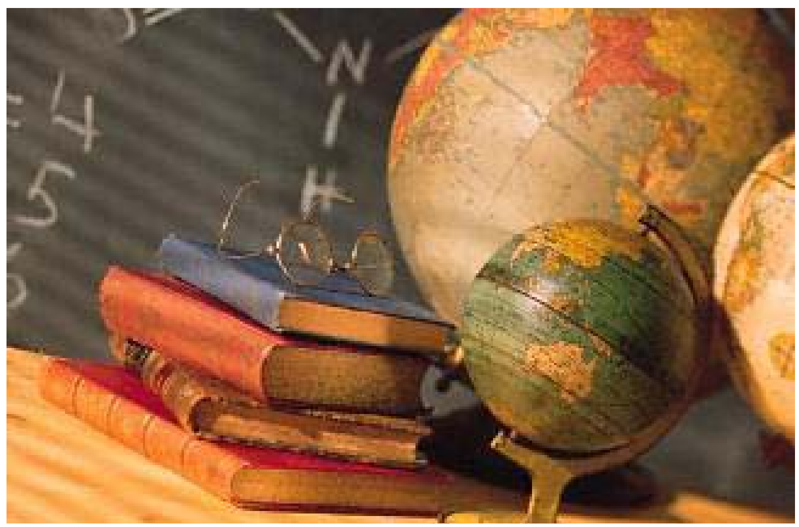
ÉCOLE DE TECHNOLOGIE SUPÉRIEURE – MONTRÉAL - CANADA

A Roadmap to Maturity for Software Measures



Alain Abran

List of topics

1. *Introduction*
2. *Metrology Concepts*
3. *A Measurement Process Model*
4. *A Measurement Body of Knowledge*
5. *Discussion*

Introduction

- *Software is an intellectual product*
- *Software is new*

Widely held beliefs:

- *We have to 'invent' how to measure software*
- *Software measurement is so unique that there is:*
  - *Not much in common from measurement of physical objects*
  - *Not much to learn from other fields of sciences*

Introduction

When we measure physical objects, what do we measure?

- *Objects*

Or

- *…..*

Introduction

- *What measurement infrastructure has been put in place at the national and international levels?*
  - *…..*
  - *…..*
  - *…..*

Introduction

Any profession dedicated to measurement?

- *…..*
- *….*
- *….*
- *….*

Introduction

The dominant approach in software measurement:

- *The 'software metrics' approach*
  - *Intuitive approach to the design of 'metrics'*
  - *Large variety of individual proposals*
  - *Focus on 'measurement theory'*
    - *Representation conditions*
    - *Mathematical properties*

Introduction

Consequences of the dominant approach

- *Direct:*
  - *Practitioners are not keen on using ‘software metrics’*
  - *Experts disagree on the relevance of using ‘software metrics’: eg. Work on fundamental principles*
- *Indirect:*
  - *Limited design expertise*
  - *Incomplete validation framework*
  - *Weaknesses of models based on ‘unsound metrics’*

