement systems

Digital Transformation

Progress	Want Music?	Want Calibration?
manual		
analog		
digitized		
digitalized		
digitally transformed		

Digital Transformation

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Digital Transformation

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Digital Transformation

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Digital Transformation

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digitalized	tagged MP3 files	?
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Digital Transformation

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digitalized	tagged MP3 files	MII, DCC, et al.
digitally transformed	Pandora, SiriusXM	new innovation

An IQI Foundation

The IQI remains key to world-wide commerce—product acceptance and interoperability.

A more challenging future environment presents problems though:

- An agile, automated world demanding inexpensive, fast service
- Sheer numbers of measuring instruments: e.g., IoT devices
- Intolerance to lost value in manual processes

Digital Transformation

Metrology's DX has begun but lags other industries:

- science, manufacturing, travel, banking, entertainment, ...

The MII initiative envisions a DX solution with opportunities:

- Higher quality and reduced costs via automation
- New value from digitalized measurement information
- Innovation: new products, services, business

A digitally transformed IQI might ensure continued viability.

Barriers to Success

DX will solve the problem and foster innovation if

- fit-for-purpose and championed for adoption.

Simple digitization will not suffice. That only . . .

- changes the package, the wrapper,
- prolongs existing manual processes and weaknesses,
- retains ambiguity that foils machine consumption,
- leaves us with manual processing in a different form.

Critical Success Factors

True fit-for-purpose DX requires rethinking our processes to leverage digital technology.

For true DX we should:

- Rethink our processes from the ground up.
- Replace our manual shortcuts.
- Discard pragmatic practices for extensible replacements.
- Champion adoption within top-level authorities.

No one ever requested a streaming music service to replace their phonograph.
Value-creating innovation and production drive demand, not consumers.
The sky poses no limit: "Build it and they will come."

Top-Level Support

We now see more awareness of this coming reality. The BIPM and OIML statements regarding World Metrology Day 2022's digital-metrology theme seem particularly encouraging.

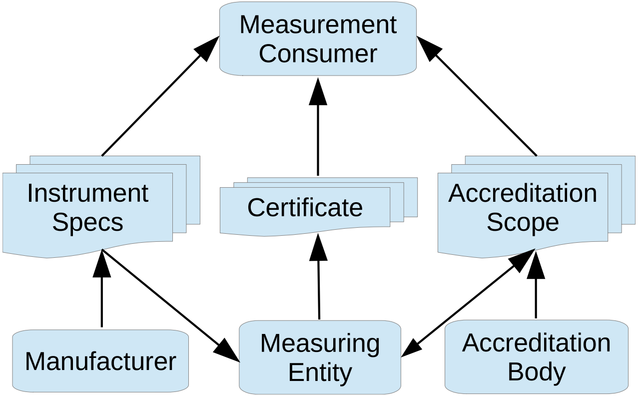
Paraphrasing:

- This exciting digital technology will revolutionize our community.
- It will enable open, transparent, human-readable, machine-actionable information exchange.
- FAIR data principles: Findable, Accessible, Interoperable and Reusable
- CIPM will develop an SI digital framework as fundamental support.

Section 3

NCSL International Efforts

MII Digital Documents in the Measurement Economy

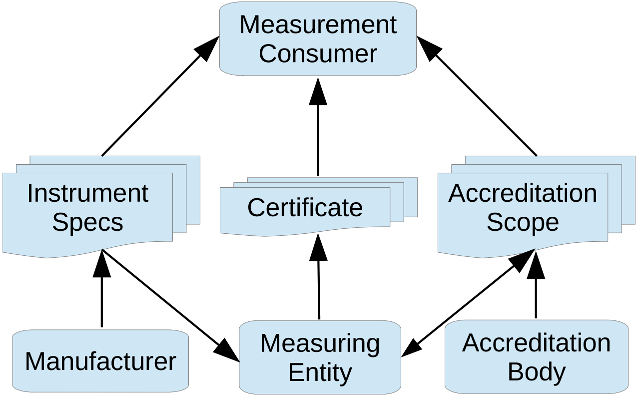


All three documents revolve around measurement information and so share a common data structure.

