

INTERNET- BASED RESEARCH, EDUCATION & TRAINING IN MEASUREMENT, INSTRUMENTATION AND TEST MANAGEMENT

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Abstract: Measurement, instrumentation and test management MM is the planning and realisation of skilful mental efforts and natural (biological) and/or artificial (technological) actions to solve measurement, instrumentation and test situations. Standard situations in information acquisition and automation are that we don't know what we don't know. If we don't know, we can't control. If we can't control, we are at the mercy of chance. To get knowledge we have to get data from the processes and products. To get valid data from the processes and products, we must measure.

Aim of the paper is to present

- *modern tools for Internet-based research, education and training in measurement, instrumentation and test management MM and*
- *modern tools of knowledge management to bridge the gap between traditional measurement theory and actual demands in technical and non-technical systems.*

Keywords: Measurement, instrumentation, test, management

"One cannot manage the change. One can only be ahead of it."

Peter Ferdinand Drucker

Management Challenges for the 21st Century, Harperbusiness 1999

1 INTRODUCTION

Traditional measurement theory is treated as an "exact" science. But that is valid only, when measurement is a comparison of physical measurement quantities with metrological standards. Keywords are: International system of units SI, ratio scales and traceability to national etalons.

Advanced measurement practices can be understood as "empirical". Considerable advances of technological, biological, medical, economical and social sciences have been accompanied by measurements as comparisons of measurement objects with particular, objective virtual or subjective virtual standards. Keywords are: Image processing, pattern recognition, diagnostics, interval, ordinal and nominal scales and traceability to identification standards.

Measurement, instrumentation and test management MM is the missing link between traditional measurement theory and advanced measurement, instrumentation & test practices. MM is a methodical key for further development of measurement science & technology as well as education & training.

2 THE TRADITIONAL ROLE OF MEASUREMENT

2.1 Why do we measure?

Influenced by the impressive informational success of measurements with artificial technical sensors most theoretical, methodical and practical efforts in science & technology are focussed on **material** measurements.

The overestimation of material measurements with artificial technical sensors and the seeming simplicity of **sensual** measurements with natural biological sensors hide the methodical complexity of measurements. The methodical competence necessary in measurements is underestimated.

2.2 Where do we measure?

Influenced by the impressive economical success of product & process measurements in trade & industry especially in the epoch of the industrial revolution since the middle of the 19th century bulk applications of measuring means has been focused on trade & industry. The overestimation of product & process measurements in the industrial era has fostered a physical science oriented management of measurement procedures. These measurements in most cases can be characterised by the application of single sensors, measurement means with big sensitivities for measurement quantities, small

sensitivities for disturbing quantities and rigid mathematical functionalities between measurement quantities and measurement values. The measurement methods are methodical classified by

- measurement quantities (length, time, mass measurements etc),
- power supplies of the auxiliary energies (mechanical, electrical, optical measurements etc)
- fields of applications (product, process, plant, environmental measurements etc).

Unifying methodical aspects obviously have been too complex or too inconvenient.

2.3 What do we measure?

Influenced by the impressive governmental success of legal metrology since the 1st General Conference of Weights and Measures in 1889 measurement is focussed on physical quantities. Physical measurements have the intellectual myth, that they are linked with truth and justice. Metrological institutions assume, that things are right which can be traced to an etalon which is right by itself. Chemical measurements yet at dawn for an internationally structured metrological system [1]. Sensual measurements yet outside the methodical framework of metrology.

2.4 How do we measure?

Influenced by the impressive scientific success of Lord Kelvin (1824-1927) in physical sciences his wordings about measurement are ranking on the level of natural laws. Lord Kelvin postulated: "I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind: It may be the beginning of knowledge, but you have scarcely, in your thoughts, advance to the stage of science, whatever the matter may be". Lord Kelvin was an intellectual follower of Platon (427-348 BC) who taught: "Numeric relations are the key to the understanding of the whole mystery of nature" [see "The Role of Measurement for Innovation and Society" www.imeko.org].

In many publications dealing with measurement Lord Kelvin is cited but the beginning of his wordings are neglected. They run as follows: "In **physical science** a first essential step in the direction of learning any subject is to find principles of numerical reckoning and methods for practicably measuring some quality connected with it."

2.5 Intermediate conclusion

The expressed standpoints concerning measurement & metrology have been very successful and therefore right for the industrial era with its dominant productivity factors matter & energy processing as well as product & process management. At dawn of the post industrial era with the new productivity factors information & man as well as knowledge management & experience it is recommended to look for revised standpoints concerning measurement & metrology.