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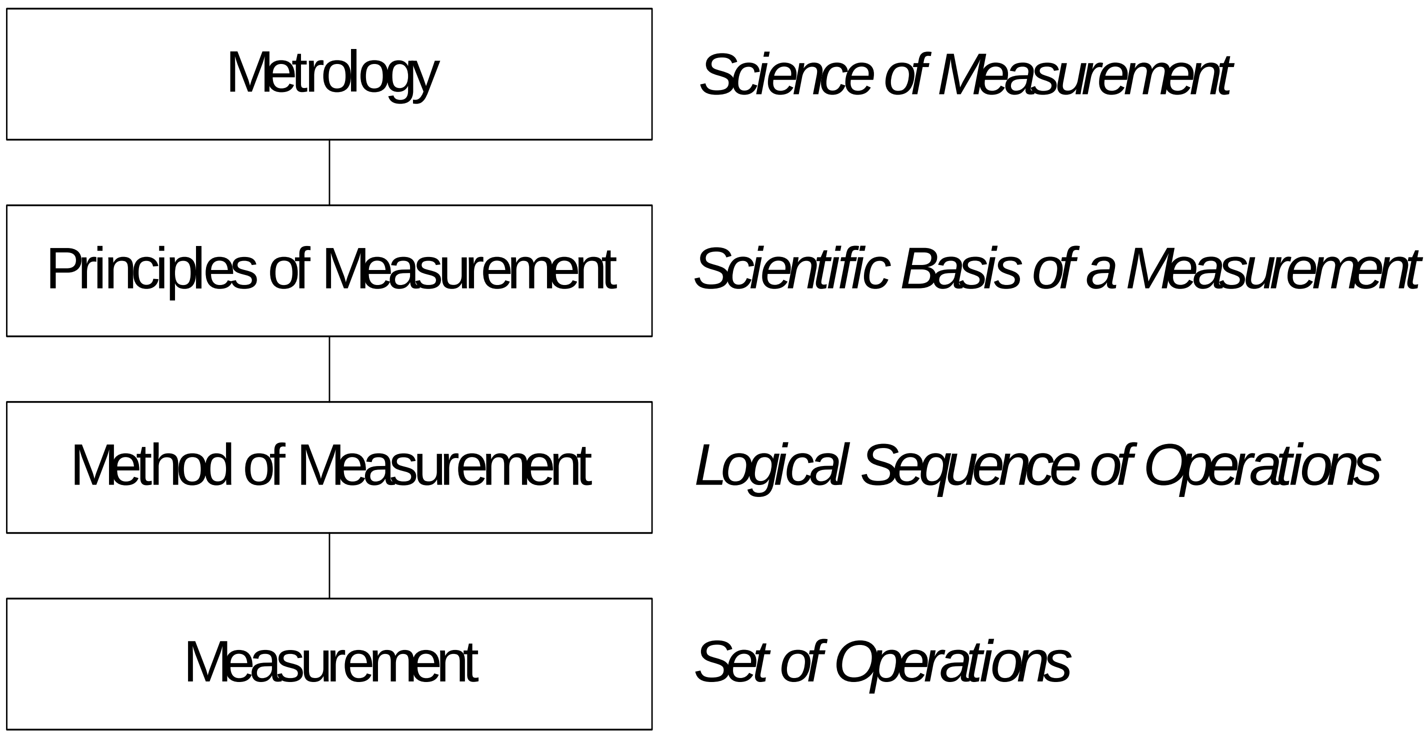

Figure 2: Measurement foundations [ABRA02a]

