CalLab Solutions
Fusing Software With Metrology

Session 5A

Method for Verifying Measurement Uncertainties Against Your Lab's ISO/IEC 17025 Scope of Accreditation

Michael L. Schwartz

Overview

- Problem: Uncertainty Calculations made by software don’t match the SoA

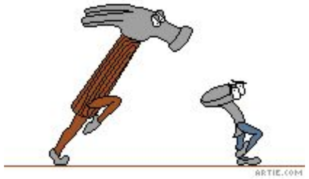
- Introduction to NCSLI 141 Committee
- Introduction to Metrology Taxonomy
- Introduction to SoA & Editor
- How we solved this problem

Learning Objectives

- Know what a RESTful call is and how it can be used in metrology.
- How standardization solves business problems.
- What the NCSLI 141 Committee is working on.

About Cal Lab Solutions

- Veteran owned business, ex-military metrologist
- Core business is **software**
  - Metrology consulting
  - Efficiencies through automation
  - Turn-key system



- Focus on finding the right solution for the customer
  - Created Metrology.NET® in 2015
  - World's largest **MET/CAL®** procedure library
  - **PS-Cal** power sensor calibration solution
  - **C#** web-based asset management system
- **Acquired Cal Lab Magazine in 2011**

KEYSIGHT TECHNOLOGIES
Solutions Partner

CAL LAB
THE INTERNATIONAL JOURNAL OF METROLOGY

Problem:

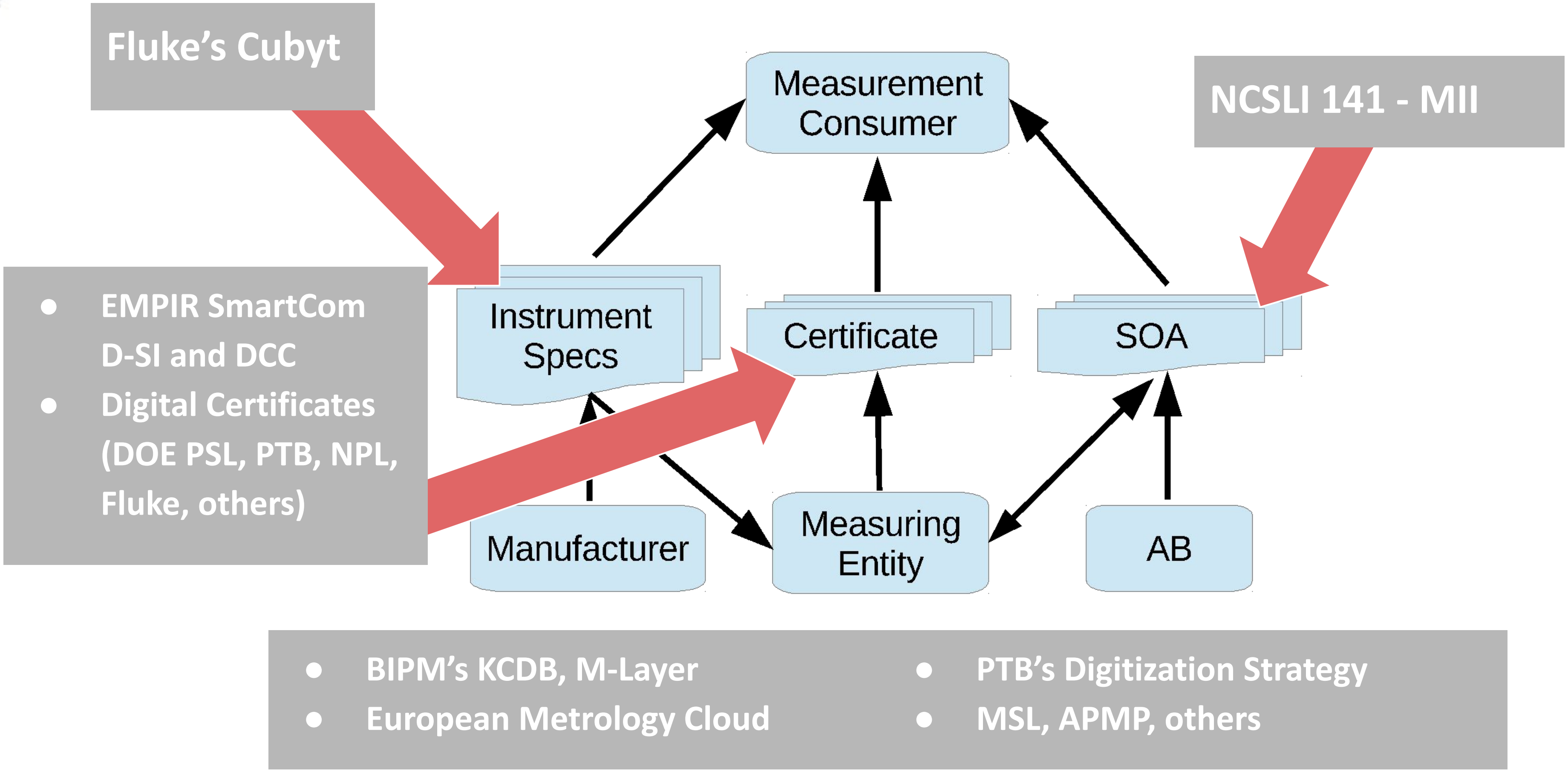
Often software will generate an uncertainty value that is lower than a calibration lab's Scope of Accreditation uncertainties.

