Taxonomy for a Measurement Information Infrastructure (MII)

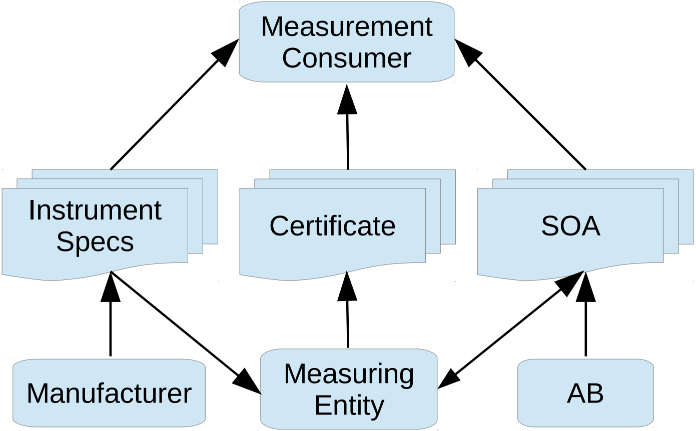
Letting Metrology Systems Talk to Each Other

Abstract

Imagine a set of normative standards that define data structures, taxonomies, service protocols and security for locating, communicating and sharing measurement information. Those standards comprise what we call a measurement information infrastructure, or MII. What if your organization's measurement, analysis and management computing systems spoke this MII language with other world-wide measurement-related systems? How would that affect your business? This session discusses the real-world benefits such an MII will create, the efforts underway to develop a common metrology language (taxonomy) for measurement data, and how you may participate.

Topics

Measurement Information Flow



Small excerpt from a vast network

MII Vision

Vision

1. Create a globally standardized infrastructure for creating, locating, communicating and processing measurement information.
2. Replace manually-processed documents with unambiguous machine-readable data.
3. Augment static web sites with smart web services.
4. Open new automation horizons and empower developers to take measurement-related software to whole new levels.
5. Lower the information barriers between testing & calibration labs, instrument manufacturers, vendors, accreditation bodies and measurement consumers.

MII Definition

Definition

Measurement Information Infrastructure–a set of normative standards that unambiguously define data structures, taxonomies, web service protocols and security for creating, locating, communicating and processing measurement information

The measurement information vehicles to structure include

- MII scopes of capability (SoCs) or accreditation (SoAs),
- MII instrument spec sheets,
- MII calibration and testing certificates.

Note that the MII itself encompasses only the open standards and infrastructure. MII-aware software then brings metrology into the modern world that airline, banking, investment, online retail and B2B industries already enjoy.

MII Motivation

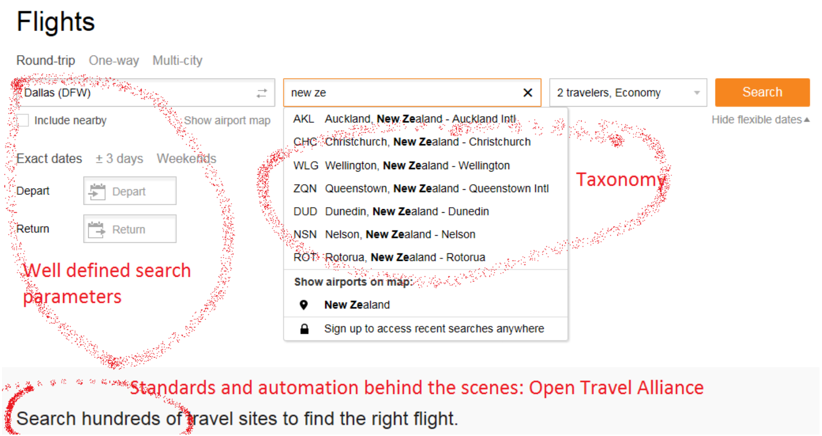
Motivation

Such an MII would eliminate ambiguity from our human-readable documents, streamline many tedious and error-prone tasks, engender new service opportunities and value streams, improve traceability, and enhance measurement quality throughout the measurement economy.

