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## **INTERNET METROLOGY, THE NEW APPROACH TO MEASUREMENT. 45 YEARS SCIENTIFIC-TECHNOLOGICAL PROGRESS WITH IMEKO**

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**Abstract** –Measurement is one source of knowledge acquisition in complex situations. The body of knowledge about sensors, instrumentation, measurement & testing is **metrology**. Metrology became tangled and unlimited for individuals. First in history of man Internet Metrology gives the chance to collect the metrological knowledge in a branch portal and to structure it for the real needs of customers. For this challenge IMEKO is well prepared. Aim of the paper is to give stimulations for collaboration in a customer-oriented Internet Metrology (Web Metrology).

Keywords: Internet Metrology, Measurement

### 1. INTRODUCTION

"Every field of endeavour, especially in engineering, is dynamic. What we taught today is discarded tomorrow. **The problems don't change but our answers to them do change**" Peter K. Stein, Phoenix Arizona USA in his book Measurement Engineering, Stein Engineering Services Inc. Phoenix, Arizona **1964**, p. ii

"Measurement systems have been in use since the time of earliest man. However, only in recent decades has it become clear to many that there exists an underlying collection of fundamentals that is applicable, in part or whole, to all measurement situations regardless of how diverse the applications appear to be" Peter H. Sydenham Adelaide, Australia in his book Handbook of Measurement Science, John Wiley & Sons, Chichester New York **1982** p. xi

"Measurement, and the instrumentation by which it is implemented, is the basis of natural science, a key enabling technology of automatic control and the management of machines and processes, an essential requirement of trade and an essential tool of quality monitoring and assurance. It is, to an ever increasing extent, the means of medical diagnosis and control of treatment and an essential means of monitoring and preserving the natural environment. It has substantial economic significance" Ludwik Finkelstein and Ken T. V. Grattan in their Concise Encyclopedia of Measurement & Instrumentation, Pergamon Press, Oxford, **1994**, p. xv.

"Measurement is a fundamental process for all human beings, and indeed for all animals and plants. All of these sense and process information derived from their environment. Measurement is also a fundamental process of the functioning of society" Komyo Kariya and Ludwik Finkelstein in their book Measurement Science. A Discussion, Ohmsha IOS Press, Amsterdam, Oxford **2000**, p. x.

### 2. ACTIVITIES OF IMEKO FOR THE DEVELOPMENT AND PROPAGATION OF METROLOGY

The authors cited in the introduction are leading specialists in the measurement community. Many decades they are active in IMEKO. They have experienced the permanent increasing demands to the International Measurement Confederation and the shifting of the centres of interest. New Technical Committees of IMEKO have broadened the scope on measurement. A unified approach in measurement accepted by all technical disciplines and persons as a fundamental curriculum is still open. It might be explained with the following situations concerning measurement (Table 1):

- complex structure
- big number of branches
- quick development
- low standardization
- specialized application.

TABLE 1. Establishment of IMEKO TCs

<b>Technical Committees established in IMEKO</b>	<b>1950</b>	<b>1960</b>	<b>1970</b>	<b>1980</b>	<b>1990</b>	<b>2000</b>
Foundation of IMEKO	58					
Photonics		62	x	x	x	x
Education & Training		67	x	x	x	x
Force, Mass & Torque		67	x	x	x	x
Traceability in Metrology			72	x	x	x
Hardness			73	x	x	x
Measurement Science			73	x	x	x
Vocabulary			74	x		
Flow			76	x	x	x
Technical Diagnostics			76	x	x	x
Metrological Infrastruct.			76	x	x	x
Temperature			79	x	x	x
Biology & Medicine				80	x	x
Geometrical Quantities				80	x	x
Electrical Quantities				84	x	x
Experimental Mechanics				84	x	x
Pressure & Vacuum				89	x	x
Robotics				87	x	x
Human Functions					98	x
Environmental Measurem					99	x
Construction Industry					99	x

It might be also explained with the shifting interests within the IMEKO TCs, following the scientific-technological progress with open end (Table 2). IMEKO TC1 has in 2001 started a web-based working style for workshops in education and training for measurement and instrumentation.