Metrology Concepts

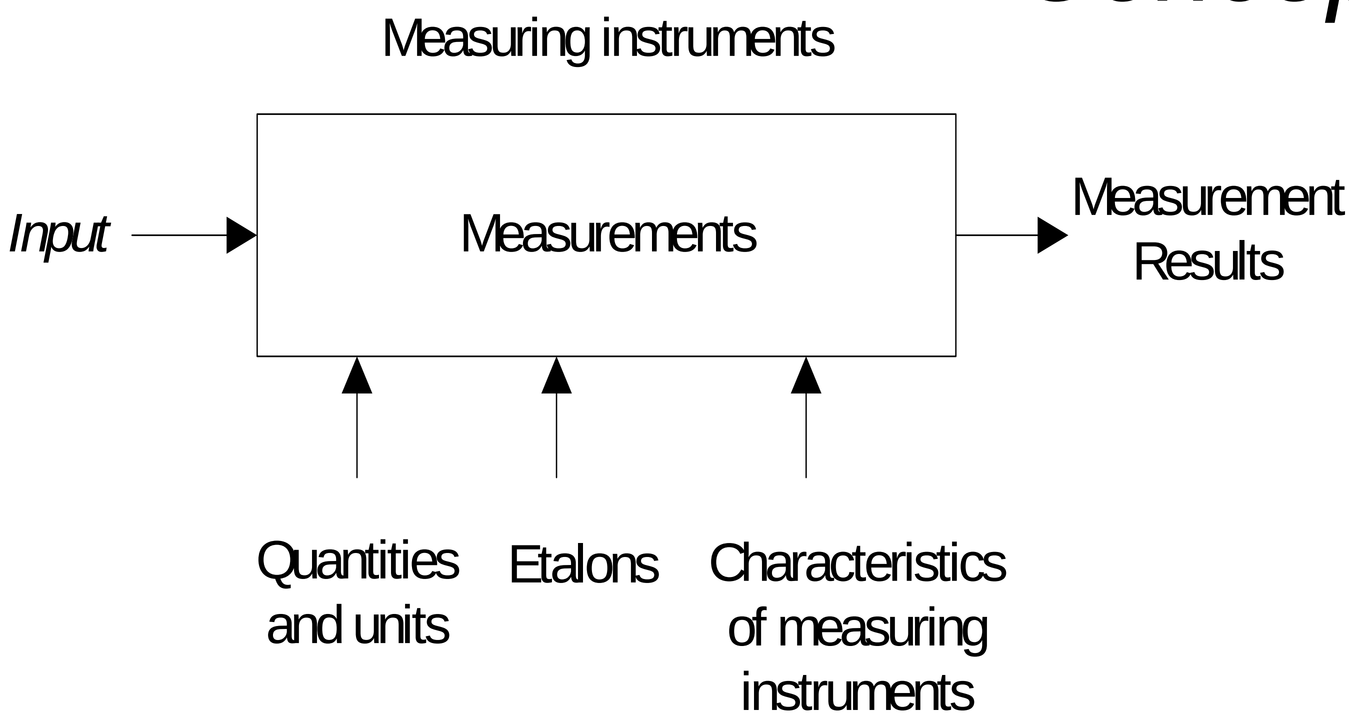

Figure 1: Model of the categories of metrology terms [ABRA02a]

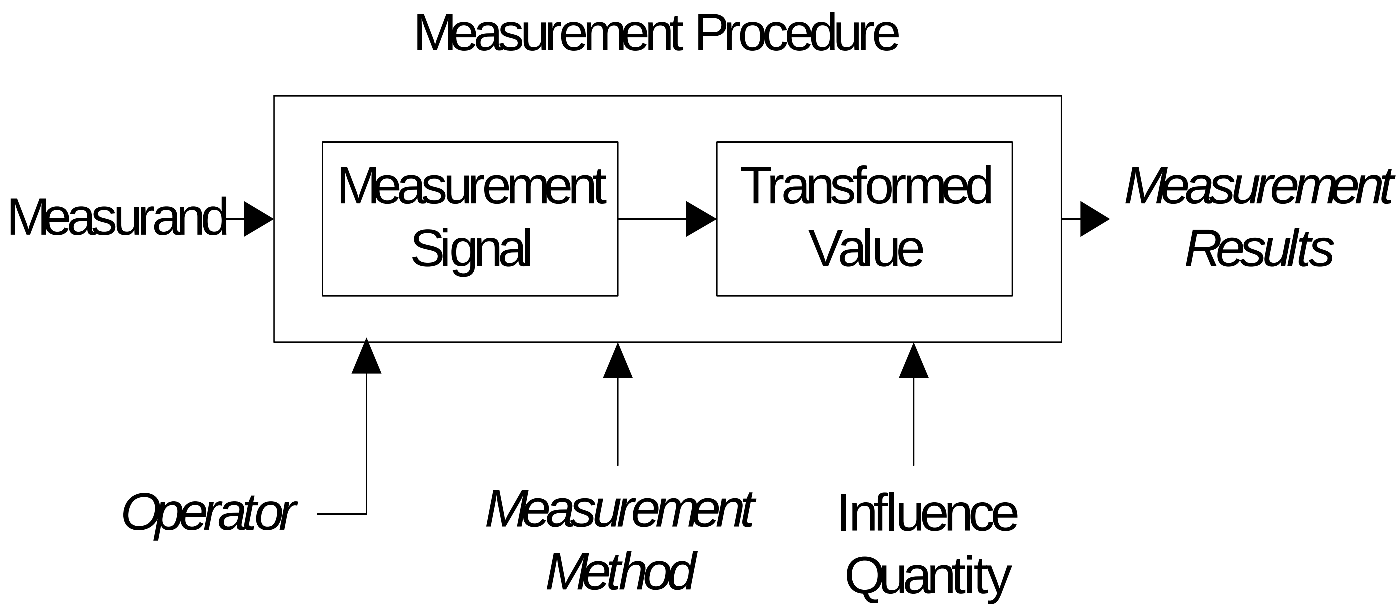

Figure 3: Measurement Procedure [ABRA02a]

