

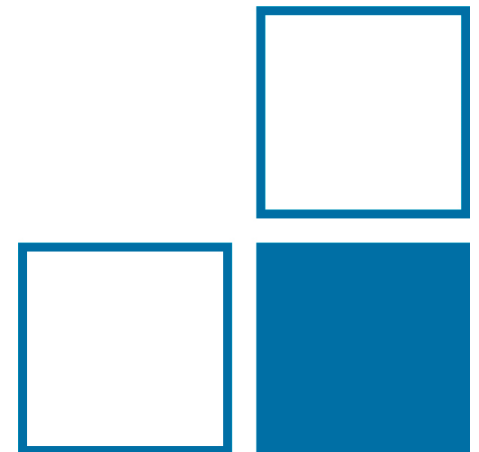


Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

The **D**igital Calibration Certificate (**D**CC)

<https://www.ptb.de/dcc>

Siegfried Hackel



ptb.de/dcc

Digital Calibration Certificate

Links /
Downloads

Development-
Platform

FAQ

Wiki

XML

Good Practice

Videos

GEMIMEG-Tool

Tutorial

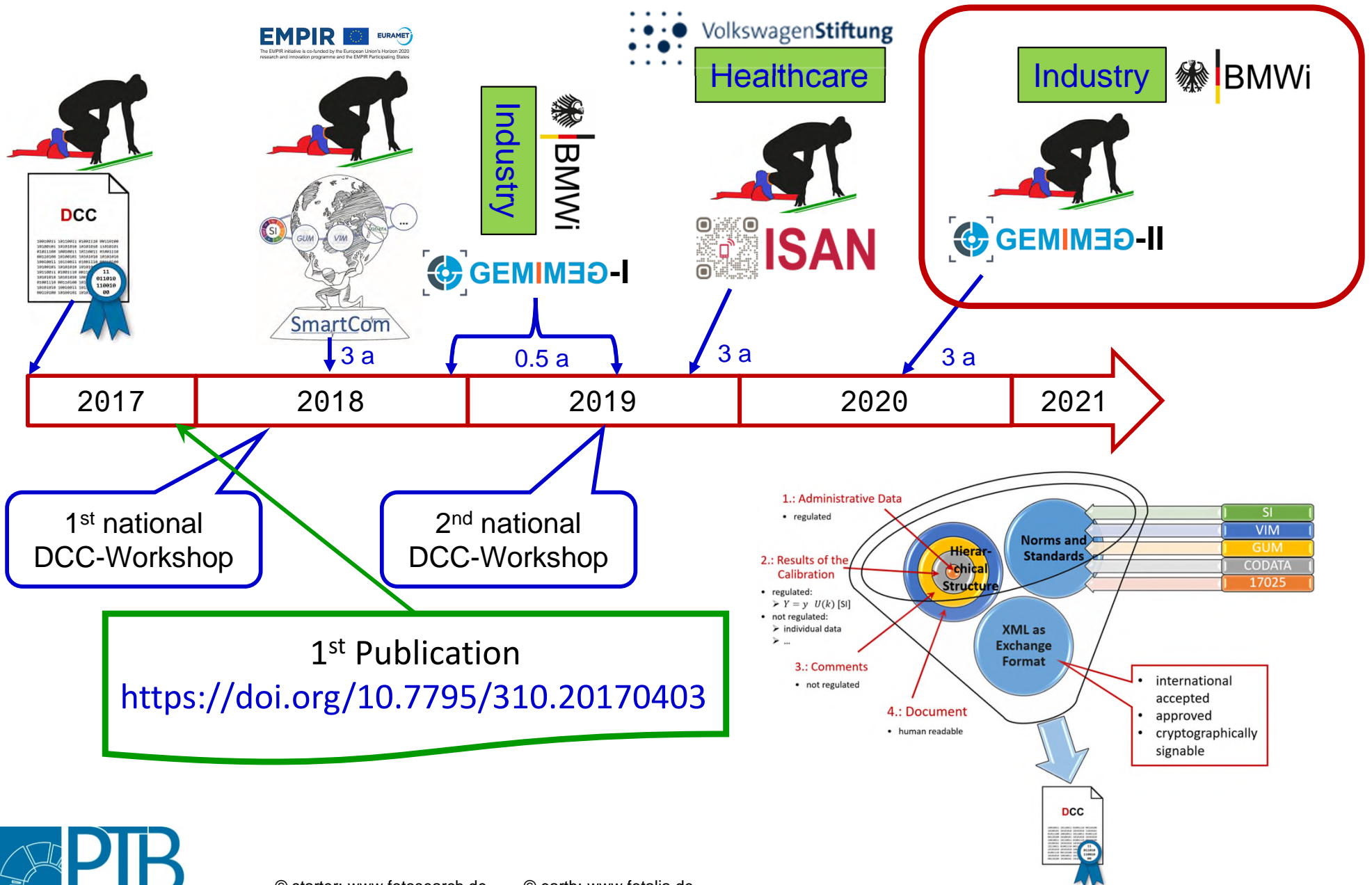
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Imprint