Definition

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

MII Digital Documents in the Measurement Economy



All three documents revolve around measurement information and so share a common data structure.

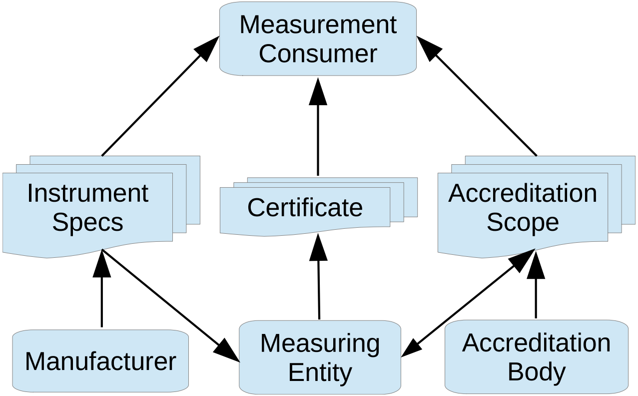
Where to start?

Calibration certificates: billions
Instrument specifications: millions
Accreditation scopes: thousands

Emphasis on commercial products:

- Practicable, yet extensible
- Minimum viable product: SoA
- Leverage the SoA structure to inform instrument specifications, certificates

MII Digital Documents in the Measurement Economy

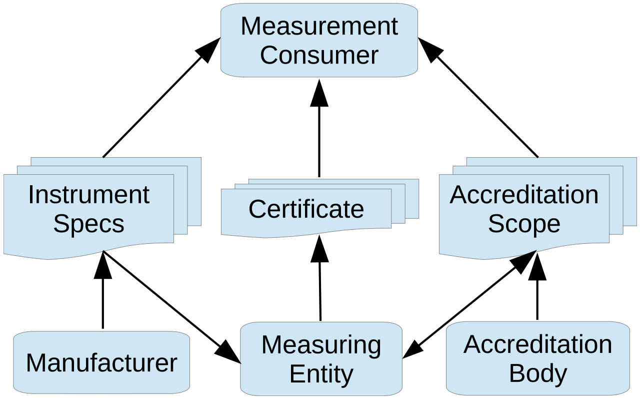


All three documents revolve around measurement information and so share a common data structure.

MII Design Requirements

- Standardization (norms)
- Interoperability (unambiguous)
- Data Completeness (full data retention)
- Identity (reusable data)
- Extensibility (compatible versioning)
- Authentication and Authorization (ownership)
- Revocation (withdrawal)

MII Digital Documents in the Measurement Economy



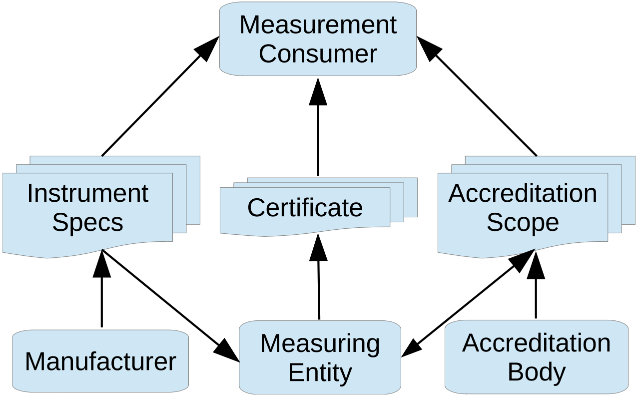
All three documents revolve around measurement information and so share a common data structure.

Rethinking measurands . . .

Current representations work for humans but remain inoperable for machines.

- Free-text quantity descriptions
- Multiple quantities per unit
- Endless dimensionless quantities
- Implicit scale-type traps
- Exceptional cases (e.g., kg)
- SI objections fill the literature.