- No more tediously searching for the right instruments and service vendors
- No more manually writing, sending, interpreting documents
- No more transcribing, entering and updating information
- Our computers do it all unambiguously and automatically.

The technology already exists; we've only to harness it.

An Easier Way



Accredited Lab Search Example

Search A2LA Directory of Accredited Organizations

Search For	dry well
Commercial Status	Search commercially available scopes only
Certificate #	
Organization Name	
City	
State	
Country	
Zip	
Accreditation Field	Calibration
Sort Order	Organization Name

Search

Accredited Lab Search Example

Your query returned 24 records

Certificate#	Organization	Contact	City, State	Country	Phone	Comm Code	Field	Standard	Expiration
1009.01	Accu-Check Instrument Service, Inc.	Robert Vaughan	Lancaster, OH	United States	740 654 0500	C1	Calibration	ISO/IEC 17025:2005	07/31/2016
2171.01	ACR Technical Services, Inc.	Richard Hogan	Newport News, VA	United States	757 890 0460	C1	Calibration	ISO/IEC 17025:2005	10/31/2016
3467.01	Al Hoty Calibration Services - A Branch of Al Hoty Co. Ltd.	Wendell Arevalo	Al Khobar 31952,	Saudi Arabia	00966 3 864 4150	C1	Calibration	ISO/IEC 17025:2005	08/31/2017
2260.01	Alpha Controls & Instrumentation Inc.	Slava Peciurov	Markham, Ontario L3R 3V8,	Canada	905 477 2133 x228	C1	Calibration	ISO/IEC 17025:2005	01/31/2017
71.05	Bowser-Morner, Inc.	Robin Wolfe	Dayton, OH	United States	937 236 8805 x 226	C1	Calibration	ISO/IEC 17025:2005	01/31/2016
3781.01	Cal-Tec, Inc.	Chris Grevemberg	Broussard, LA	United States	337 839 0450	C1	Calibration	ISO/IEC 17025:2005	05/31/2017
2147.01	ENI Labs	Andrew Burd	Fort Wayne, IN	United States	260 471 6775	C1	Calibration	ISO/IEC 17025:2005	03/31/2016
2496.01	Eustis Co., Inc./Pyrocom Calibration Lab	Bill LeMesurier	Lynnwood, WA	United States	425 423 9996	C1	Calibration	ISO/IEC 17025:2005	10/31/2016

Accredited Lab Search Example

Searching for “Dry well”

Liquid-In-Glass Thermometers[3]	32 °F	0.6 °F	Comparison to digital thermometer in water bath at fixed point (32 °F)
	(68 to 662) °F	0.52 °F	Dry block calibrator

Accredited Lab Search Example

Searching for “Dry well”

Calibration of Thermocouple Wires[3] –			
Type			
J,K,T,E,R,S,C,U,N	32 °F	0.61 °F	Ice bath/precision thermometer CMART 25 calibrator, Fluke 5502A
Type J	(91) °F to (660) °F	0.43 °F	Fluke metrology well CMART 25 calibrator Fluke 5502A
Type K	(91) °F to (660) °F	0.43 °F	
Type T	(91) °F to (400) °F	0.43 °F	
Type R	(91) °F to (662) °F	0.43 °F	
Type S	(91) °F to (662) °F	0.43 °F	
Type E	(91) °F to (662) °F	0.43 °F	
Type C	(91) °F to (662) °F	0.43 °F	
Type U	(91) °F to (662) °F	0.43 °F	
Type N	(91) °F to (662) °F	0.43 °F	

Accredited Lab Search Example

Searching for "Dry well"