E-Mail



The DCC-Story



Calibrated measuring systems in the Industry 4.0-environment

**... is a lighthouse-project of the German
Ministry for Economic Affairs and Climate Action**

Start: 2020-08-01

Duration: three years

Partners

SIEMENS



U N I K A S S E L
V E R S I T Ä T



Heinrich-Hertz-Institut



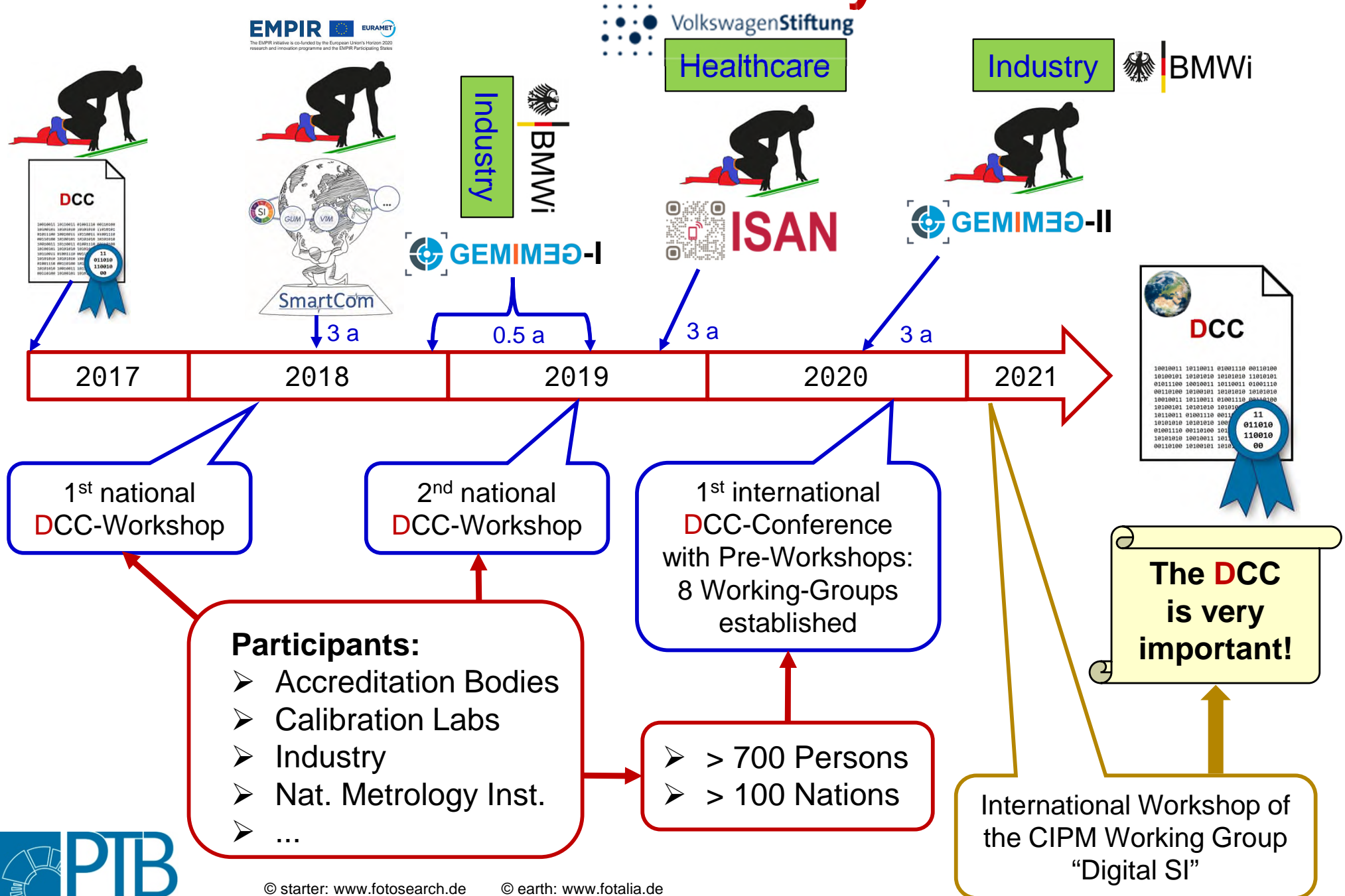
BOSCH



T · · Systems ·



The DCC-Story



Evaluation of Good Practice (GP)

Today 1:10 PM
A. Matamala
(Beamex)

POC Pharma: DCC (Temp);
DCR; DCA

GP Temperature

GP for
- Pressure
- Humidity
- Mass
- ...



1st int.
DCC-
Conference

The DCC
is very
important!

Evaluation of a
Digital SchemaX
(DX) for Digital
Certificates
(DCC; DCR; DCA;
DTC; DRM, ...)

2nd int.
DCC-
Conference
(Week No 9)

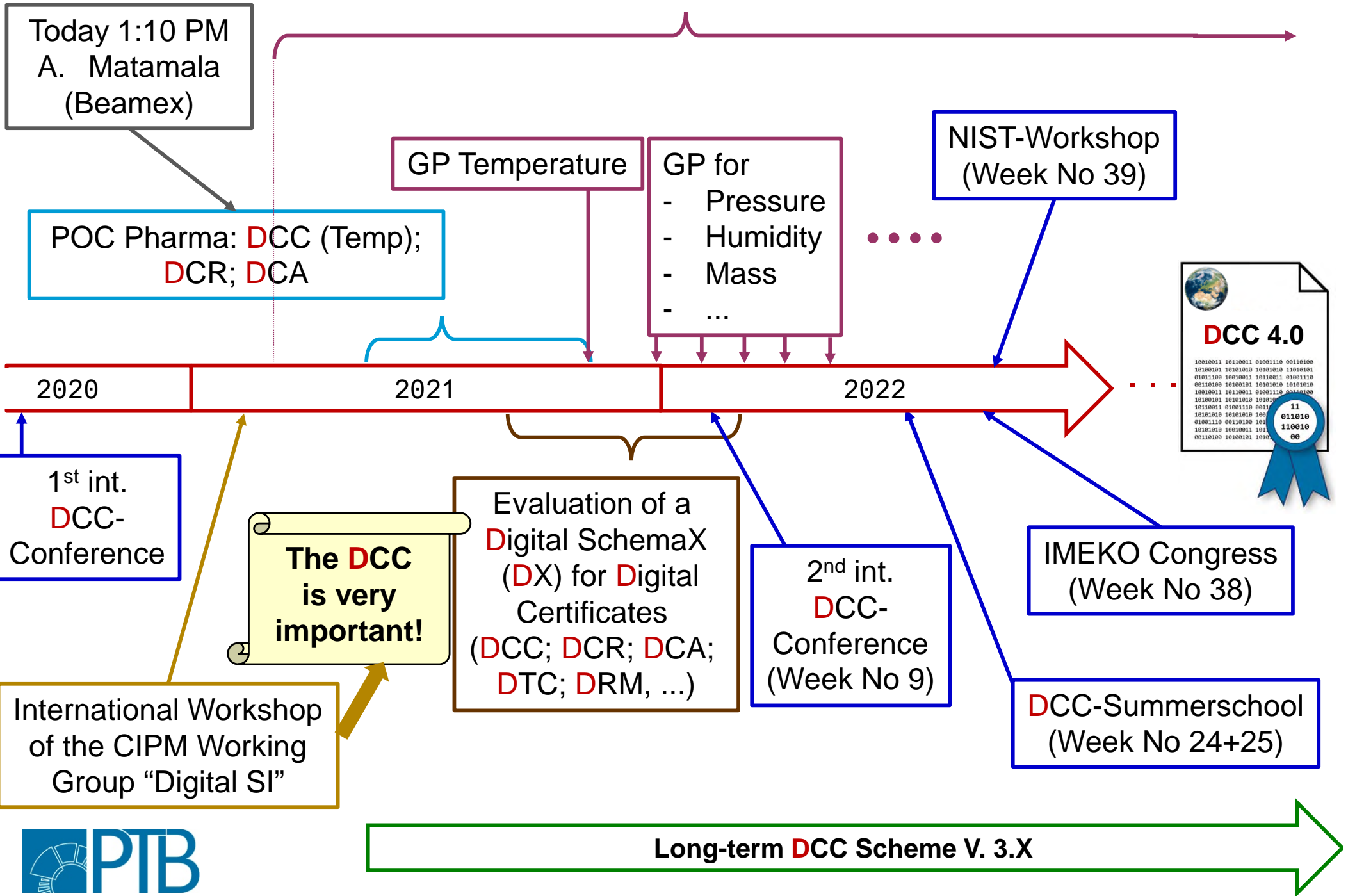


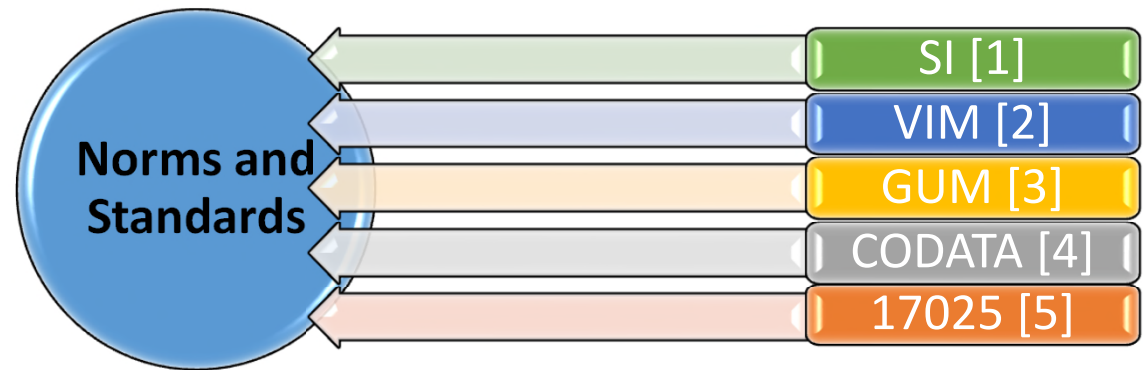
International Workshop
of the CIPM Working
Group "Digital SI"

