Software Measurement & Lessons from the Masters: Benefits for Industry

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Egyptian Pyramids
Egyptian Measurement & Tools

New Kingdom Dynasty XVIII-XX (1550-1070 B.C.)

New Kingdom

Architect Kha

Amenhotec II

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Golden étalon - New Kingdom Dynasty XVIII-XX (1550-1070 B.C.)
Folding étalon - New Kingdom Dynasty XVIII-XX (1550-1070 B.C.)

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Late Dynasty Tool - (712-332 BC)

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Measurement of Time

Evolution of Time Perceptions, & Measurement Concepts & Tools
Astronomical Calendars
The communal local time

Sun shadow

The house sun dial

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Communal Time: The “horloge”

Communal Time – XVIII Century
Personal Time: Watches with Minituarization

**Mechanical**

**Quartz**

**Atomic**

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Geneva Science Museum
Lack of universally accepted references & Impact
Masters from the Past

The meter as the **universal étalon:**

A product of the French Revolution!

- A consensual definition: A fraction of the Meridian at the Equator
- A practical étalon: it took 7 years to measure the Meridian at the Equator..!
- After 200 years, there are still some countries which have not adopted it..

Key Lessons from the Masters

1. Evolutionary societal & consensual understanding of measurement concepts
   - Perfection is not expected first: the search for precision – when necessary only!
2. Development of Measuring Instruments
3. Establishment of measurement ‘etalons’
4. Specialized measurement training & certification:
   - Land surveyors
   - Accountants,
   - Engineers,
   - Testing labs,
   - etc.
Measurement is a Technology

- Technology is defined as:
  - the set of methods & materials used to achieve industrial or commercial objectives.

- Not limited to materials alone:
  - It also includes processes & the knowledge related to them, referred to as “know-how”.
What does it take for software measurement to be adopted as a new technology?

• **On the part of a software organization:**
  – Software measurement must promise enough benefits to overcome the pain of changing to an initially unknown technology.
  – The organization must have the technological know-how in software measurement to make it work.
  – The organization must be clever enough, and enthusiastic enough, to harvest the benefits:
    • this takes time…..
Measurement as a Technology

What does it take for software measurement to be adopted as a new technology across an industry?

– Software measurement must already have been proven to work well in a large variety of contexts:
  • i.e. it must be mature as a technology, or maturing rapidly).

– Software measurement must become integrated into the technological environment of the software industry.

– It must become integrated into the business context (which includes its legal & regulatory aspects).
Measurement as a Technology

What does it take for an industry to promote software measurement as a new technology?

– The industry must recognize that the players will not, by themselves, submit to the pain of change (unless the environmental-regulatory context forces such a change).

– It wants to speed up the transition to quantitative support for decision making.

– Current software measurement practices must be ‘good enough’ – perfection is not required.
GUIDE 99

International vocabulary of metrology — Basic and general concepts and associated terms (VIM)

Vocabulaire international de métrologie — Concepts fondamentaux et généraux et termes associés (VIM)
Current Masters

- International Bureau of Weights & Measures,
- International Electrotechnical Commission,
- International Federation of Clinical Chemistry & Laboratory Medicine,
- International Organization for Standardization (ISO),
- International Union of Pure & Applied Chemistry,
- International Union of Pure & Applied Physics,
- International Organization of Legal Metrology,
- International Laboratory Accreditation Cooperation.
Current Masters

Guidelines for setting up structures in metrology & articles for the law:

1. Definitions
2. National metrology
3. Traceability & uncertainties
4. Legal units of measurement
5. Transparency of metrological information.
6. Legal metrology
7. Application of the Law
8. Offences
9. Responsibilities & duties
10. Conformity assessment procedures
Measurement in Metrology

Ref. : Asma Sellami PhD thesis & Abran

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Measurement in Metrology

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Table 3: Description of the measurement elements

<table>
<thead>
<tr>
<th>Measurement result</th>
<th>Measurement procedure</th>
<th>Measuring device</th>
<th>Measurement conditions</th>
<th>Measurement error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured quantity value</td>
<td>Reference measurement procedure</td>
<td>Measuring system</td>
<td>Repeatability condition of measurement</td>
<td>Systematic measurement error</td>
</tr>
<tr>
<td>True quantity value</td>
<td>Primary reference measurement procedure</td>
<td></td>
<td>Intermediate precision condition of measurement</td>
<td>Measurement bias</td>
</tr>
<tr>
<td>Conventional quantity value</td>
<td></td>
<td></td>
<td>Reproductibility condition of measurement</td>
<td>Random measurement error</td>
</tr>
</tbody>
</table>

Ref. : Asma Sellami PhD thesis & Abran
Measurement in Software

• The academic view & achievements

• The software industry needs & track record
Enduring Software Measurement Myths:

• Software is different:
  – It is an intellectual product & it is not material
• Software metrics = an algorithm
  – Foundation = measurement theory! (limited to maths)
• Innovation in metrics = again, another proposal...

Impact - Examples:

• +100 proposals on software complexity
• The vast majority of software metrics from academia not used in industry.....
A typical new software metrics:

- A modified algorithm
- Additions of conditions to the algorithms
- As many metrics as can be extracted automatically from files (codes, models,..)

Typical empirical analyses:

- No hypothesis to be tested!
- Highest correlation with something else!
- Little verification of the relevance to the concept to be measured!
Software Industry & Measurement

Out of the +1,000 of software metrics proposed in the literature, which ones have reached some maturity with respect to industry needs?

• How do you recognize maturity in measurement?
  – Of the +100 Software Quality metrics, which ones would you consider mature?
Software Measurement & Industry

For industry, measurement has little to do with maths!