MII Digital Documents in the Measurement Economy



All three documents revolve around measurement information and so share a common data structure.

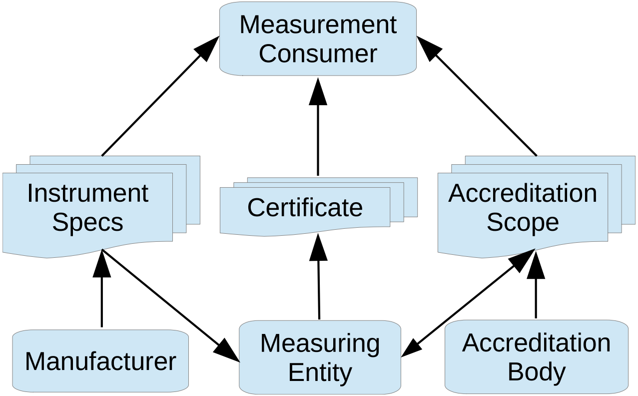
Machines require metadata to process documents correctly.

Measurement metadata = measurand descriptions = MII taxons

∴ The MII uses a standard measurand taxonomy drawn from a test-bed quantity database.

SoA	`Measure.Voltage.DC`
Spec	`Source.Voltage.DC`
Cert	`Source.Voltage.DC`

MII Digital Documents in the Measurement Economy



All three documents revolve around measurement information and so share a common data structure.

However, the MII test-bed lacks

- Global interoperability
- Scale & operator definitions
- Quantity relations

$\therefore$ We want a more general metrology information basis (the M-Layer).

$\langle q \rangle$	aspect—generalized "quantity"
q	numeric (usually) value
$[Q]$	scale—generalized unit or ref.

Beagle Smart CMC Search

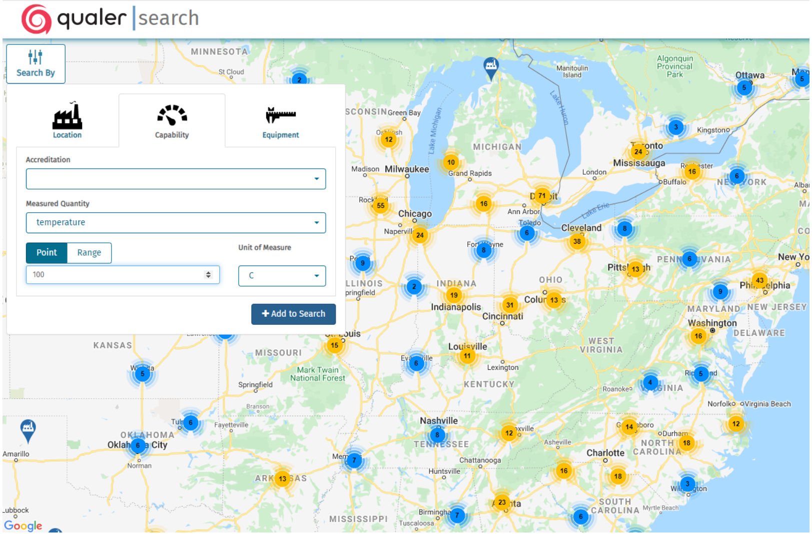
Project Beagle Home Files API

Welcome to project Beagle

Select Parameter Category	Select Quantity Measured	Data Point	Enter CMC
electrical	voltage	96.545	