TABLE 2. Scopes of IMEKO TC1 and TC7 Conferences

Centres of interests of IMEKO TC1 and TC7	19 50	19 60	19 70	19 80	19 90	20 00
Higher Education Rostock/Berlin		68				
Information Processing in Measurement. Pezinok		69				
Problems of Information Processing. Budapest			71			
Measurement Theory Dresden			73			
Measurement. Error Analysis. Enschede			75			
Nature & Scope of Measurement Science. London			75			
Nature & Scope of Measur. Science. Armidale			76			
Statistical Methods in Measurement. Leningrad			78			
Computerized Measurement. Dubrovnik				81		
Application of Micro-computers. Zagreb				81		
Maintenance & Calibration. Zagreb				83		
Measurement & Estimation. Bressanone				84		
Intelligent Measurement Jena				86		
Signal Processing in Measurement. Budapest				87		
Knowledge Based Measurement. Karlsruhe					90	
Artificial Intelligence Based Meas. Kyoto					91	
Advances of Measurement Science. London					93	
Quality Measurements Brussels					96	
Education & Training in Microsensors. Erfurt					98	
Advances in Measurement Science. Kyoto					99	
<b>1<sup>st</sup> Internet-Workshop:</b> Tools for Educ. Tampere						01
Virtual & Real Tools for Education. Enschede						01
<b>2<sup>nd</sup> Internet-Workshop:</b> Tools for Educ. Tampere						02
Challenges of New Technologies. Wroclaw						02

Finally it might be explained with the history of unifications in legal, theoretical and applied metrology. Landmarks of unification and world wide standardization are shown in Table 3. The introduction of fundamental terms and definitions and of guides to the expression of uncertainties in measurements took some hundred years.

TABLE 3. Standardizing measures in metrology

Decade of the Century	19 50	19 60	19 70	19 80	19 90	20 00
<b>Base Units of the International System</b>						
Metre, Second, Kilogram,	46	x	x	x	x	x
Ampere, Kelvin, Candela	54	x	x	x	x	x
International System SI		60	x	x	x	x
Mol			71	x	x	x
<b>Fundamental Physical Constants</b>						
1 <sup>st</sup> CODATA Set			73	x		
2 <sup>nd</sup> CODATA Set				86	x	
3 <sup>rd</sup> CODATA Set					98	x
<b>Terms &amp; Definitions, Rules &amp; Style Convent.</b>						
Internat. Vocabulary VIM					93	x
Measuring Equipment					96	x
Rules&Style Conventions					99	x
<b>Guide to the Expression of Uncertainties in Meas</b>						
GUM BIPM				80		
GUM CIPM				86	x	
GUM ISO					95	x

### 3. RECENT TRENDS IN TECHNOLOGY AT THE BEGINNING OF THE 3<sup>rd</sup> MILLENNIUM

Information society technologies (IST) are big challenges and chances for metrology. Sensors, instrumentation and measurement are fundamental sources of new knowledge in complex situations (see chapter 1). Selected trends in technologies for information societies are compiled in Table 4. Drivers for this development are not only a smaller number of large enterprises but recently also a very big number of small and medium sized enterprises (SME) with limited resources.

TABLE 4. Recent trends in information societies

ubiquitous compatible & flexible computing	Laptop, Tablet & Pocket PCs
ubiquitous networking	Internet & Ethernet
ubiquitous mobility	Bluetooth & Cell phones
ubiquitous knowledge bases	Home Pages & Portals
unified operation system	MS Windows
unified communicat. software	MS Office
unified communicat. language	English
unified customer expectations from SME	Comfort & Affordability for SME

The application of the Internet runs through a number of stages from the location of first simple "now I see" experiences till collaboration as standard:

- 1<sup>st</sup> stage: Be present in the Internet is in (learning & acclimatization)
- 2<sup>nd</sup> stage: Flash, sounds and banners are beautiful (acceptance & entertainment)
- 3<sup>rd</sup> stage: Self presentation with logo, slogan & special effects is nice (ingenious & confusing)
- 4<sup>th</sup> stage: Self organization for administration via Internet is standard (efficient & comfortable)
- 5<sup>th</sup> stage: Collaboration via Internet is standard (wireless, compatible, real-time & open, every time, every where).