3 INTERNET- BASED MEASUREMENT RESEARCH & EDUCATION

3.1 Internet-based Research and Education of Measurement for Automation

Influenced by the increasing power of micro computers and the decreasing costs for processors and equipment the shift from centralised local data management to distributed global knowledge management is at dawn. The unification and standardisation of operation systems and application software under the influence of Microsoft is obvious. The capability, willingness and economy for automation of technical and non-technical processes is quick expanding. Examples are

- vision and image processing with LabVIEW and interchangeable virtual instrumentation to overcome the costs and limits of traditional proprietary hardware and software solutions and to enjoy the convenience of graphical intuitive programming [www.ni.com],
- wireless measurements to overcome the costs of wire, the confusion of numerous busses as Foundation Fieldbus HSE, Profibus-DP, ControlNet, P-Net, Interbus-S, SwiftNet, WorldFIP and IEC 61158 TS, to come back to Internet protocols TCP/IP and Ethernet and to enjoy the convenience of wireless measurement data transfer via special circuits [www.bluetooth.com] and handies [www.nokia.com] with bluetooth-enabled devices for worldwide communication.
- internet measurements and Cyberlab as new paradigms in distance measurement & testing as well as distance teaching & learning [www.ni.com].

All these developments make a visible change in society by creating new jobs, cleaner environment, safer and energy-efficient products & services and a more exciting and easier life. But new sensors are the critical component that determine the feasibility of new measurement information systems for automation in different fields (Tables 1-4) [see "The Role of Measurement for Innovation and Society" in www.imeko.org]

Table 1. Measurement information systems for facility & home automation



air conditioning systems
audio & television systems
cleaning & cooking systems
door & window management
energy & water management
garden management systems
health care systems
heating & cooling systems
home computer systems
information & training systems
lighting & shutter systems
maintenance systems
monitoring & control systems
security & alarm systems
telephone & fax systems
washing & drying systems



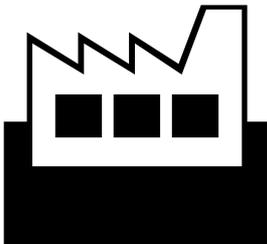
Table 2. Measurement information systems for car & transport automation



alarm & security systems
controlling by wire systems
crash & surveillance systems
display & monitor systems
guide systems
maintenance systems
motor management systems
navigation systems
seat memory systems
sensor systems
X by wire systems



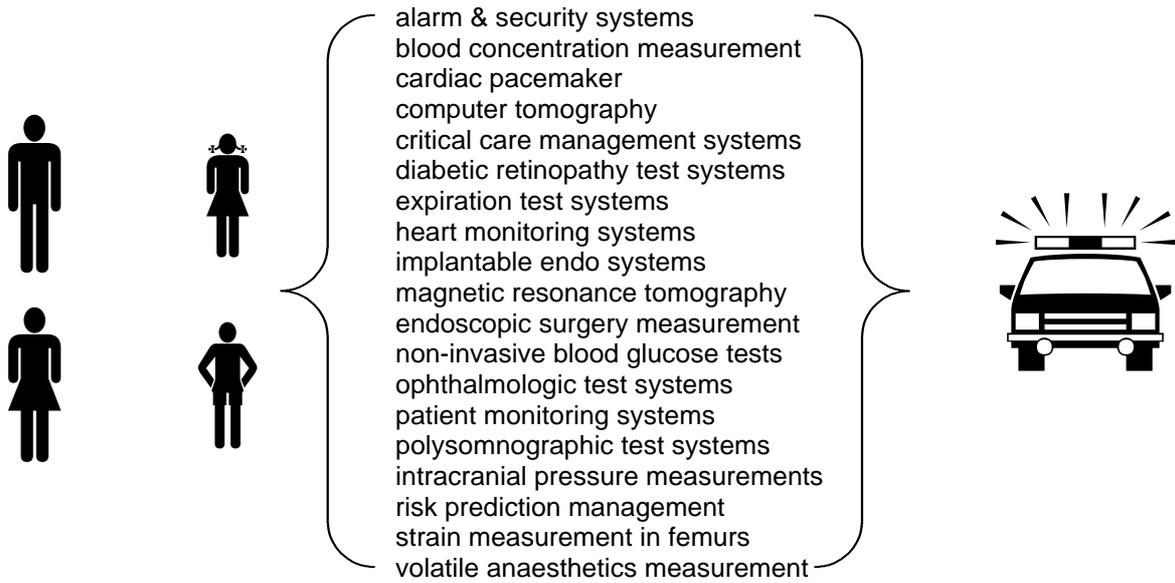
Table 3. Measurement information systems for plant & machine tool automation



assembling systems
autonomous transport systems
business management systems
conveyor systems
customer management systems
design & construction systems
development systems
energy & water management
machine tool control systems
maintenance systems
manufacturing systems
monitoring systems
process management systems
project management systems
quality management systems
recycling & waste systems
remote control systems
robot systems
storehouse systems
testing systems



Table 4. Measurement information systems for health care & medical treatment automation



Many new applications are driven by more **convenience** for the users at work or at home. For details see Biobench in the interactive encyclopedia of instrumentation INSTRUPEDIA [www.ni.com].