Indirect Verification of Rockwell Hardness Testers[3] –			
Rockwell and Portable Rockwell	HRA: (60.5 to 69) HRA (70 to 79) HRA (80 to 92) HRA	0.42 HRA 0.41 HRA 0.29 HRA	Indirect verification per ASTM E18, E110
	HRBW: (0 to 59) HRBW (60 to 79) HRBW (80 to 100) HRBW	1.5 HRBW 0.92 HRBW 0.66 HRBW	
	HRC: (20 to 35) HRC (35 to 60) HRC (60 to 80) HRC	0.59 HRC 0.51 HRC 0.47 HRC	

Centered on Measurement Data

Absolute Uncertainty Specifications

± 5 °C of Calibration Temperature

Voltage Range	Frequency Range	Absolute Uncertainty			
		AC/DC Transfer Mode ± ppm 2 Years	Measurement Mode ± (ppm of Reading + µV)		
			90 Days	1 Year	2 Years
2.2 mV	10 Hz - 20 Hz		1700 + 1.3	1700 + 1.3	1700 + 1.3
	20 Hz- 40 Hz		740 + 1.3	740 + 1.3	740 + 1.3
	40 Hz - 20 kHz		420 + 1.3	420 + 1.3	420 + 1.3
	20 kHz - 50 kHz		810 + 2.0	810 + 2.0	820 + 2.0
	50 kHz - 100 kHz		1200 + 2.5	1200 + 2.5	1200 + 2.5
	100 kHz - 300 kHz		2300 + 4.0	2300 + 4.0	2300 + 4.0
	300 kHz - 500 kHz		2400 + 6.0	2400 + 8.0	2600 + 8.0
	500 kHz - 1 MHz		3200 + 6.0	3500 + 8.0	5000 + 8.0

Similar information in all three doc types:

- Measured quantity (electric potential difference)
- Influence quantities (frequency)
- Quantity values (ranges, MPE, results, uncertainty)
- Formulas

Centered on Measurement Data

Parameter/Range	Frequency	CMC[2, 4, 5, 6, 7] (±)	Comments
AC Voltage – Generate, Fixed Points			
2 mV	10 Hz, 20 Hz, 100 Hz, 1 kHz, 10 kHz, 20 kHz, 50 kHz 100 kHz	0.02 % 0.022 %	Fluke 792 AC/DC Transfer Standard with AC Divider

Similar information in all three doc types:

- Measured quantity (electric potential difference)
- Influence quantities (frequency)
- Quantity values (ranges, MPE, results, uncertainty)
- Formulas and measurement techniques

Centered on Measurement Data

Calibration Data					
Parameter	Nominal Value	Measurement Result	Limits of Error Lower Limit	Limits of Error Upper Limit	Expanded Uncertainty
INPUT 1 ABSOLUTE AC ERROR					
2.2mV Range, 2mV Applied					
1 Year Specification Limits shown					
0.0 µV/V @ 10 Hz	0.00	XXX.X	-2350.0	2350.0	200 µV/V
0.0 µV/V @ 20 Hz	0.00	XXX.X	-1390.0	1390.0	200 µV/V
0.0 µV/V @ 100 Hz	0.00	XXX.X	-1070.0	1070.0	200 µV/V

Similar information in all three doc types:

- Measured quantity (electric potential difference)
- Influence quantities (frequency)
- Quantity values (ranges, MPE, results, uncertainty)
- Formulas

Required Taxonomy

The existing XML schema specifies the structure but we lack

- Standard names for
  - Quantity kinds (Electromagnetics, AC-Low Frequency)
  - Measured quantity (alternating current)
  - Influence quantities (frequency)
  - Input quantities (voltage, impedance, temperature)
  - Measurand qualifiers (RMS, peak, etc.)
  - Instrument types and make-models
- Structured definitions for
  - Measurement processes (general: measure alternating current)
  - Measurement techniques (specific instance, e.g. AC shunt)