Proceedings see:
<https://doi.org/10.7795/820.20220411>

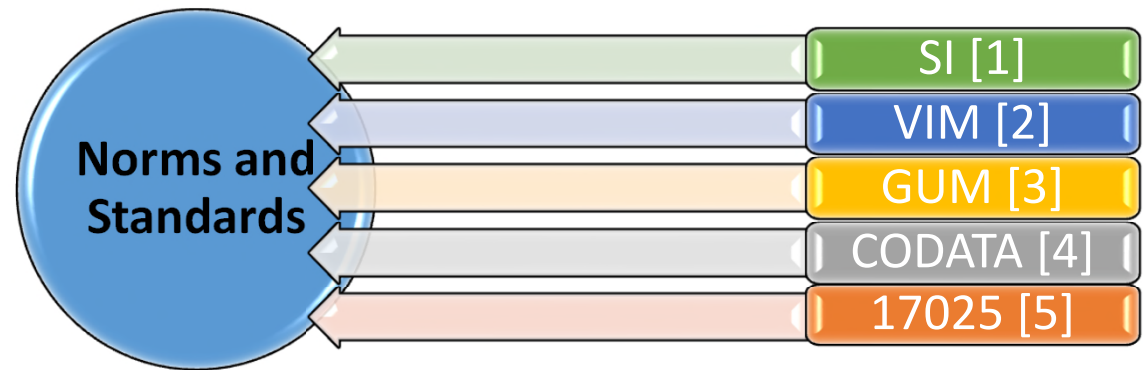
Long-term DCC Scheme V. 3.X



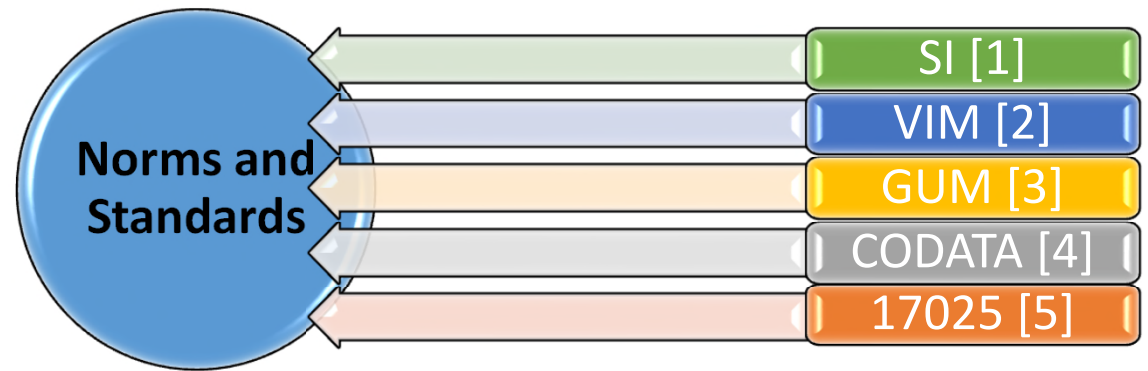




- [1] *Le Système international d'unités/The International System of Units (Brochure sur le SI/SI brochure), 2019*
- [2] Brinkmann, B.: Internationales Wörterbuch der Metrologie. Grundlegende und allgemeine Begriffe und zugeordnete Benennungen (VIM); ISO/IEC-Leitfaden 99:2007 = Vocabulaire international de métrologie. Wissen: Messwesen. Berlin, Wien, Zürich: Beuth 2012
- [3] Norm JCGM 104:2009; Juli 2009. *Auswertung von Messdaten – Eine Einführung zum "Leitfaden zur Angabe der Unsicherheit beim Messen" und zu den dazugehörigen Dokumenten (GUM)*
- [4] Mohr, P. J., Newell, D. B. u. Taylor, B. N.: CODATA recommended values of the fundamental physical constants. 2014. *Reviews of Modern Physics* 88 3, S. 337
- [5] DIN EN ISO/IEC 17025:2018-03 General requirements for the competence of testing and calibration laboratories



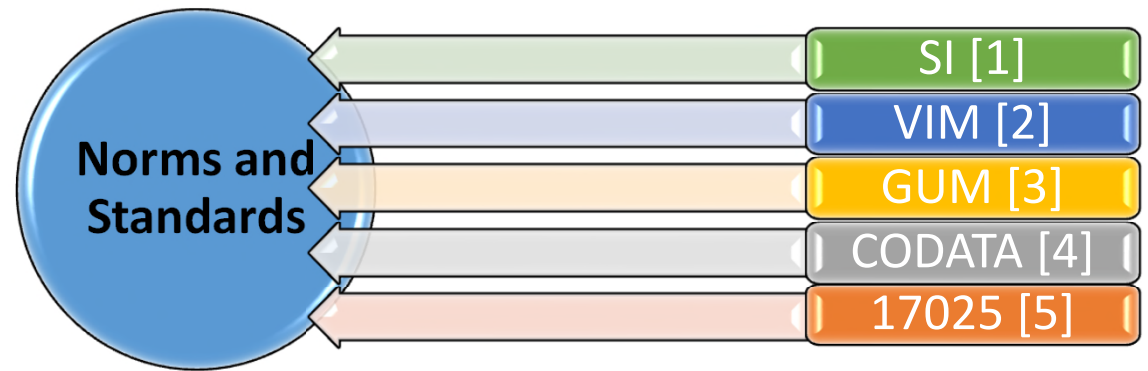
- **DCC complies with ISO/IEC 17025:**
 - ✓ Accreditation Body DAkkS has accepted this
 - ✓ Press releases on this will soon be available on the homepages



Presentation of Catherine Cooksey last week at the IMEKO-Conference:

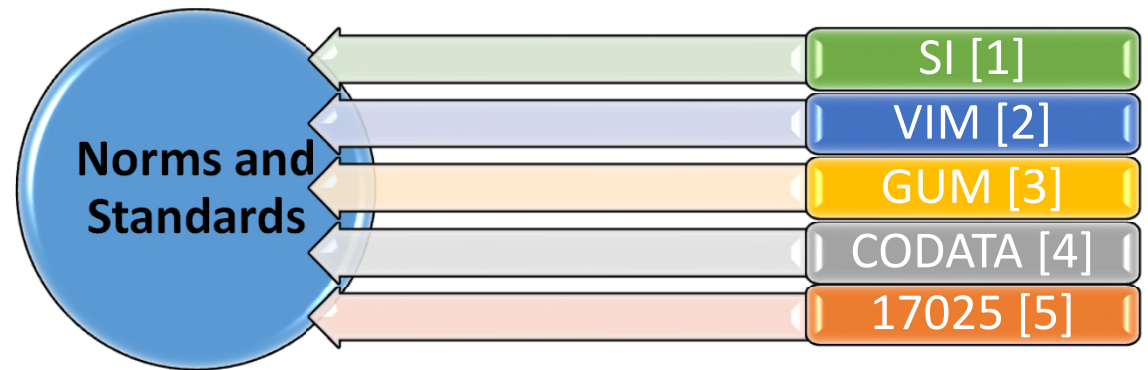
“Another important thing to consider is that **NIST issues calibration reports, not calibration certificates.**”

NIST doesn't make any adjustments or repairs to instruments or artifacts that are calibrated at NIST, and this also assures **traceability directly to the SI** or other specified standards through capabilities that NIST provides itself.”



ISO/IEC 17025:2017 Chapter 7.8.1.2:

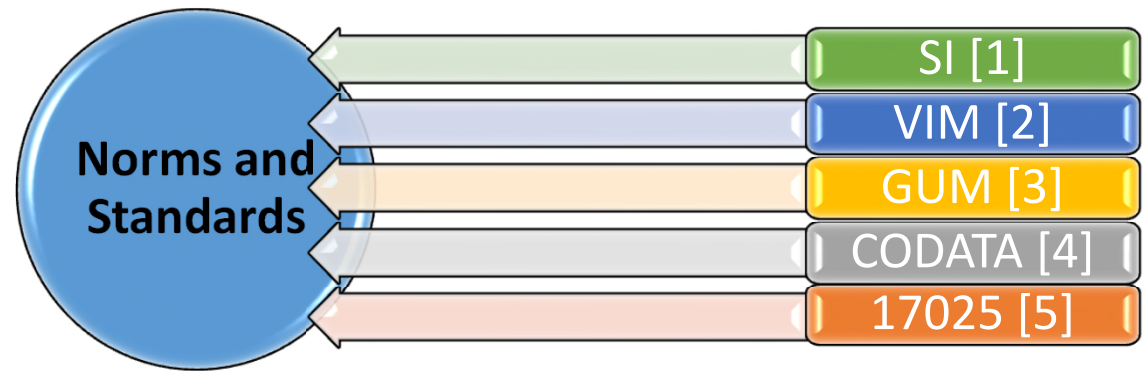
The results shall be provided accurately, clearly, unambiguously and objectively, usually in a **report** (e.g. a test report or a **calibration certificate** or report of sampling), and shall include all the information agreed with the customer and necessary for the interpretation of the results and all information required by the method used. All issued reports shall be retained as technical records.



Calibration Report ← → Calibration Certificate

- Adjustment and Repair (As found / as left)
 - ✓ ISO/IEC 17025 - compatible
 - ✓ Demanded by the customers
- Conformity
 - ✓ ISO/IEC 17025 - compatible
 - ✓ Demanded by the customers

➔ NMI and customers have different needs, which the DCC takes into account



Digital System of Units (**D-SI**), Hutzschenreuter et. al,
V. 1.3, 2019: see

<https://zenodo.org/record/3522631#.YQeLio4zbq8>

- [1] *Le Système international d'unités/The International System of Units (Brochure sur le SI/SI brochure), 2019*
- [2] Brinkmann, B.: Internationales Wörterbuch der Metrologie. Grundlegende und allgemeine Begriffe und zugeordnete Benennungen (VIM); ISO/IEC-Leitfaden 99:2007 = Vocabulaire international de métrologie. Wissen: Messwesen. Berlin, Wien, Zürich: Beuth 2012
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- [5] DIN EN ISO/IEC 17025:2018-03 General requirements for the competence of testing and calibration laboratories

The Digital SI

real quantity type <i>atomic</i>	components (of the real quantity type)			
	label	value	unit	dateTime
basic real quantity (atomic)				

mandatory

optional

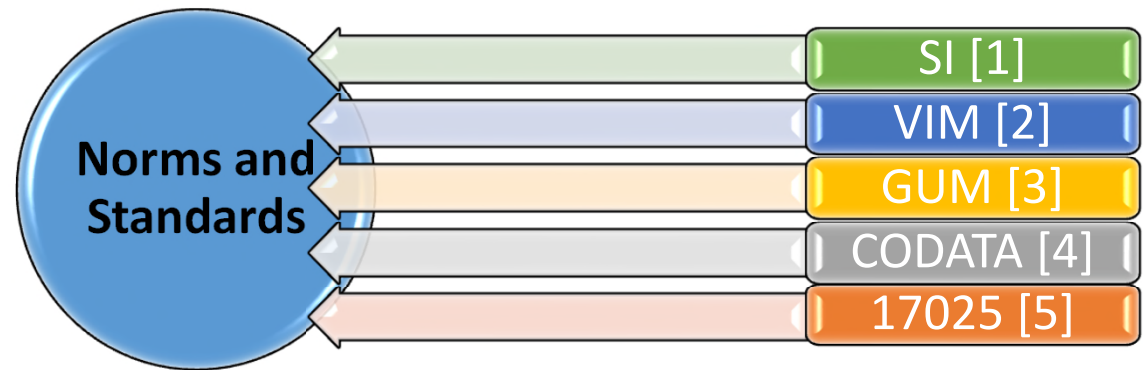
real quantity type <i>extended</i>	components (of the real quantity type)					
	label	value	unit	dateTime	expandedUnc (\$)	coverageInterval (\$)
Basic real with expanded measurement uncertainty						
Basic real with coverage interval (probabilistic-symmetric)						

sub type - expandedUnc <i>expanded measurement uncertainty for real quantity</i>	components (of the expandedUnc type)			
	uncertainty	coverageFactor	coverageProbability	distribution
expanded measurement uncertainty				

Any unit can be used!!!