3.2 Internet- based Research and Education of Measurement for Quality Control

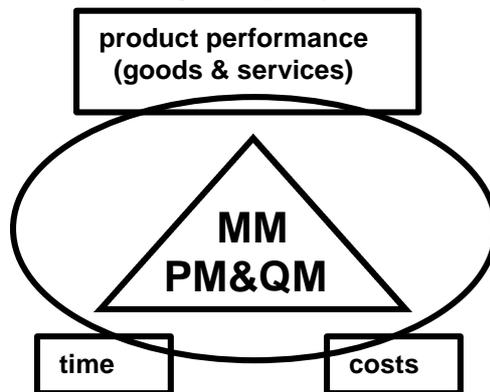
Influenced by the impressive success of quality movements in the second half of the 20th century the revised version ISO 9000:2000 is at dawn. Its aims are to give users the opportunity to add value to their activities and to improve their performance continually by focussing at major processes within the organisations [www.iso.ch]. The value of information for organisations and for individuals will change fundamentally. In measurement and information technology main interest will shift from instrumental high lights to the profitable content of measurement information.

The new demands for measurements are [www.bsi.org.uk]:

- Measurement of customer satisfaction,
- Measurement for continual improvement,
- Measurement extended to systems, processes, products and services,
- Analysis of collected data on the performance of the quality management system (Table 5).

Meaning of abbreviations in Table 5: MM measurement, instrumentation & test management; PM project management; QM quality management

Table 5. Optimisation triangle for quality control, productivity and profit



3.3 Internet- based Research and Education of Measurement for Globalisation

Influenced by the impressive success of metrological institutions for the uniformity and correctness of measurements a strong confidence in the results of measurements is proverbial. Globalisation of trade & industry at the beginning of the 21st century and new possibilities of digital nervous systems DNS [www.microsoft.com] increase the demands to measurement & metrology management.

The new demands to measurement & metrology for trade & industry are [2]:

- One measurement to achieve world-wide acceptance
- One product - one world-wide regulation
- One product - one world-wide written standard
- One product - one world-wide accreditation
- One-stop measurement based on world-wide traceability.

The prepositions for the introduction of global metrological systems are good due to the long-standing successful cooperation of metrologists in the BIPM (International Bureau for Weights and Measures) [www.bipm.fr], CIPM (International Committee for Weights and Measures), OIML (International Organisation for Legal Metrology) [www.oiml.org], IMEKO (International Measurement Confederation) [www.imeko.org], NIST (National Institute of Standards and Technology, USA) [www.nist.gov] and PTB (Physikalisch-Technische Bundesanstalt, Germany) [www.ptb.de].

Measurement related questions and disputes which handicap the globalisation of trade & industry may solved by the new international database of measurement comparisons [www.bipm.fr] and [icdb.nist.gov].

An illustration for enormous losses by bad managed measurements is the loss of the NASA Mars Climate Orbiter in September 1999. A supplier had calculated the propulsion jets by English pound instead of kilogram. It was a loss of 125 million US \$ [www.astronews.com]. For comparison: The budget of Physikalisch-Technische Bundesanstalt PTB is in the same dimension (Table 6).

Table 6. Figures of Physikalisch-Technische Bundesanstalt PTB and Deutscher Kalibrierdienst DKD [3]

Staff PTB	1.800	Publications PTB	600
Budget PTB (DM)	240.000.000	Seminars PTB	800
Pattern approvals PTB	3.200	Labs DKD	230
Certificates PTB	100.000	DKD certificates	90.000
Regulations PTB	500	In-house certificates	865.000

For elimination of redundant product testings between the world's largest trading partners U.S.A. and EU with an account of 50 billion US \$ per year a pact of mutual recognition has been signed to accept as equivalent the results of measurements, tests, inspections and other evaluations performed by accredited laboratories or organisations on either continent [www.ustr.gov].

4 UNSOLVED PROBLEMS IN MEASUREMENT & INSTRUMENTATION

4.1 Internet-based Measurement with Intelligent Sensor Systems

Influenced by global networking the brain power of knowledge workers will be concentrated, amplified and supplemented by information acquisition and processing machines.