SureCAL !=

≠

N7800/TME

NCSLI 141 Committee



Digital Metrology Overview

Current Technology SoA

Current Technology

Calculate in Excel

Copy to Word

Create a PDF

Current Technology SoA

"Dry well" Search Using Keywords

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

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			
Type C			
Type U			
Type N			

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	

Units of Measure are Ambiguous

Units of Measure aren't enough!

400 fpm
1.7 g
22 °
101 Nm
98.5 %

Units are really about "Scale"

Scale or Count of a Quantity

We need Quantity Definitions

To Exchanges data between systems
Convert between Scales

Metrology Taxonomy

Category Hierarchy

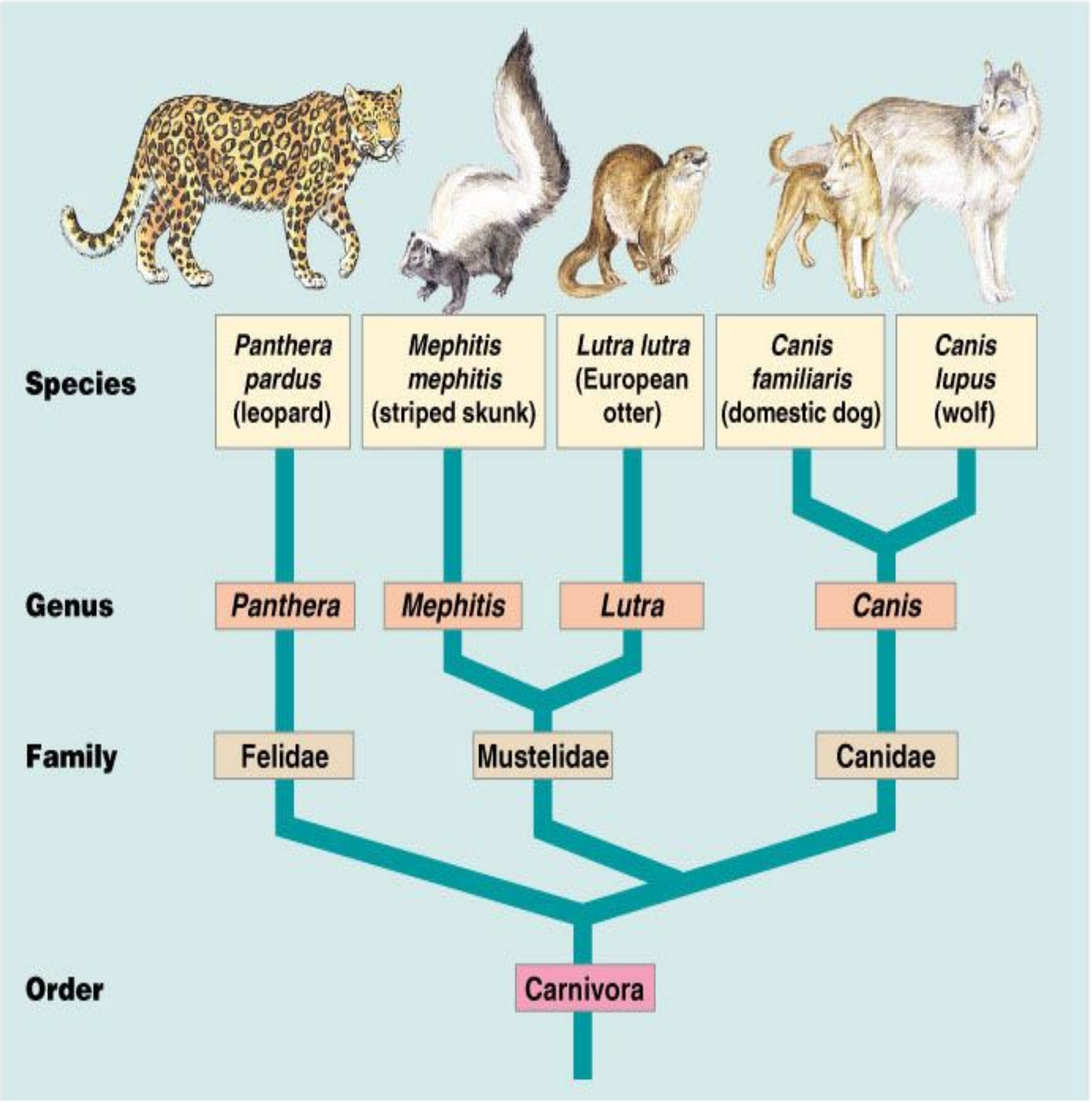
1) Source / Measure

2) Quantity Measured

3) Sub Category

Sub Category

Sub Category



Metrology Taxonomy

Example for - Source.Voltage.AC.SineWave

The process of sourcing a sinusoidal AC Voltage signal from a device.