#### 4. HOME PAGES & PORTALS FOR BODIES OF KNOWLEDGE IN LEGAL, THEORETICAL & APPLIED METROLOGY

Metrology to-day is for individuals tangle and borderless. First in history of man Internet Metrology is an innovative tool and working principle that gives the chance to collect and systematize abundant sensor, measurement & test knowledge in Web sites. This knowledge can be structured and used by every one, every where & every time on standardized equipment. Internet applications in small and mediums sized enterprises SME at present are between stages 3 and 4 (see chapter 3).

Due to historical pattern the structures of the Web sites of similar institutions are of similar nature. Examples are the Institutes of Legal Metrology (Table 5). That makes easier the practical use for specialists in the appropriate branch. Most Web sites are still supplier-oriented: "That is what we do". Slowly they are moving to customer needs. The normal customer is no specialist and has therefore questions to the Web sites. He prefers not an ingenious and confusing but an efficient and comfortable Internet access to new knowledge: "Show me reliable & affordable pattern for solutions".

TABLE 5. Home pages and branch portals for metrology

International Committee for Weights & Measures CIPM	<a href="http://www.bipm.fr">www.bipm.fr</a>
Bureau International des Poids et Mesures BIPM	<a href="http://www.bipm.fr">www.bipm.fr</a>
National Institute for Science & Technology. NIST	<a href="http://www.nist.gov">www.nist.gov</a>
National Physical Laboratory NPL	<a href="http://www.npl.co.uk">www.npl.co.uk</a>
Physikalisch-Technische Bundesanstalt PTB	<a href="http://www.ptb.de">www.ptb.de</a>
Interactive Knowledge Base for Measurement Systems	<a href="http://www.measurementor.com">www.measurementor.com</a>
msn Learning & Research Channel	<a href="http://www.encarta.msn.com">www.encarta.msn.com</a>
Database of Technical Products & Services	<a href="http://www.globalspec.com">www.globalspec.com</a>
Computer Based Instruments & Internet Training	<a href="http://www.ni.com">www.ni.com</a>
International Organisation for Standardisation	<a href="http://www.iso.ch">www.iso.ch</a>

#### 5. CHALLENGES FOR METROLOGY COMMUNITY

The Internet is increasingly becoming the primary source of real-time free or low-paid information for knowledge workers. Research papers, scientific journals and conference materials due to comfort, time expense and affordability of suppliers and users increasingly are published in the web. The leading search machine Google has 100 Million inquiries a day [[www.vdi-nachrichten.com](http://www.vdi-nachrichten.com)] 31. Januar 2003, Nr. 5, S. 33.

**First challenge** for metrology community is to elaborate **ontological terms** [[citeseer.nj.nec.com/450313.html](http://citeseer.nj.nec.com/450313.html)] and harmonized definitions on metrology because "You can not control what you can not measure" [Tom DeMarco]. Ontological terms are favourable prepositions for successful collaboration in the semantic web. "The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation." [[www.w3.org/2001/sw/](http://www.w3.org/2001/sw/)].

**Second challenge** for metrology community is to support **wireless linking for measurement and calibration**. In the past, industrial measurements and controls were wired. Wireless connections were slow and expensive. Today, wireless links are fast and economical. The old islands of measurement and automation will disappear, and the Internet Metrology and Control will be pervasive with:

1. Wireless networks: Lots of small, cheap, low-power wireless devices proliferating in the plant and connecting all traditional "field" instruments.
2. Micro-tiny, low-cost, low-power sensors: Battery-powered sensors that (coupled with wireless networks) monitor products, processes, machines, and almost everything else in the plant and everywhere else.
3. Wireless PDAs: For everything in the factory, plant, or process-communications, calibration, diagnostics, maintenance, connected to the plant network and home

[[www.isa.org/Content/ContentGroups/News/20031/January12/InTech11/Pintos\\_Point\\_Technologies\\_to\\_watch\\_in\\_2003.htm](http://www.isa.org/Content/ContentGroups/News/20031/January12/InTech11/Pintos_Point_Technologies_to_watch_in_2003.htm)].

An example for PDA-instrumentation is Figure 1.



Fig. 1. Cross-Sectional

Tyre Analysis for Trucks

[[www.mitutoyoauto.com/software.htm#digichecktruck](http://www.mitutoyoauto.com/software.htm#digichecktruck)]

The PDA is displaying profiles and tread depths across the tyre's cross-sectional surface. The software delivers:

- Automatic calculation of percentage of tread remaining
- Calculation of tread wear block by block
- Predictive analysis of tyre life
- Analysis of wear rate per km (wpkm).