Measuring Entity	Techniques	Quantities	Ranges	CMC	Assertion	
Acme Calibration Labratory	Measure.Voltage.DC.LowVoltage.4Wire	voltage	11 .. 110	0.001	Resolution = 6-1/2 digit	Download
	Measure.Voltage.DC.LowVoltage.4Wire	voltage	11 .. 110	0.01	Resolution = 5-1/2 digit	
	Measure.Voltage.DC.LowVoltage.4Wire	voltage	11 .. 110	0.1	Resolution = 4-1/2 digit	
Acme Calibration Labratory	Measure.Voltage.AC.LowVoltage	voltage	11 .. 110	0.002	Resolution = 6-1/2 digit Connection = 4 Wire	Download
	Measure.Voltage.AC.LowVoltage	voltage	11 .. 110	0.003	Resolution = 6-1/2 digit Connection = 4 Wire	
	Measure.Voltage.AC.LowVoltage	voltage	11 .. 110	0.02	Resolution = 5-1/2 digit Connection = 4 Wire	
	Measure.Voltage.AC.LowVoltage	voltage	11 .. 110	0.03	Resolution = 5-1/2 digit	

Qualer Search (https://search.qualer.com)



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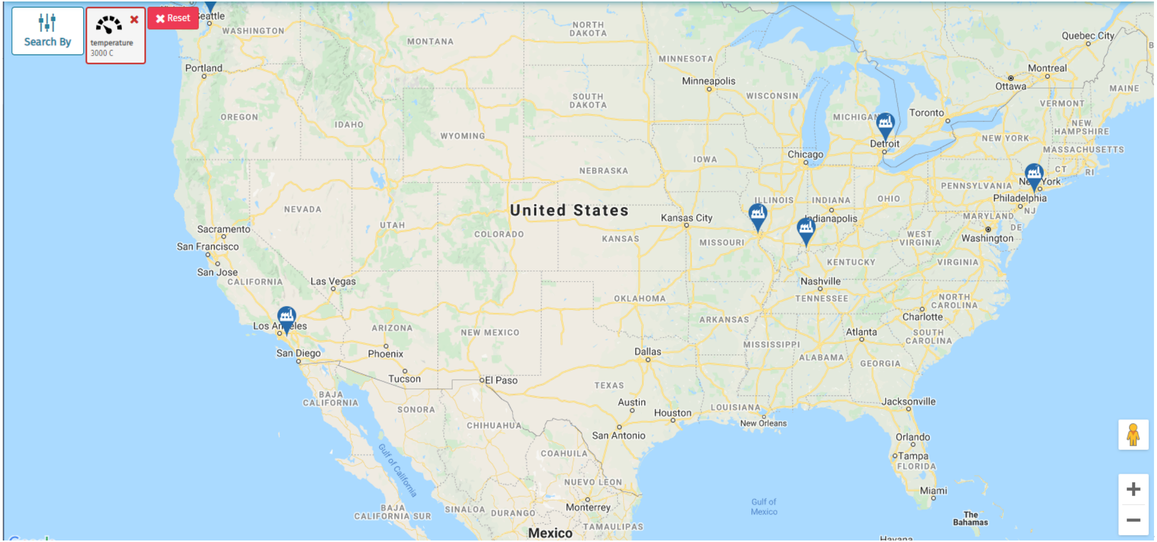
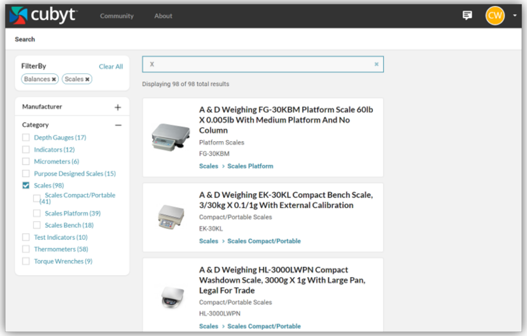
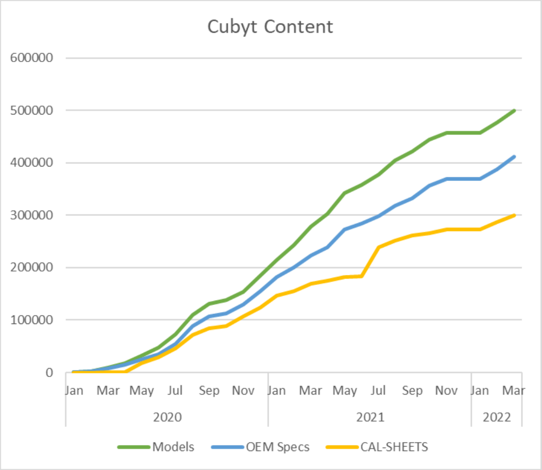