This can be used by any device that can generate AC Sinewave Voltage.

Required Parameters

- **Volts** – Volts RMS
- **Frequency** - Hz

Measured Value & Uncertainty

- Volts

Optional Parameters

- **Impedance**
- **UUT.Range**
- **UUT.Input** – Input Name of the UUT Connecting Point

Parameter METADATA

Metadata is data about the data.

In Metrology.NET, parameters further define the specifics of a test point.

- **Source.Voltage.Sinewave**
  - Volts= 120 V
  - Frequency= 60 Hz

- **Source.Voltage.Sinewave**
  - Volts= 10 V
  - Frequency= 1 MHz

- **Source.Voltage.Sinewave**
  - Volts= 100 kV
  - Frequency= 60 Hz

Parameter METADATA

Metadata is data about the data.

By adding Metadata to an SoA it becomes easier to searcy

- **Source.Voltage.Sinewave**
  - Volts= 120 V
  - Frequency= 60 Hz
- **Source.Voltage.Sinewave**
  - Volts= 10 V
  - Frequency= 1 MHz
- **Source.Voltage.Sinewave**
  - Volts= 100 kV
  - Frequency= 60 Hz

ANAB
ANSI National Accreditation Board

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source [1]	Up to 330 mV	18 nV/mV + 2.4 µV	Fluke 5520A/SC1100 Multiproduct Calibrator
	(0.3 to 3.3) V	12 µV/V + 2.7 µV	
	(3.3 to 33) V	11 µV/V + 64 µV	
	(33 to 330) V	18 µV/V + 0.47 mV	
	(330 to 1 000) V	21 µV/V + 4.7 mV	
AC Voltage – Source [1]	(1 to 33) mV		Fluke 5520A/SC1100 Multiproduct Calibrator
	(10 to 45) Hz	0.88 µV/mV + 37 µV	
	45 Hz to 10 kHz	0.17 µV/mV + 37 µV	
	(10 to 20) kHz	0.29 µV/mV + 37 µV	
	(20 to 50) kHz	1 µV/mV + 36 µV	
	(50 to 100) kHz	3.4 µV/mV + 33 µV	
	(100 to 500) kHz	8 µV/mV + 61 µV	
	(33 to 330) mV		
	(10 to 45) Hz	0.65 µV/mV + 51 µV	
	45 Hz to 10 kHz	0.2 µV/mV + 37 µV	
	(10 to 20) kHz	0.29 µV/mV + 38 µV	
	(20 to 50) kHz	0.7 µV/mV + 38 µV	
	(50 to 100) kHz	1.2 µV/mV + 50 µV	
	(100 to 500) kHz	2.1 µV/mV + 92 µV	
	(0.33 to 3.3) V		
	(10 to 45) Hz	0.64 mV/V + 0.27 mV	
	45 Hz to 10 kHz	0.21 mV/V + 0.11 mV	
	(10 to 20) kHz	0.31 mV/V + 0.11 mV	
	(20 to 50) kHz	0.68 mV/V + 0.11 mV	
	(50 to 100) kHz	1.1 mV/V + 0.17 mV	
	(100 to 500) kHz	2.5 mV/V + 0.78 mV	
	(3.3 to 33) V		
	(10 to 45) Hz	0.64 mV/V + 2.7 mV	
	45 Hz to 10 kHz	0.21 mV/V + 1.1 mV	
	(10 to 20) kHz	0.41 mV/V + 1.1 mV	
	(20 to 50) kHz	0.89 mV/V + 1.1 mV	
	(50 to 100) kHz	2.2 mV/V + 1.6 mV	
	(33 to 330) V		
	45 Hz to 1 kHz	0.64 mV/V + 5.4 mV	
	(1 to 10) kHz	0.28 mV/V + 8.8 mV	
	(10 to 20) kHz	2.5 mV/V + 5 mV	
	(20 to 50) kHz	2.5 mV/V + 7.1 mV	
	(50 to 100) kHz	4.5 mV/V + 48 mV	
	(330 to 1 000) V		
	45 Hz to 1 kHz	0.68 mV/V + 18 mV	
	(1 to 5) kHz	0.38 mV/V + 19 mV	
	(5 to 10) kHz	0.41 mV/V + 19 mV	