Description	Kalibrierpunkt Calibration value Valeur de calibrage	Bezugswert Reference value Valeur de référence	Angezeigter Messwert Kalibriergegenstand Indicated measured value probe Sonde de la valeur mesurée indiquée	Messabweichung Measurement error Erreur de mesure	Uncertainty	Coverage Factor	Coverage Probability	Distribution Function
Label								
Unit	\kelvin	\kelvin	\kelvin	\kelvin	\kelvin			
Value(s)	306 373 448 523 593	306.248 373.121 448.253 523.319 593.154	306.32 373.21 448.36 523.31 593.07	0.072 0.089 0.107 -0.009 -0.084	0.061	2	0.95	normal

Decription	Kalibrierpunkt Calibration value Valeur de calibrage	Bezugswert Reference value Valeur de référence	Angezeigter Messwert Kalibriergegenstand Indicated measured value probe Sonde de la valeur mesurée indiquée	Messabweichung Measurement error Erreur de mesure	Uncertainty	Coverage Factor	Coverage Probability	Distribution Function
Label								
Unit	°F	°F	°F	°F	°F			
Value(s)	91.13 211.73 346.73 481.73 607.73	91.576 211.948 347.185 482.304 608.007	91.706 212.108 347.378 482.288 607.856	0.130 0.160 0.193 -0.016 -0.151	0.110	2	0.95	normal



Our philosophy is:

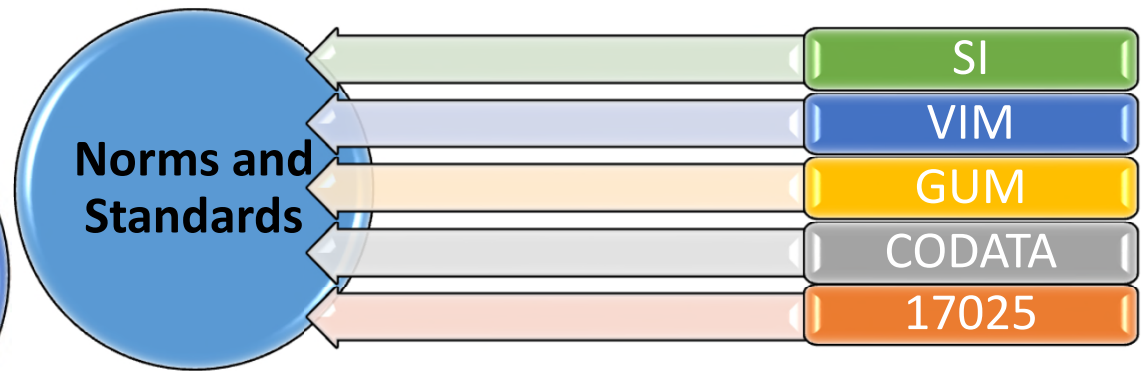
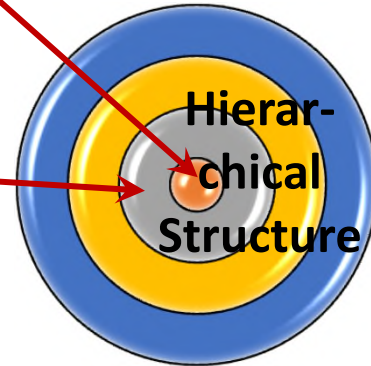
- Let the specialists in the calibration laboratory do the unit conversion!
 - ✓ Minimisation of conversion risk
 - ✓ Application of at least one SI unit
- Statement on the use of additional units:
 - ✓ Please do not calibrate blood pressure monitors in Pascal only
 - ✓ $1 \text{ mm Hg} = 1.33322 \text{ hPa}$
 - ❖ The conversion factor can be dangerous for health

1.: Administrative Data

- regulated

2.: Results of the Calibration

- regulated:
 - $Y = y U(k) [SI]$
- not regulated:
 - individual data
 - ...



- **Need for unification**
 - ✓ Machines are stupid
 - ✓ Example:
 - ❖ Ring comparison for a mass piece

Ring comparison for a mass piece ptb.de/dcc 18

Lämpötila alussa Ilmanpaine Ilman tiheys	24,0 °C 1011 mbar 1,178 kg/m ³	lopussa Kosteus	24,0 °C 56 %
--	---	--------------------	-----------------

	Tlak zraka Air pressure hPa	Temperatura zraka Air temperature °C	Relativna vlažnost zraka Relative humidity of air %RH
Početak umjeravanja	1005,7	20,90	51,3
Kraj umjeravanja	19	21,00	51,2

Temperatur Temperature	=(21,6 +/-0,2)°C
Relative Feuchte der Luft Relative humidity of air	=(51,1 +/-5,0)%
Luftdruck Air pressure	=(1012,5 +/-0,1)hPa

Temperatura media (Average ambient temperature)	Pressione media (Average atmospheric pressure)	Umidità Relativa media (Average ambient moisture)
(17,8 ± 1,0) °C	(959,5 ± 3,0) hPa	(49,0 ± 4,0) % U.R.

Temperatura otoczenia: (19,8 + 21,9) °C
Wilgotność: (30,9 + 36,7) %

	von from	bis to	Unsicherheit uncertainty k = 2
Temperatur / °C temperature	21,57	21,57	0,20
rel. Luftfeuchte / % relative humidity	45,3	45,6	2,0
Luftdruck / mbar air pressure	994,90	995,50	0,20

	from von	up to bis	Measurement uncertainty Messunsicherheit U(k=2)	
Temperatur temperature	21,64	- 22,65	0,10	°C
Rel. Luftfeuchtigkeit rel. humidity	44,0	- 46,1	1,5	%
Luftdruck Air pressure	966,7	- 990,6	0,2	mbar

Zum Zeitpunkt der Kalibrierung betrug die mittlere Luftdichte $\rho_l = 1,17 \text{ kg m}^{-3}$.
Sie wurde mit einer erweiterten Messunsicherheit von $0,03 \text{ kg m}^{-3}$ berechnet.

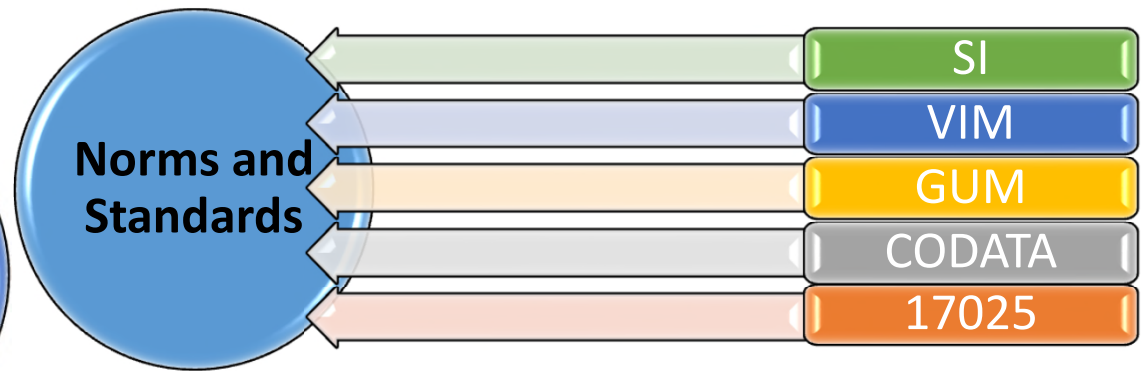
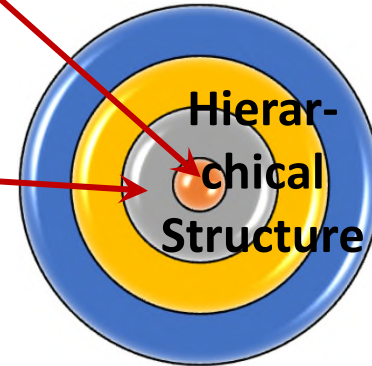
gewicht in lucht van $1,2 \text{ kg/m}^3$ in evenwicht is. De omgevings-
temperatuur tijdens de kalibratie bedroeg $(20 \pm 5) ^\circ\text{C}$.