To be ahead, one must focus on the meaning (semantics) and aims (pragmatics) of information acquisition and processing and **not** on technology only that collects it. Bottle necks in the beginning of the information era are:

1. improvement of technological solutions in the field of human-like multiple sensor system and methodical incorporation of man with his knowledge and emotional intelligence into the management of measurement, instrumentation & testing (Table 7).

Table 7. Information acquisition and processing capabilities of human

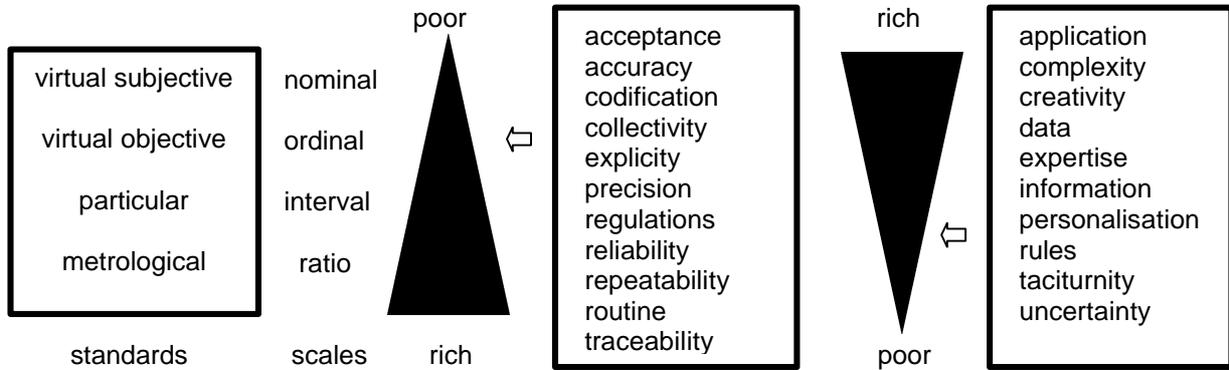
nose	10 million receptors (sensors)		nerves	1 million strings
eyes	100 million receptors (sensors)		brain	10 billion bit/s unconscious information transfer
ears	10 thousand receptors (sensors)			100 bit/s conscious information processing
mouth	10 million receptors (sensors)			
skin	1 million receptors (sensors)			

2. quicker growth of inexpensive reliable micro technology- and Internet-compatible sensors in the overall sensor market which is expanding from 1994 through 2004 from 16 to 28 billion US \$. Selected examples for the market growth are: Automotive sensors from 3 to 8,5 billion US \$, process automation sensors from 4 to 6 billion US \$ and office & home automation sensors from 3 to 5 billion US \$ [see "The Role of Measurement for Innovation and Society" www.imeko.org].

4.2 Internet- based Measurement with Non-metrological Standards and Scales

Measurement information acquisition is based on natural (biological) and/or artificial (technological) identification processes. Identification processes are **sensual** (biological) and/or **sensory** (technological) procedures (Table 8).

Table 8. Classification of measurement standards and scales and their performances



The unbalanced concentration on metrological standards and ratio scales as well as the meaning and conceptual interpretation of numbers [4] must be revised. Definitions and further explanations for the above mentioned standards can be ordered free of charge from hofmann@sensorshop.com.

5 FINAL CONCLUSIONS AND RECOMMENDATIONS

The understanding of measurement & instrumentation is strongly influenced by traditional experiences in metrology like the mind power of authorities such as Platon and Lord Kelvin, the convincing power of success stories like development of physical measurements for trade & industry, the structural power of organisations like OIML and BIPM and the governmental power of national metrological institutions like NIST and PTB.

To put recent developments together with reliable facts and approved experiences in measurement, instrumentation & testing under one methodical roof the new discipline:

MEASUREMENT, INSTRUMENTATION & TEST MANAGEMENT MM.

must be developed. Fundamental support in knowledge management can be expected from products for Internet-based research, education & training like:

- ✓ information search [www.altavista.com], ✓ investigation & reporting [**MS Encarta Investigation Planner & MS Word 2000**], ✓ documentation & retrieval [www.docunet.com], ✓ information translation from and to foreign languages [www.lhsl.com], ✓ teaching & learning [www.in-tele.org].

The current definition: "Measurements are executions of planned actions for a quantitative comparison of a measurement quantity with a unit" [DIN 1319:1995] is too simple to solve complex measurement tasks.

As a new working definition "Measurement is the comparison of a measurement object with a measurement standard" can be recommended.

Measurement, instrumentation & test management MM is yet a missing link in both measurement theory & practice as well as management theory & practice. Let's be ahead in developing MM.

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