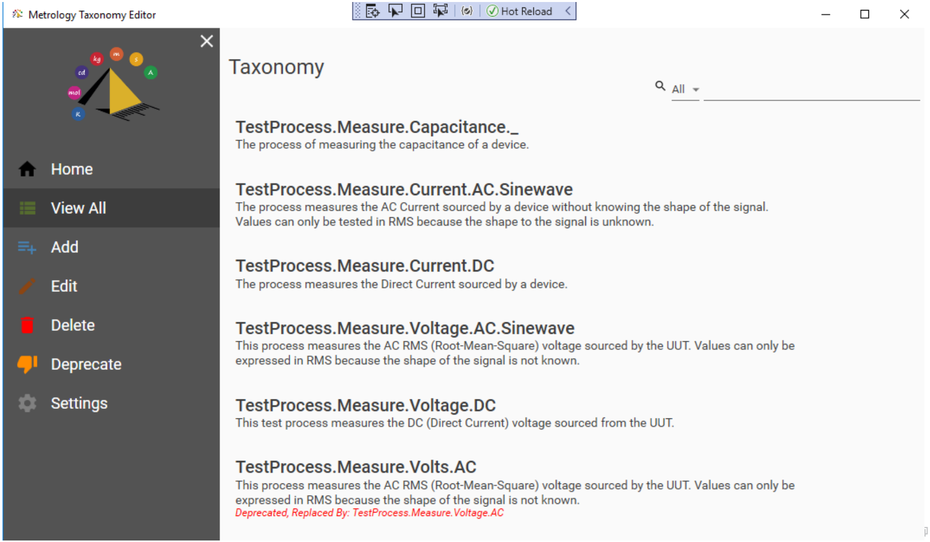
Cubyt (http://www.cubyt.io, Fluke Calibration)



Opportunities for managers to become involved and make a difference.



Taxonomy Editor (https://github.com/CalLabSolutions/Metrology.NET_Public)



SoA Editor (https://github.com/CalLabSolutions/Metrology.NET_Public)

Company Info

Cals-R-Us

- TestProcess.Measure.Voltage.DC
  - Measure DCV
    - All
    - 200mV
    - 2V
    - 20V
    - 200V
    - 1000V

Measure DCV
All

Ranges: 5
Please select a row by clicking on any of the values.

Formula

Volts *(ppm_IV/1E+6) + Volts * (ppm_Range/1E+6)
.15 *(4.5/1E+6) + .15 * (0.5/1E+6)

Volts .15

Calculate **7.50E-007**

Range	Resolution	Volts	Constants
200mV	8.5	-0.199999999 to 0.199999999	ppm_IV = 4.5 ppm_Range = 0.5
2V	8.5	-1.99999999 to 1.99999999	ppm_IV = 3 ppm_Range = 0.2
20V	8.5	-19.9999999 to 19.9999999	ppm_IV = 3 ppm_Range = 0.2
200V	8.5	-199.999999 to 199.999999	ppm_IV = 4.5 ppm_Range = 0.2
1000V	8.5	-1050 to 1050	ppm_IV = 4.5 ppm_Range = 0.5

Section 4

Panel and Audience Discussion

Section 5

Conclusion

Conclusions

Metrology in the Digital Era:

- Rethink our processes from the ground up.
- Replace our manual shortcuts.
- Discard pragmatic practices for extensible replacements.
- Champion adoption within top-level authorities.

Other Key Elements:

- An M-Layer for digital quantity representations
- Measurand taxonomy for interoperable digital documents
- Standards and specification documents (Recommended Practice)