Free 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

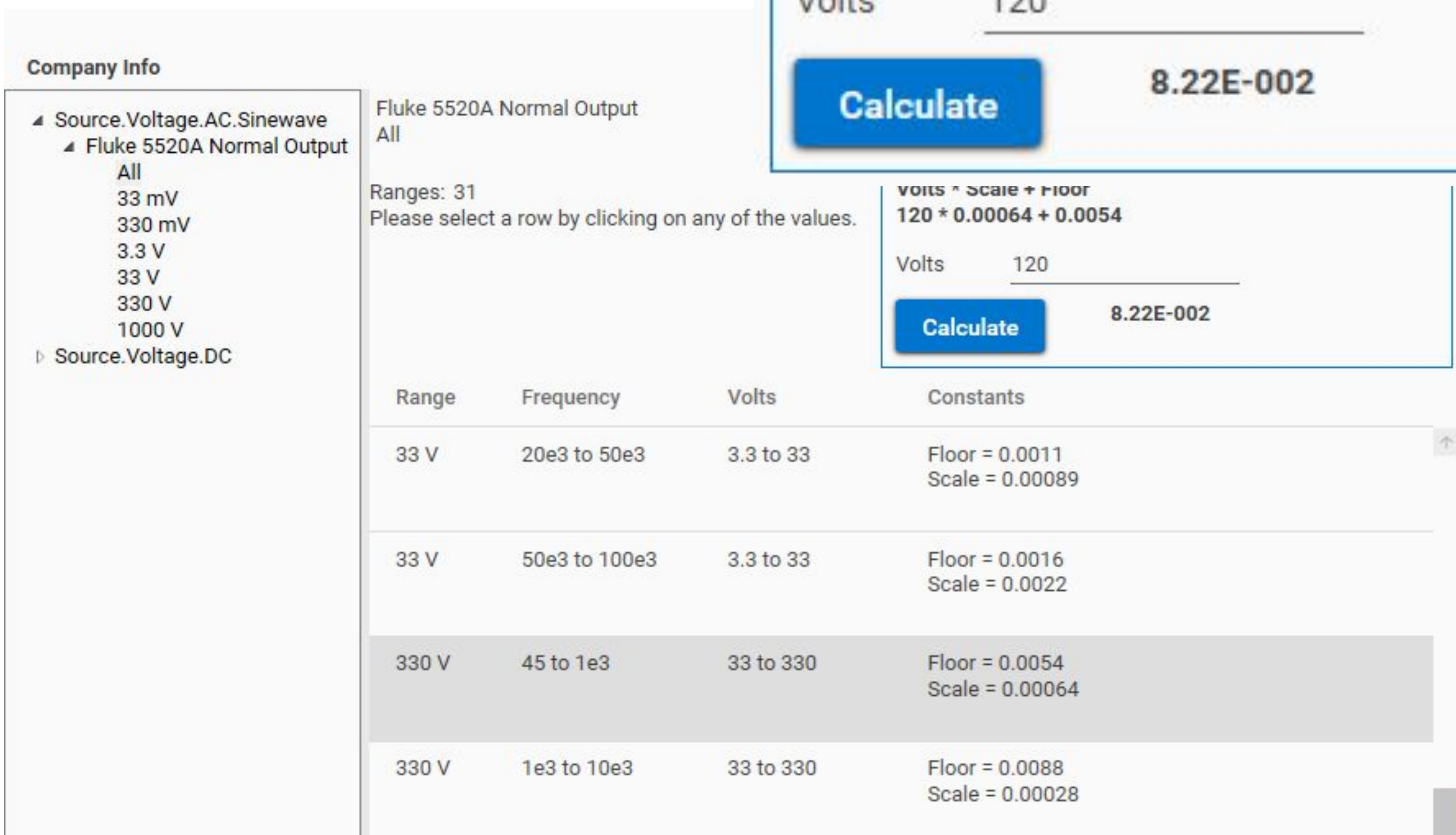
Calculate **7.50E-007**

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

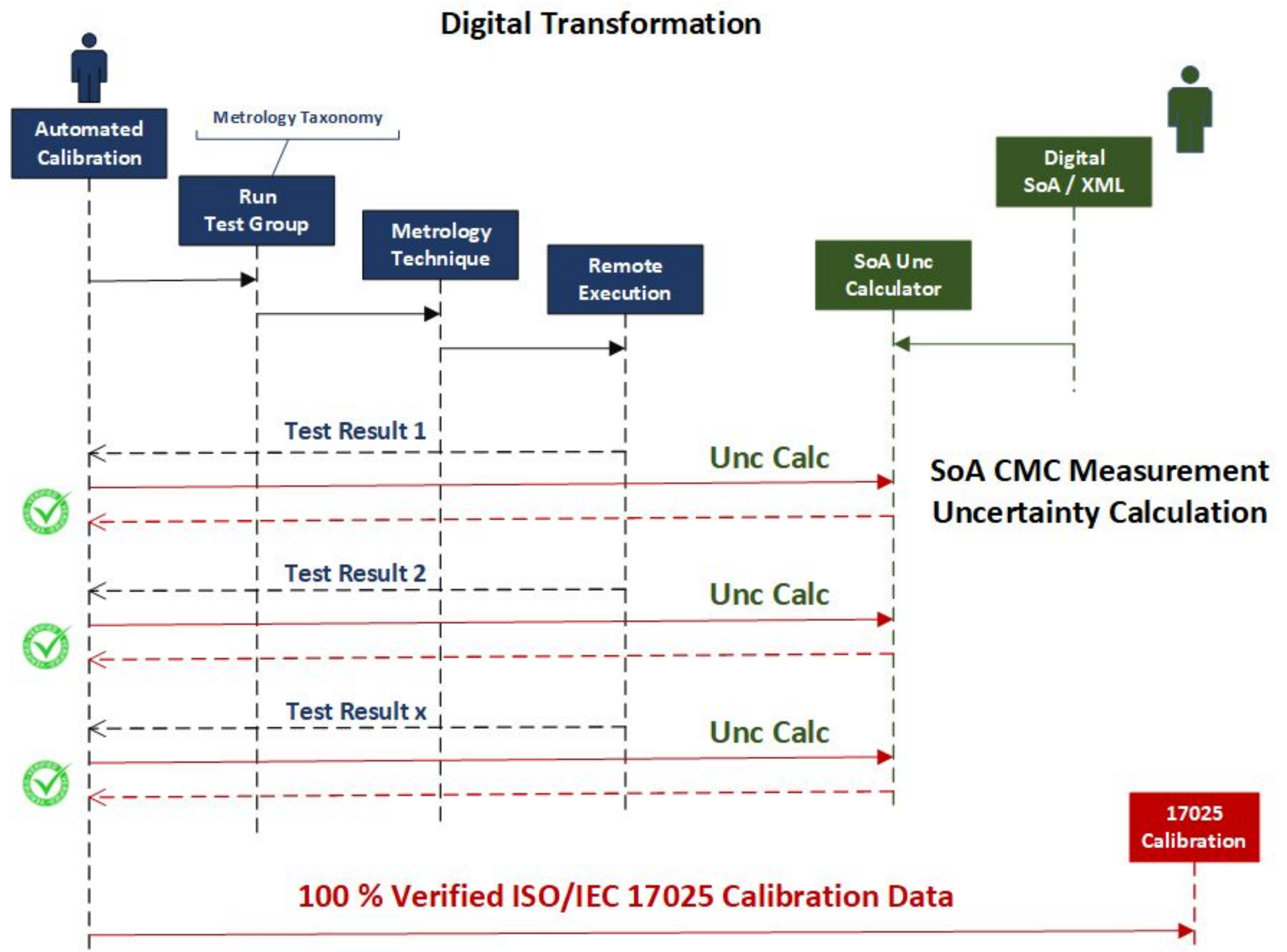
SoA Editor /Calculator

- **Source.Voltage.Sinewave**
  - Volts= 120 V
  - Frequency= 60 Hz

8.2E-2 or 0.082V



SoA Calculated Unc Check



Real World Example

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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source [1]	Up to 330 mV (0.3 to 3.3) V (3.3 to 33) V (33 to 330) V (330 to 1 000) V	18 nV/mV + 2.4 µV 12 µV/V + 2.7 µV 11 µV/V + 64 µV 18 µV/V + 0.47 mV 21 µV/V + 4.7 mV	Fluke 5520A/SC1100 Multiproduct Calibrator
AC Voltage – Source [1]	(1 to 33) mV (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz (33 to 330) mV (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz (0.33 to 3.3) V (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz (3.3 to 33) V (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (33 to 330) V 45 Hz to 1 kHz (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (330 to 1 000) V 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 0.88 µV/mV + 37 µV 0.17 µV/mV + 37 µV 0.29 µV/mV + 37 µV 1 µV/mV + 36 µV 3.4 µV/mV + 33 µV 8 µV/mV + 61 µV 0.65 µV/mV + 51 µV 0.2 µV/mV + 37 µV 0.29 µV/mV + 38 µV 0.7 µV/mV + 38 µV 1.2 µV/mV + 50 µV 2.1 µV/mV + 92 µV 0.64 mV/V + 0.27 mV 0.21 mV/V + 0.11 mV 0.31 mV/V + 0.11 mV 0.68 mV/V + 0.11 mV 1.1 mV/V + 0.17 mV 2.5 mV/V + 0.78 mV 0.64 mV/V + 2.7 mV 0.21 mV/V + 1.1 mV 0.41 mV/V + 1.1 mV 0.89 mV/V + 1.1 mV 2.2 mV/V + 1.6 mV 0.64 mV/V + 5.4 mV 0.28 mV/V + 8.8 mV 2.5 mV/V + 5 mV 2.5 mV/V + 7.1 mV 4.5 mV/V + 48 mV 0.68 mV/V + 18 mV 0.38 mV/V + 19 mV 0.41 mV/V + 19 mV	Fluke 5520A/SC1100 Multiproduct Calibrator

"BestCal" has the Fluke 5520A on their ISO/IEC 17025/2017 Scope of Accreditation.