Classification of terms in the category of 'Measurement Results' [ABRA02a]

Types of measurement results	***Modes of verification of measurement results***	**Uncertainty of measurement**	
Indication (of a measuring instrument) Uncorrected result Corrected result	Accuracy of measurement Repeatability (of results of measurements) Reproducibility (of results of measurements)	Experimental standard deviation Error (of measurement) Deviation	Relative error Random error Systematic error Correction Correction factor

Functional Size

A unique set of measures in software engineering:

- *Designed in the late 1970's:*
  - *By Albrecht, from IBM, using 24 MIS projects*
- *Published in the early 1980's*
- *User group in the mid 1980's*
  - *Measurement Manual*
  - *Training & Certification*

Functional Size

Innovation = Standardization through ISO

A meta-standard to layout the ground rules about functional size measurement: ISO 14143

- *Part 1 = Definitions of Key Concepts*
- *Part 2 = Conformity Assessment*
- *Part 3 = Verification Guide*
- *Part 4 = Set of References*
- *Part 5 = Functional Domains*
- *Part 6 = A Guide*

Functional Size

Four specific methods approved by ISO

- *ISO 19761: COSMIC-FFP*
- *ISO 20926: IFPUG*
- *ISO 20968: MKII*
- *ISO 24570: NESMA*
  - ☞ *Will they withstand the test of time as measurement methods?*
  - ☞ *Are there good measuring instruments?*
  - ☞ *Are these instruments calibrated and certified?*

Software Quality?

ISO 9126 on Software Products Quality

- *Part 1: Quality Models and Definitions*
- *Parts 2 to 4: + 120 Metrics !*
  - *And little about:*
    - *measurement method for each of the +120 metrics*
    - *quality of measurement results.*
  - *Then (if used in a non consistent manner), how do you figure out how measurement results compare across contexts, across time, and across measurers?*
  - *How do you benchmark?*

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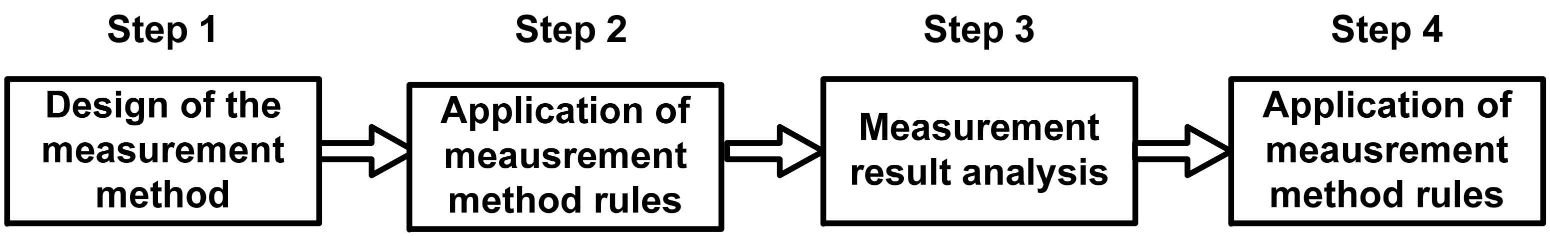
High-level measurement process model