Problem Example: Category and Subcategory

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) Notes 1,2

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty Note 3, 5	Remarks
THERMODYNAMIC			
HUMIDITY (20/T02)			
Humidity Generation Field calibrations available Note 4			
Relative Humidity	1E-05 % RH to 99 % RH	0.31 %	Dry Bulb temperature range of -10 °C to 70 °C
Frost Point Temperature	-90.0 °C to -70.0 °C	0.20 °C	
Dew/Frost Point Temperature	-70.0 °C to -20.0 °C -20.0 °C to 70.0 °C	0.10 °C 0.05 °C	
Humidity Measurement Frost Point Temperature	-90.0 °C to -70.0 °C	0.20 °C	
Dew/Frost Point Temperature	-70.0 °C to 70.0 °C	0.10 °C	
PRESSURE (20/T05)			
Pressure	1 psi to 600 psi	0.006 %	Ruska 2465 Piston Pressure Gage
RESISTANCE THERMOMETRY (20/T07)			
Platinum Resistance Thermometers	-80 °C to 85 °C	0.003 °C	Hart 1575/5680
END			

Wild, Wild, West of Measurement Taxonomy

Source	Category Hierarchy, General to More Specific →		
BIPM KCDB[12] & CMCs	Electricity and Magnetism	Radio frequency measurements	RF power
	Thermometry	Temperature / various services[13]	various sub-services[14]
NIST SP 811	Power		
	Temperature		
	Temperature Interval		
NCSLI RP-9	Electrical	unspecified subcategories	
	Temperature	unspecified subcategories	
NVLAP Parameter Selection List	Electromagnetics - RF/Microwave	RF/Microwave Power (R17)	
	Thermodynamic	Laboratory Thermometers (T03)	
		Radiation Thermometry (T06)	
		Resistance Thermometry (T07)	
		Temperature Indicators (T08)	
		Thermocouples (T11)	
ANAB Calibration Scope	Electromagnetic	RF/Microwave	
	Thermodynamic	-	
ISO/IEC 80000	Electromagnetism		
	Thermodynamics		
MII	Electromagnetics	RF	
	Thermodynamics	Temperature	
		Temperature Interval	

Current Efforts

- Draft measurement taxonomies.
  Efforts underway or under consideration include
  - Grouping and organizing the 250,000 CMC records
  - Solidfying a master quantity list
  - Building processes & technique definition forms
  - Outsourcing the preliminary work
  - Leveraging work done in Turkey
  - Analyzing a volunteer lab's CMCs for XML encoding
- Develop an SoA Editor
  - Significant progress made toward a local Windows application
  - Will scale to a web application
  - Use in conjunction with a volunteer lab

Initial Steps

- 2013 to present: Formulate ideas.
  - Kick off the *Metrologist* MII column. ✓
  - Uncover related projects and gather them under an MII umbrella. (ongoing)
  - Envision & imagineer applications. (ongoing)
  - Draft MII document data models. ✓
  - Stimulate interest via conferences, *Cal Lab*, etc. (ongoing)
- 2015 to 2016: Begin real work.
  - Propose a project to AB representatives at NCSLI 2015. ✓
  - Present the MII concept & feasibility at MSA 2015. ✓
  - Develop an XML unit-of-measure (UoM) schema. ✓

Accelerate

- 2016 to 2017: Expand development, gather momentum.
  - Present the draft UoM schema at NCSLI 2016. ✓
  - Hold an MII Forum at NCSLI 2016. ✓
  - Plan & start Project Beagle. ✓
  - Stand up demo MII web sites and interim host servers. ✓
  - Draft an XML scope of accreditation (SoA) schema. ✓
  - Enhance the UoM schema. ✓
  - Write a C# object model. ✓
  - Develop an SoA DB and web search tool. (ongoing)
  - Demo proof-of-concept search tools at MSC 2017. ✓
  - Revise the SoA schema. ✓
  - Begin developing an SoA editor. ✓
  - Capture all U.S. AB-issued SoAs (∼250,000 CMCs). ✓
  - Draft temperature & RF power taxonomies. ✓
  - Reform and repurpose NCSLI 141. ✓
  - Sketch an MII development roadmap. ✓