They bought a new Fluke 5730A with an accredited calibration.

They CAN'T report better than a 5520A.

SoA Calculated Unc Check

Source.Voltage.AC.SineWave

Voltage= 3.5

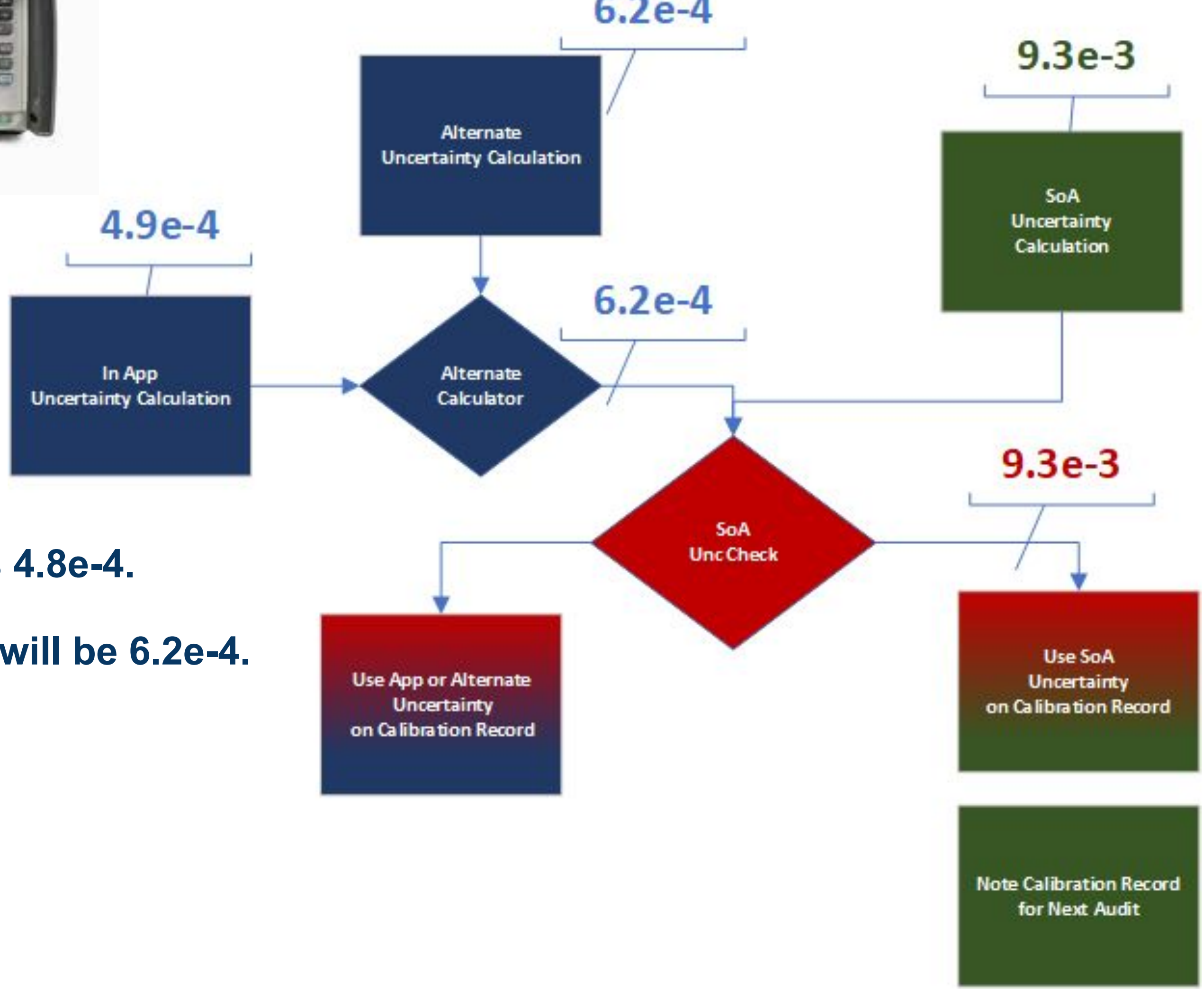
Frequency= 100e3

The software generated Unc is 4.8e-4.

When approved, the lab's unc will be 6.2e-4.