Source: Abran and Jacquet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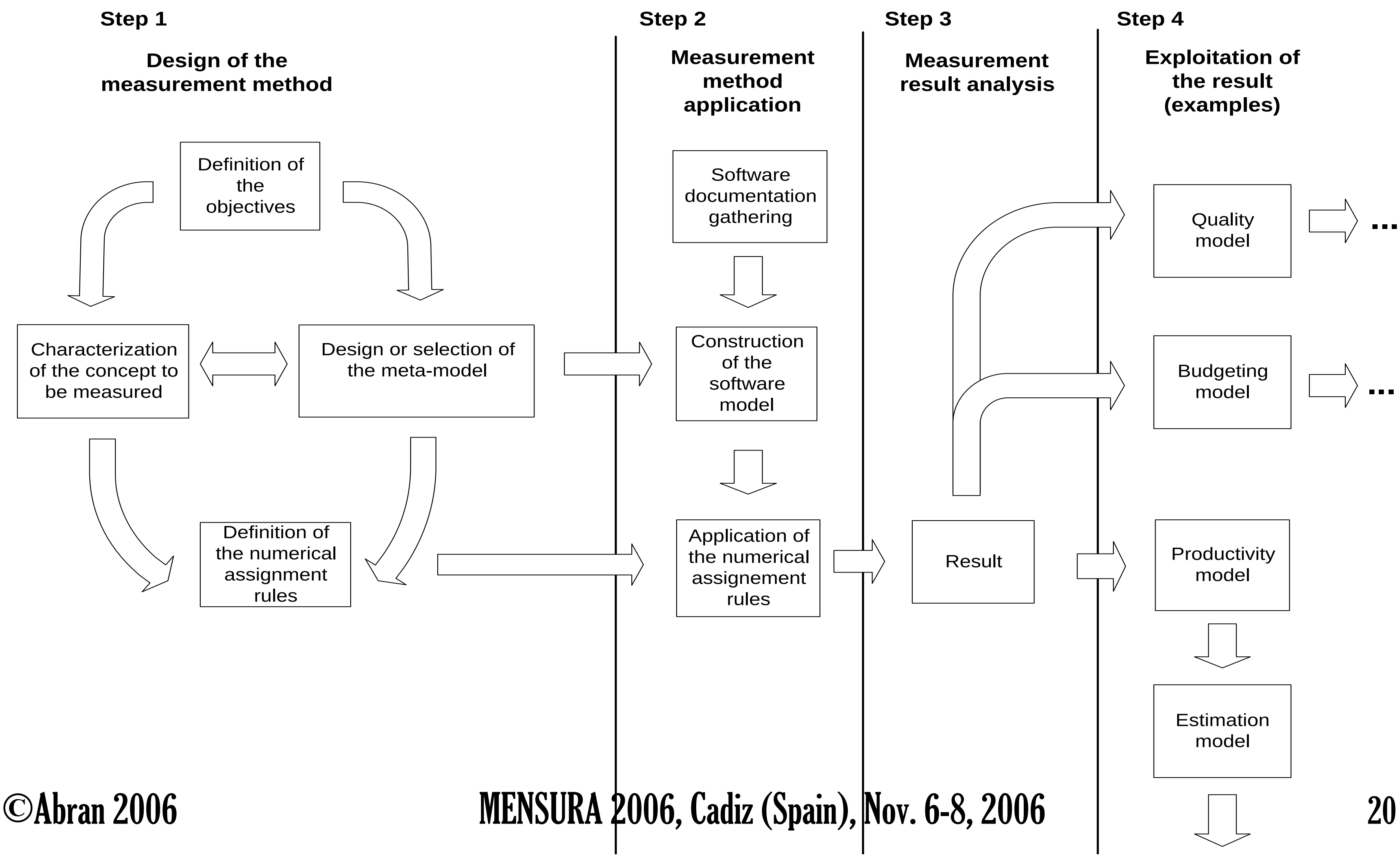
Step 1
Design of the measurement method
Definition of the objectives
Characterization of the concept to be measured
Design or selection of the meta-model
Definition of the numerical assignment rules
Step 2
Measurement method application
Software documentation gathering
Construction of the software model
Application of the numerical assignement rules
Step 3
Measurement result analysis
Result
Step 4
Exploitation of the result (examples)
Quality model
...
Budgeting model
...
Productivity model
Estimation model

Alignment of metrology concepts with the measurement process model

Measurement process model	Design of measurement methods	Application of measurement method rules	Measurement results analysis	Exploitation of measurement results
ISO metrology model	Quantities and units	Measuring instruments Characteristics of measuring instruments	Measurement results	