**Third challenge** for metrology community is to accelerate the **web training in measurement and instrumentation with virtual laboratories and plants**. The high expectations of SME to e-learning and knowledge management up to now are unfulfilled. SME need Training-for-the-Job (TfJ). Workforces in SME are looking

- not for knowledge only, but for capability
- not for ID and password, but for individual free training
- not for investments in the future, but for the present day
- not for delayed answers, but for just-in-time (real-time)
- not for academic considerations, but for practical help
- not for communication only, but for collaboration
- not for external training, but for training-on-the-job
- not for wired intranets, but for wireless Internet
- not for running into debt, but for affordability
- not for arduousness, but for comfort.

Web training with virtual labs and plants is necessary due to

- coherent working style
- quicker comprehension
- longer remembrance.

People generally remember 10% of what they have read (in text) and up to 90 % what they have done and understood (Fig. 2).

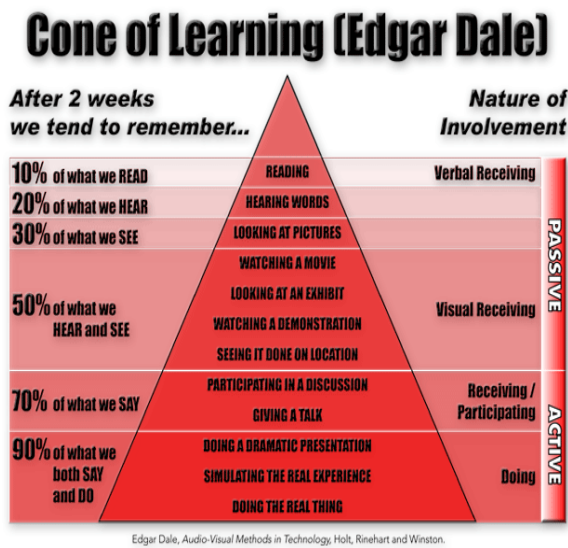


Fig. 2. Cone of Learning  
[\[www.intech.com/education/training.htm\]](http://www.intech.com/education/training.htm)

Education programs from universities and industry have often a personalized access to the study material with charging conditions. Increasingly institutions and enterprises put **links to learn** into the Internet, free for individual e-tuning.

Practical examples are:

**Metrological Institute:**

NIST/SEMATECH: **e-Handbook** of Statistical Methods  
[\[www.itl.nist.gov/div898/handbook\]](http://www.itl.nist.gov/div898/handbook)

**Manufacturer of Measuring Instruments:**

FLUKE: **Virtual Demo** Scopemeter 190C Series (Fig. 3)

[\[www.fluke.com/products/home.asp?SID=14&AGID=6&PID=31768\]](http://www.fluke.com/products/home.asp?SID=14&AGID=6&PID=31768)



Fig. 3. Scopemeter 190C for handheld measurements  
[\[www.fluke.com/products/home.asp\]](http://www.fluke.com/products/home.asp)

**Nationally recognised, funded qualification program:**

BEGINNERS.co.uk: Wizard on the Web  
[\[www.beginners.co.uk/v21/webwizard.html\]](http://www.beginners.co.uk/v21/webwizard.html)

**Broadcasting Company:**

BBC: Becoming WebWise  
[\[www.bbc.co.uk/webwise/learn/menu.shtml\]](http://www.bbc.co.uk/webwise/learn/menu.shtml)

These courses and demonstrations are presented in an interactive and user-friendly format with clear learning outcomes and online support material. In some cases the knowledge and capability can be tested as one has learned with online activities and assessments.

## 6. CONCLUSIONS

The first decade at the beginning of the 3<sup>rd</sup> Millennium changes education and training in measurement & instrumentation as well as the understanding of measurement science in a fundamental way. Buzzwords are: Digitalization, virtualisation & networking, everywhere, every time, with every device. IMEKO TC1 & TC7 are challenged to elaborate new solutions for "old" problems in collaboration thru Internet Metrology. Practical stimulations were given.

## REFERENCES

see [brackets] and [Weblinks](#)

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