Recent Progress

- 2017 to 2018: Moving along.
  - Kick off the new NCSLI 141 MII&AC at NCSLI 2017. ✓
  - Host an NCSLI 2017 MII session and conceptual demo. ✓
  - Present XML schema enhancements at NCSLI 2017. ✓
  - Publish the MII vision. ✓
  - Re-engage ABs. (ongoing)
  - Begin taxonomy-generation online meetings. ✓
  - Complete an SoA search tool and web API. (ongoing)
  - Release an SoA editor. (ongoing)
  - Demo and train SoA editor users at NCSLI Section Meetings.
  - Draft an instrument specifications XML schema.

MII Roadmap Sketch

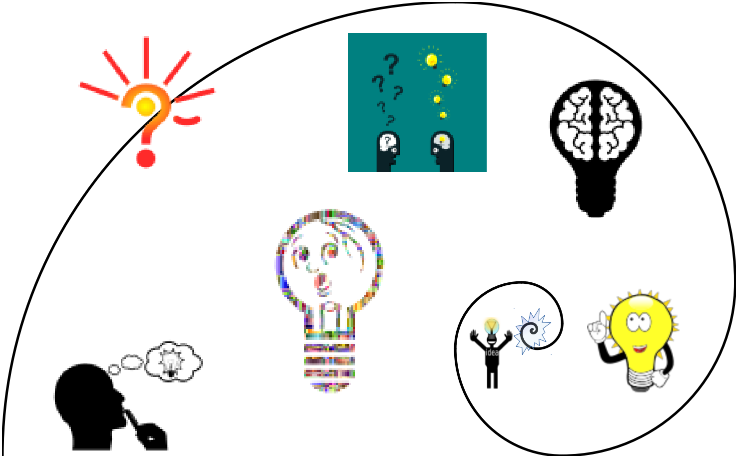
- 2018 to 2019
  - Build an instrument specifications editor.
  - Engage instrument manufacturers.
  - Draft an XML certificate schema. (Michael Johnston, Fluke)
- 2019 forward
  - Build certificate generation & editing tools.
  - Engage laboratories.
  - Establish official taxonomy and definition host sites.
  - Create human-readable document renderers.
  - Move to distributed database model.
  - Add extensibility provisions to schemas.
  - Write and release an MII documentary standard.

NCSLI 141 MII & Automation Committee Charter

1. Collect, develop, and disseminate information relative to the Metrologist magazine recurring series on MII & automation topics.
2. Develop and define data structures, taxonomies and libraries to populate MII industry documents: accreditation scopes, instrument specifications, and certificates.
3. Write the MII-defining document: e.g., RP, standard, etc.
4. Document ways for companies to support and use the MII.
5. Periodically review and update the existing NCSLI information on the band of topics.
6. Provide a point of contact for member organizations requiring assistance with the MII standard.
7. Allow members to openly participate, volunteer and create product relating to MII.

Adoption or Development First?

Simultaneously Expanding Adoption & Development



Challenges, Participation Opportunities

If this excites you, please participate:

- Research & develop taxonomies,
- Gather stakeholder advice & input,
- Discover and understand prior efforts,
- Liason with related NCSLI committees and organizations,
- Develop XML schemas,
- Develop software–MII applications or APIs,
- Maintain MII web sites,
- Coordinate and host web meetings,
- Write articles and news releases for *Metrologist*, *Cal Lab*, etc.,
- Present papers and participate on future panel sessions,
- Help develop the MII documentary standard.

To get involved. . .

Colin Walker, colin@qualer.com
Mike Schwartz, mschwartz@callabsolutions.com
Mark Kuster, mjk@ieee.org
MII community page at ncsli.org
MII wiki at miiknowledge.wikidot.com

Acknowledgments

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- Cal Lab Solutions
- Qualer
- Pantex Metrology, Cherine-Marie Kuster

Thank You for your time!