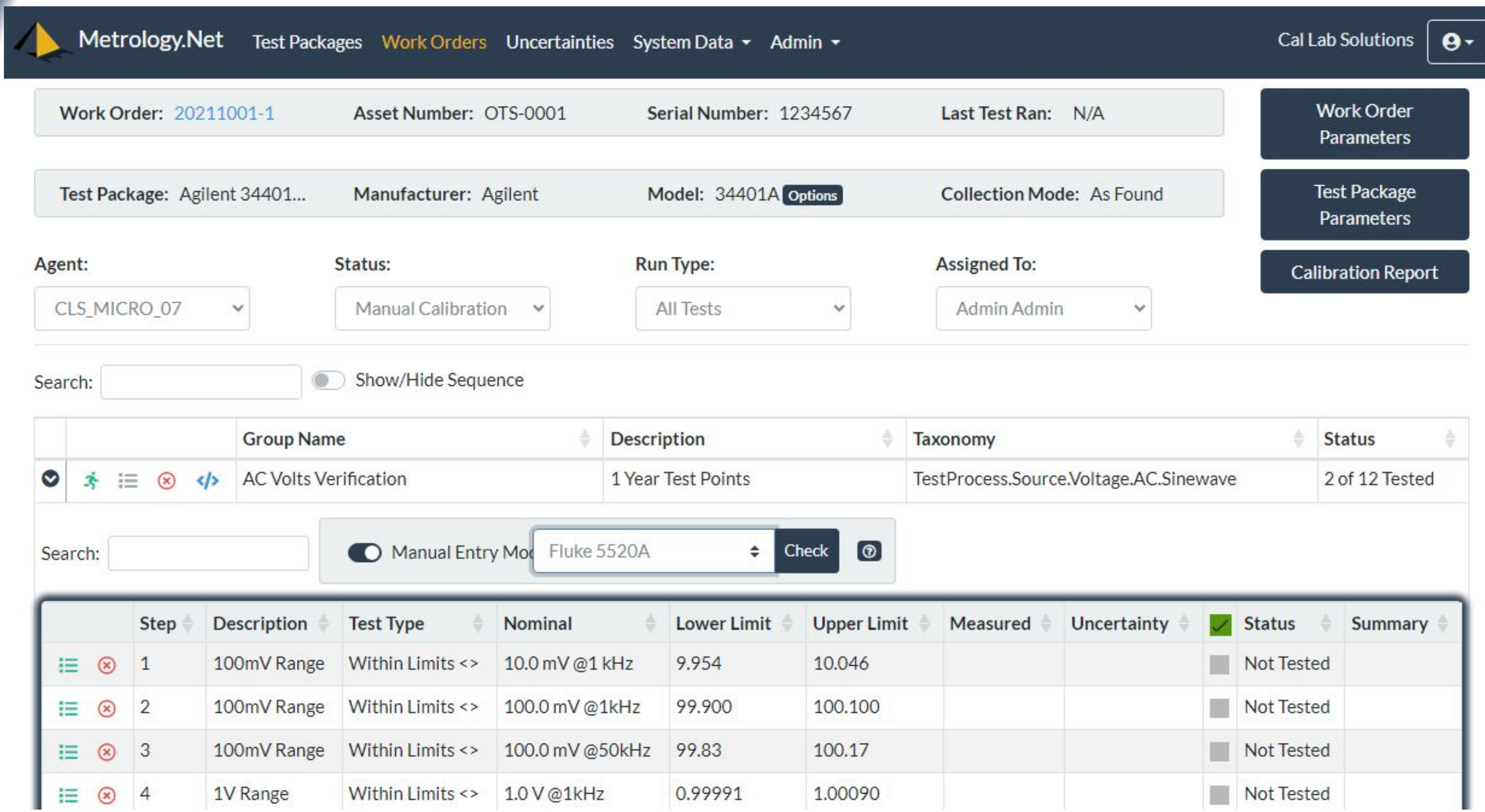
But the SoA's CMC is 9.3e-3.

So, we must report 9.3e-3.



Software in Action

Manual Entry Mode with Fluke 5520A Uncertainty Calculator



Software in Action

Green - The custom calculator's uncerty was equal to or greater than the SoA

Grey - The custom calculator's uncertainty was lower than the SoA & REPLACED

Metology.Net | Test Packages | Work Orders | Uncertainties | System Data | Admin | Cal Lab Solutions

DC Volts Gain Verification	1 Year Test Points	TestProcess.Source.Voltage.DC
AC Volts Verification	1 Year Test Points	TestProcess.Source.Voltage.AC.Sinewave