1.: Administrative Data

- regulated

2.: Results of the Calibration

- regulated:
 - $Y = y \ U(k) \ [SI]$
- not regulated:
 - individual data
 - ...



- **Need for unification**
 - ✓ Machines are stupid
 - ✓ Example:
 - ❖ Ring comparison for a mass piece

The Utility-Model

Level 5: Machine controllable Contents

AI
Dig. Twin

Level 4: Machine readable and interpretable content



Level 3: Machine readable and executable content



Level 2: Machine readable document



Level 1: Digital document

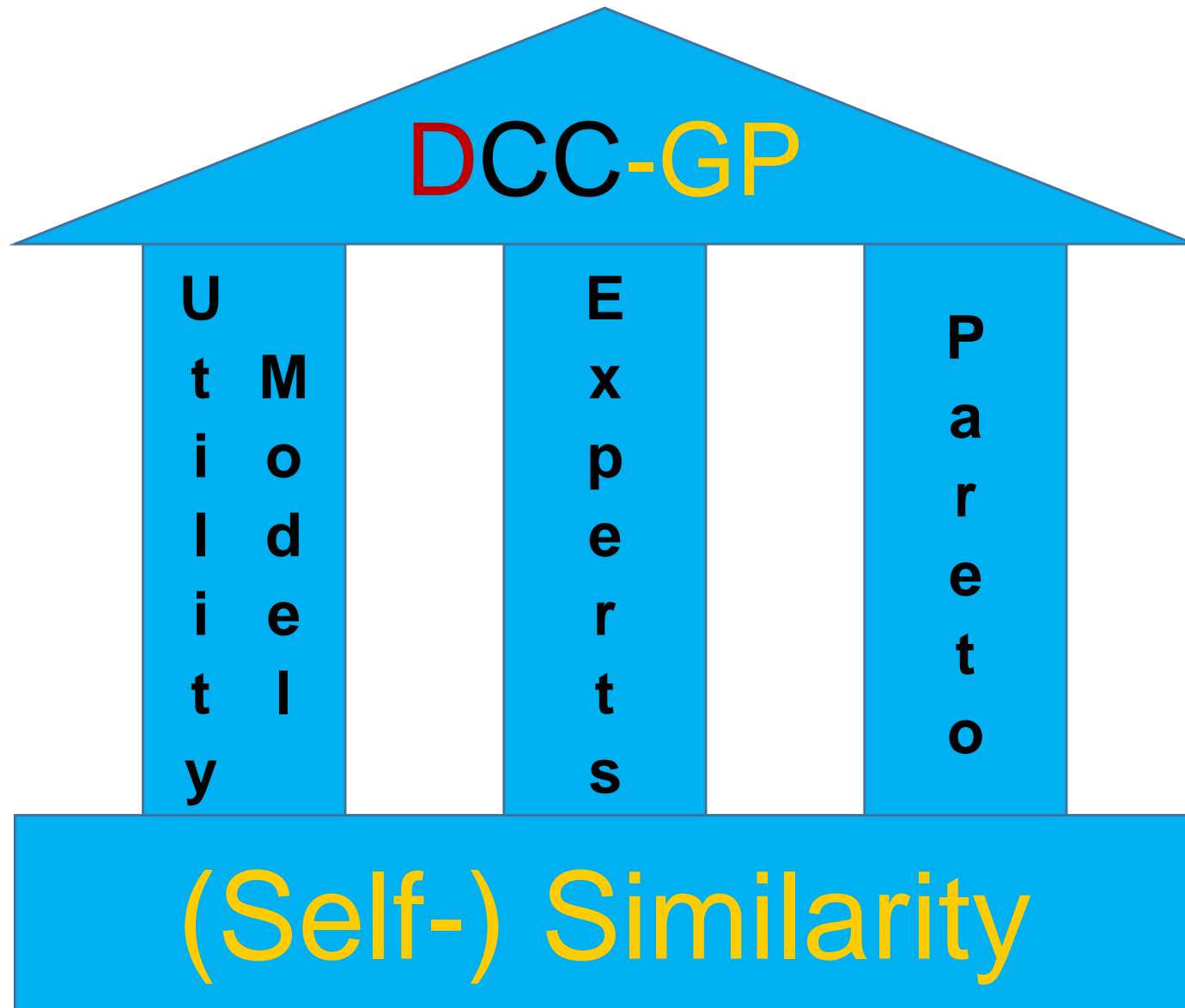


Level 0: Paper



©: www.fotosearch.de

The basic idea for DCC -GP



The Digital Calibration Certificate ptb.de/dcc 22

1.: Administrative Data

- regulated

2.: Results of the Calibration

- regulated:
 - $Y = y \ U(k)$ [SI]
- not regulated:
 - individual data
 - ...

3.: Comments

- not regulated

4.: Document

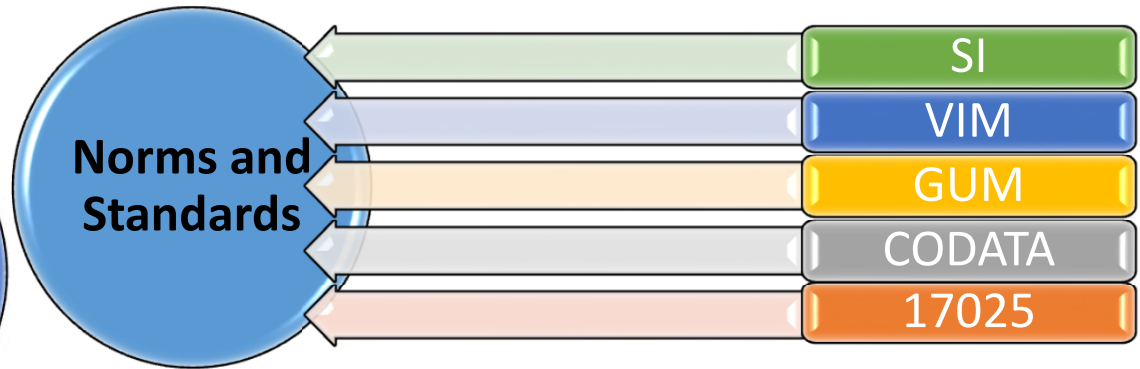
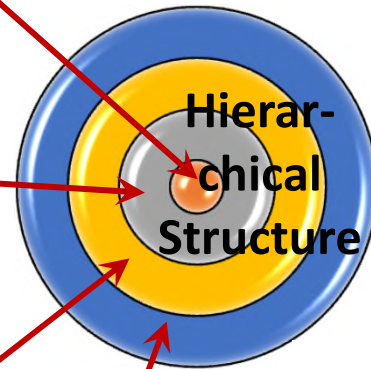
- human readable

➢ See slide 10

- ✓ Kelvin
- ✓ Fahrenheit

➢ Common tools

- ✓ Oxygen
- ✓ Altova XMLSpy
- ✓ XML Notepad (Microsoft; p. d.)
- ✓ ...