- Measurement is not maths, but a technology with considerable **consensual knowledge on**:
  - the concepts to be measured,
  - credible references for measurement, &
  - expected measurement errors
Quality Criteria for Software Measurement

The criteria for a good design of measurement are already defined in Metrology:

- The components of a measurement system
- The quality criteria for measurement
Software Industry & Measurement

How do you recognize maturity in measurement?

• Measurement Maturity = Standardization

Which ‘software metrics’ are recognized as ISO standards?
Functional Size Measurement is an exception in software measurement

Out of the +1,000 of software metrics proposed in the literature, only 5 Functional Size Measurement (FSM) methods have been adopted as ISO standards!

- What has been done differently?
Software Measurement

ISO 14143 meta-standard on Functional Size Measurement:

Part 1: Definitions & Concepts
Part 2: Conformity Evaluation of FSM methods
Part 3: Verification Guide of FSM methods
Part 4: Reference Model (but only samples of FUR!)
Part 5: Determination of Functional Domains for FSM methods
Part 6: Guide for the use of ISO 14143!
Software Functional Size Measurement

5 distinct FSM methods
  – ISO 20926 : IFPUG (1979)
  – ISO 29881 : FISMA (198?)

What is common in their design & design process?
Measurement Infrastructure

To increase consensus to ensure repeatability, a **measurement practice committee** that sets detailed measurement procedures for typical contexts

- When a ‘measurement étalon’ does not yet exist:
  - Case studies for various topics-contexts
- Outside recognition, through standardization channels (ISO xxx and ISO 90003, ISO 19760, etc)
- Certification process
- Training, specialized guides, etc.
Testing the design of a software measure

Criteria to be tested

Relevance:
- must be perceived by practitioners (within a functional domain) as adequately measuring the functional size of the applications in their domain.

Measurement instrumentation:
- Automated, or in the form of a measurement standard which documents & clarifies the measurement objectives & perspective, and defines the measurement procedures adopted by a user group.

Repeatability:
- different individuals, in different contexts, at different times, & following the same measurement procedures will obtain the same measurement results.

Measurement results;
- obtained with minimal judgment.
- results auditable.

Measurement method: in the public domain……
Measurement Tools & Tools Usage

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Tools Usage

Adapted from: Jayakumar, Amitysoft 2012
# Measurement Tools

<table>
<thead>
<tr>
<th>VALUE</th>
<th>TOOL SOPHISTICATION</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Simple Feel Good</td>
</tr>
<tr>
<td></td>
<td>Basic Political</td>
</tr>
<tr>
<td></td>
<td>Craft Use</td>
</tr>
<tr>
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</table>

**WORK BREAKDOWN**

- Craft Use: ✓
- Feel Good: ✓
- Real Good: x

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Measurement Tools Maturity

Adapted from: Jayakumar, Amitysoft 2012
1st Generation FSM Key Contributions

User Groups built the essential metrology support infrastructure:

- Procedural Measurement Manuals
- Central technical authority:
  - Measurement Practice Committee
- Certification criteria & exams
- Case studies for reference materials
1st Generation FSM Key Weaknesses

Weights-like FSM methods:

• A structure with weights to integrate multi variables:
  – An end number with a symbol (FP) but without a well defined measurement unit!

• A number of structural weaknesses pointed out in the literature over the past 30 years:
  ➢ Partially discredited it in academia for almost 20 years.
  ➢ A recent comeback
1st Generation FSM Key Weaknesses

1- Not aligned with the terminology in other fields of measurement (engineering, sciences, etc).

2- Not fully aligned with the ISO criteria in ISO 14143 series (which, for instance, rejected the VAF)

3- Researchers:
   – Tweaking the structure, rather than radical re-design.

4- User groups:
   – Researchers have not influenced User Groups
2\textsuperscript{nd} Generation FSM criteria

1- Adoption of consensual concepts from ISO Metrology
   • measurement method,
   • measurement procedure,
   • base quantity,
   • derived quantity
   • measurement unit, etc.

   Many of the ISO definitions explicitly quoted ‘as is’ in the COSMIC glossary.
2nd Generation FSM criteria

2- Correction of all known structural weaknesses:

• adopting a clear & unique ‘measurement unit’:
  – ‘a data movement of a single data group’ to which a size unit of 1 is assigned, together with the 1CFP as its measurement symbol.

• Making sure that it did not included any invalid mathematical operations.

• The CFP represents a single measurable concept, size of a FUR, making it a true ‘base quantity’.
2nd Generation FSM criteria

3- Designed to entirely meet the ISO 14143-1 FSM requirements:
   – Measurement of FUR
   – No reference to technical & quality characteristics, &
   – No reference to effort
2nd Generation FSM criteria

4- A collective effort with practitioners, including:

- Fields trials in industry
  - Ensuring relevance of measurement results: Does it capture quantitatively well the expected functionality?
  - Measurement procedures to ensure repeatability & reproducibility of measurement results
- ‘Good enough’ criteria met
  - In estimation models, the other major variable (effort) typically has a much larger range of variation!
2nd Generation FSM criteria

5- Designed to be application domain independent

6- Open access
2nd Generation FSM

VALUE

TOOL SOPHISTICATION

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2nd Generation FSM

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Automated Measurement

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ISO/IEC 19761:2002 COSMIC - A functional size measurement method

Method Overview

Measurement Manual

Advanced & Related Topics

Beginners

Practitioners

Experienced Practitioners

DOMAIN-SPECIFIC SUPPORT DOCUMENTS:

Guidelines
- Business V1.0
- Real-time

Case Studies
- Business
- Real-time

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When will we get our golden measurement étalons for software design & control?
Thanks to:

- Monica Villavicencio & Luigi Buglione & Charles Symons for a number of pictures
- Jayakumar for some slides
You want to know more?
Questions?