Search: | Manual Entry Mode | Fluke 5520A | Check

Step	Description	Test Type	Nominal	Lower Limit	Upper Limit	Measured	Uncertainty	✓	Status	Summary
1	100mV Range	Within Limits <>	10.0 mV @1 kHz	9.954	10.046	**10.000**	38.70E-6	✓	Passed	TUR 5.2 to 1. Confidence > 99
2	100mV Range	Within Limits <>	100.0 mV @1kHz	99.900	100.100	**100.001**	57.00E-6	✓	Passed	TUR 3.7 to 1. Confidence > 99
3	100mV Range	Within Limits <>	100.0 mV @50kHz	99.83	100.17	**100.00**	17.00E-5	✓	Passed	TUR 3.7 to 1. Confidence > 99
4	1V Range	Within Limits <>	1.0 V @1kHz	0.99991	1.00090	**1.00004**	32.00E-5	✓	Passed	TUR 2.0 to 1. Confidence 84.9
5	1V Range	Within Limits <>	1.0 V @50kHz	0.99830	1.00170	**1.00000**	12.70E-4	✓	Passed	TUR 4.7 to 1. Confidence > 99
6	10V Range	Within Limits <>	10.0 V @1kHz	9.9910	10.0090	**10.0000**	9.202E-2	✓	Passed	TUR 0.1 to 1. Confidence 15.5
7	10V Range	Within Limits <>	10.0 V @50kHz	9.9830	10.0170				Not Tested	
8	10V Range	Within Limits <>	10.0 V @10Hz	9.9910	10.0090				Not Tested	
9	100V Range	Within Limits <>	100.0 V @1kHz	99.910	100.090				Not Tested	
10	100V Range	Within Limits <>	100.0 V @50kHz	99.830	100.170				Not Tested	
11	750V Range	Within Limits <>	750.0 V @1kHz	749.325	750.675				Not Tested	
12	750V Range	Within Limits <>	750.0 V @50kHz	748.725	751.275				Not Tested	

Software in Action

Green - The custom calculator's uncerty was equal to or greater than the SoA

Grey - The custom calculator's uncertainty was lower than the SoA & REPLACED

Metology.Net | Test Packages | Work Orders | Uncertainties | System Data | Admin | Cal Lab Solutions

DC Volts Gain Verification	1 Year Test Points	TestProcess.Source.Voltage.DC
AC Volts Verification	1 Year Test Points	TestProcess.Source.Voltage.AC.Sinewave

Search: | Manual Entry Mode | Fluke 5520A | Check

Step	Description	Test Type	Nominal	Lower Limit	Upper Limit	Measured	Uncertainty		Status	Summary
1	100mV Range	Within Limits <>	10.0 mV @1 kHz	9.954	10.046	**10.000**	38.70E-6	✓	Passed	TUR 5.2 to 1. Confidence > 99
2	100mV Range	Within Limits <>	100.0 mV @1kHz	99.900	100.100	**100.001**	57.00E-6	✓	Passed	TUR 3.7 to 1. Confidence > 99
3	100mV Range	Within Limits <>	100.0 mV @50kHz	99.83	100.17	**100.00**	17.00E-5	✓	Passed	TUR 3.7 to 1. Confidence > 99
4	1V Range	Within Limits <>	1.0 V @1kHz	0.99991	1.00090	**1.00004**	32.00E-5	✓	Passed	TUR 2.0 to 1. Confidence 84.9
5	1V Range	Within Limits <>	1.0 V @50kHz	0.99830	1.00170	**1.00000**	12.70E-4	✓	Passed	TUR 4.7 to 1. Confidence > 99
6	10V Range	Within Limits <>	10.0 V @1kHz	9.9910	10.0090	**10.0000**	9.202E-2	✓	Passed	TUR 0.1 to 1. Confidence 15.5
7	10V Range	Within Limits <>	10.0 V @50kHz	9.9830	10.0170				Not Tested	
8	10V Range	Within Limits <>	10.0 V @10Hz	9.9910	10.0090				Not Tested	
9	100V Range	Within Limits <>	100.0 V @1kHz	99.910	100.090				Not Tested	
10	100V Range	Within Limits <>	100.0 V @50kHz	99.830	100.170				Not Tested	
11	750V Range	Within Limits <>	750.0 V @1kHz	749.325	750.675				Not Tested	
12	750V Range	Within Limits <>	750.0 V @50kHz	748.725	751.275				Not Tested	

CalLab Solutions
Fusing Software With Metrology

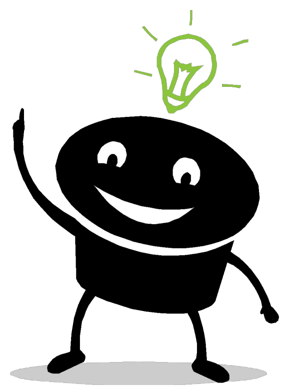
Questions? / Comments

6D Panel Discussion 1:00 PM

Gatlin E1

Metrology’s Digital Transformation

Booth #118



Michael L. Schwartz

Cal Lab Solutions

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Metrology Taxonomy

The NCLI 141 Committee meets weekly to discuss Metrology Taxonomies, M-Layer and other topics related to Digitizing Metrology

Mondays 2:00 pm Mountain Time

Gotomeeting ID 909-871-373

https://github.com/CalLabSolutions/Metrology.NET_Public

Changes in Test Equipment Interaction