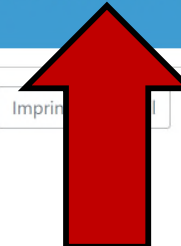


Digital Calibration Certificate

Links / Downloads	Development-Platform	FAQ
Wiki	XML	Good Practice
Videos	GEMIMEG-Tool	Tutorial

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Imprint



Example Masspeace

Description		Measurement error		Metadata		
Label	0,30 mg			refType	basic_conformity	basic_conformity
Unit	\kilogram			refId	conformityStatement1	conformityStatement3
Value(s)	0.00000030			Declaration	Conformity OIML R111-1:2004	Conformity stronger than OIML R111-1:2004
Date Time	2018-02-26T12:18:38			Conformity	pass	pass
				refType	basic_acceptanceLimitLower	basic_acceptanceLimitLower
MU	Unit	\kilogram		Description	Lower acceptance limit	Lower acceptance limit
	Uncertainty	0.00000009		Label	-0,5 mg	-0,4 mg
	Cov. Factor	2		Unit	\kilogram	\kilogram
	Cov. Prob.	0.95		Value(s)	-0.00000005	-0.00000004
	Distr. Function			refType	basic_acceptanceLimitUpper	basic_acceptanceLimitUpper
				Description	Upper acceptance limit	Upper acceptance limit
				Label	0,5 mg	0,4 mg
				Unit	\kilogram	\kilogram
				Value(s)	0.00000005	0.00000004

1.: Administrative Data

- regulated

2.: Results of the Calibration

- regulated:
 - $Y = y \ U(k)$ [SI]
- not regulated:
 - individual data
 - ...

3.: Comments

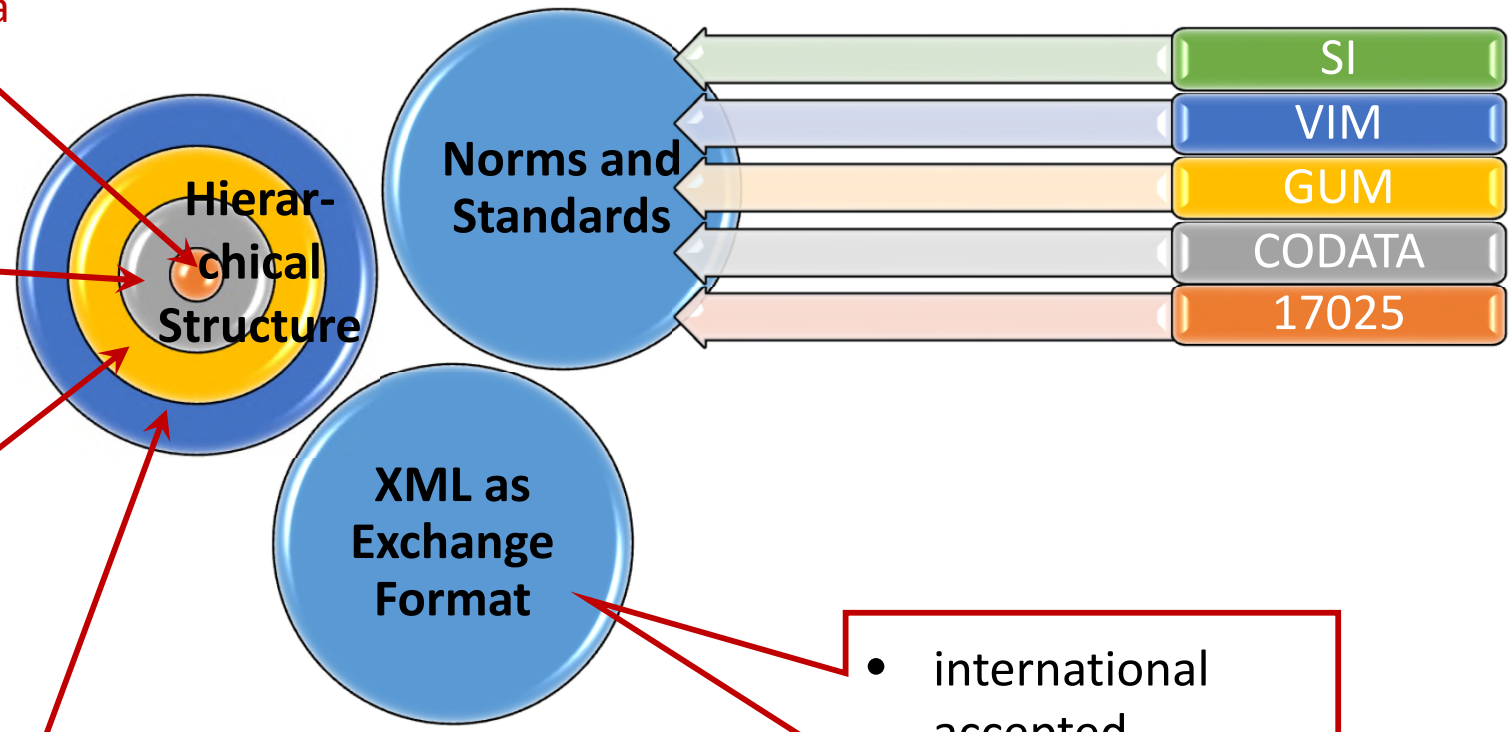
- not regulated

4.: Document

- human readable

➤ Why XML?

- ✓ Stable for more than 20 years
- ✓ Everywhere in use
- ✓ JSON Schema not yet standardized
- ✓ Trouble-free conversion to other data formats
- ✓ Established document-handling
- ✓ Long-term storage
- ✓ ...



1.: Administrative Data

- regulated

2.: Results of the Calibration

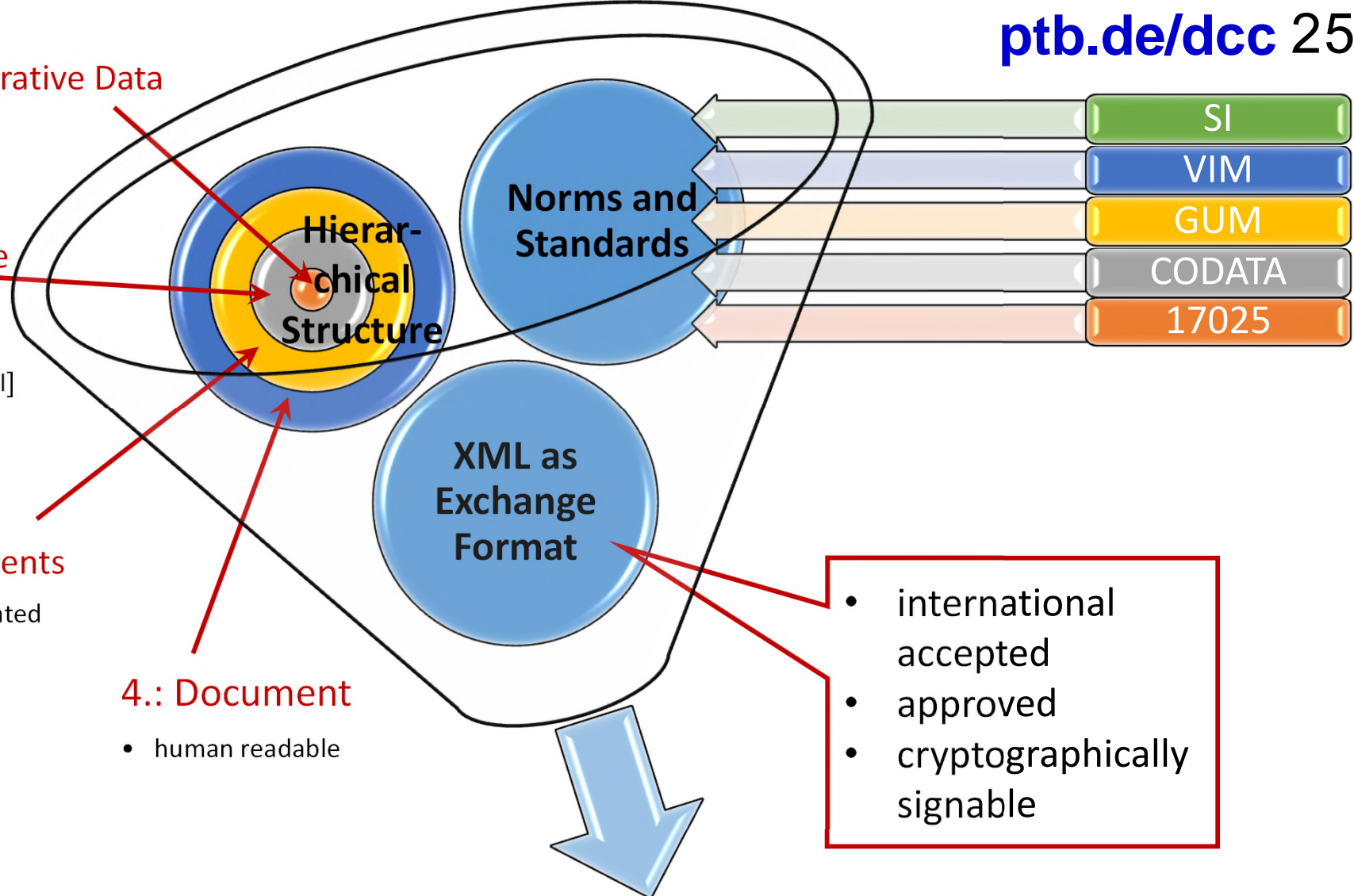
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 - ...

3.: Comments

- not regulated

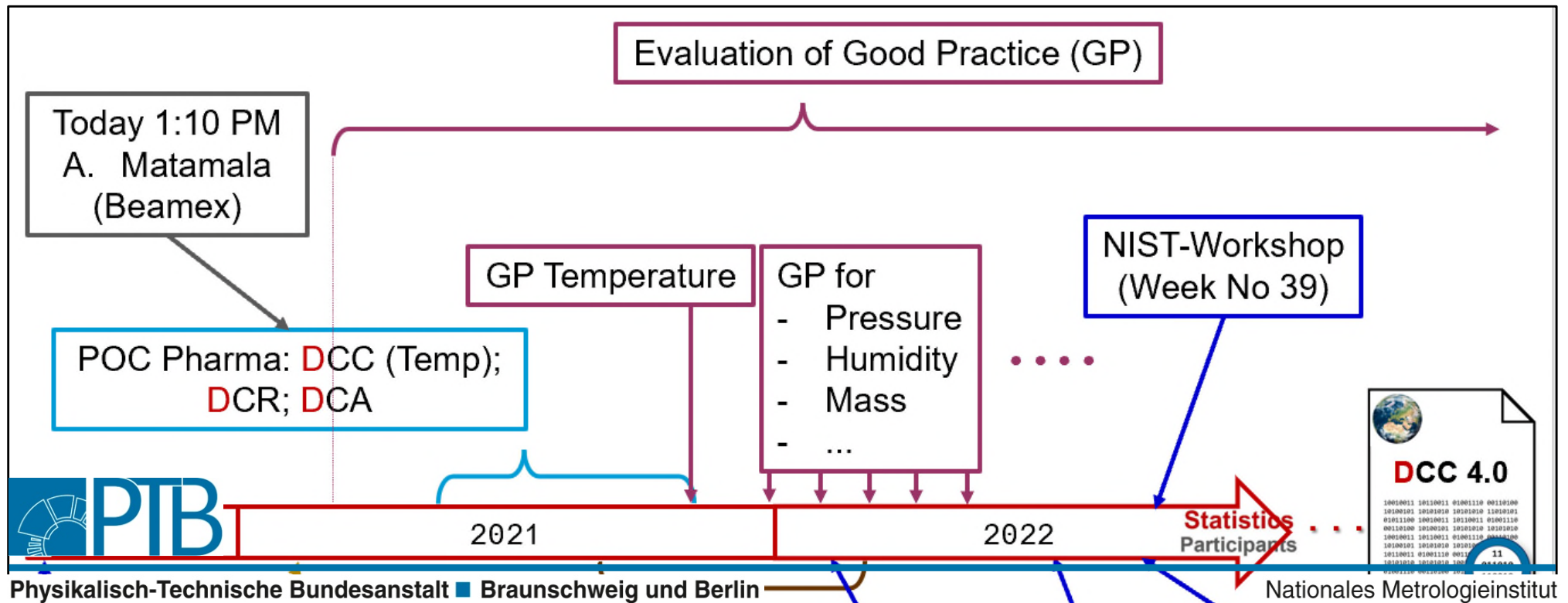
4.: Document

- human readable



Working together with all of you

- Cooperation with customers and calibration laboratories is very important
- Join us and take part in the Third International DCC Conference
- **Save the date:** 2023-02-28 to 2023-03-02 (complete online)



Working together with all of you

- Cooperation with customers and calibration laboratories is very important
- Join us and take part in the Third International **DCC** Conference
- **Save the date: 2023-02-28 to 2023-03-02 (complete online)**

Evaluation of a D igital SchemaX (D X) for D igital Certificates (D CC; D CR; D CA; D TTC; D RM, ...)	D CR: Digital Calibration Request D CA: Digital Calibration Answer D TTC: Digital Test Certificate D RM: Digital Certificate for Reference Materials
--	--

- Let us use **one language** for all **Digital Certificates**
 - **D**X can be used for all Digital Certificates
 - POC with Pharma Industry for **D**CR

Cooperation with NIST

What happened:

- NIST participates the international DCC-Conferences
- DCC Summer School – Contact
- PTB-Scientist goes to NIST in early 2023

We would like to see the following happen soon:

- Visiting scientist exchange
- High Level Expert Meeting
- Close cooperation on Digital Certificates



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Physikalisch-Technische Bundesanstalt Braunschweig und Berlin

Bundesallee 100
38116 Braunschweig
Germany

More questions? Please contact:

Dir. u. Prof. Dr. Siegfried Hackel

Phone: +49 531 592-1017

E-Mail: siegfried.hackel@ptb.de

Dr. Shanna Schönhals

-1240

shanna.schoenhals@ptb.de

www.ptb.de/dcc

2022-09-28