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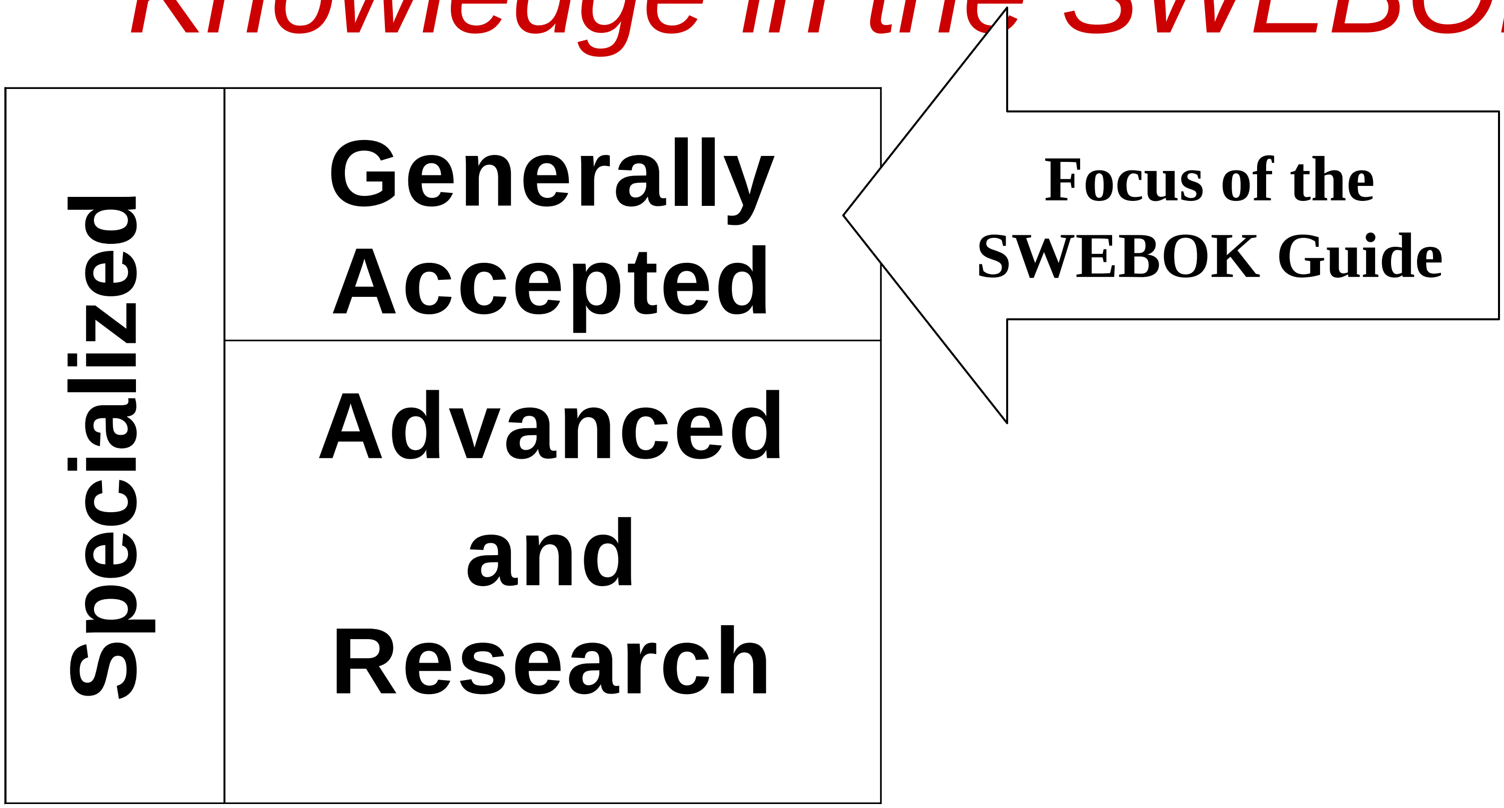
What is Software Engineering?

- *IEEE 610.12:*
  - *"(1) The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software.*
  - *(2) The study of approaches as in (1)."*

Categories of Knowledge in the SWEBOK



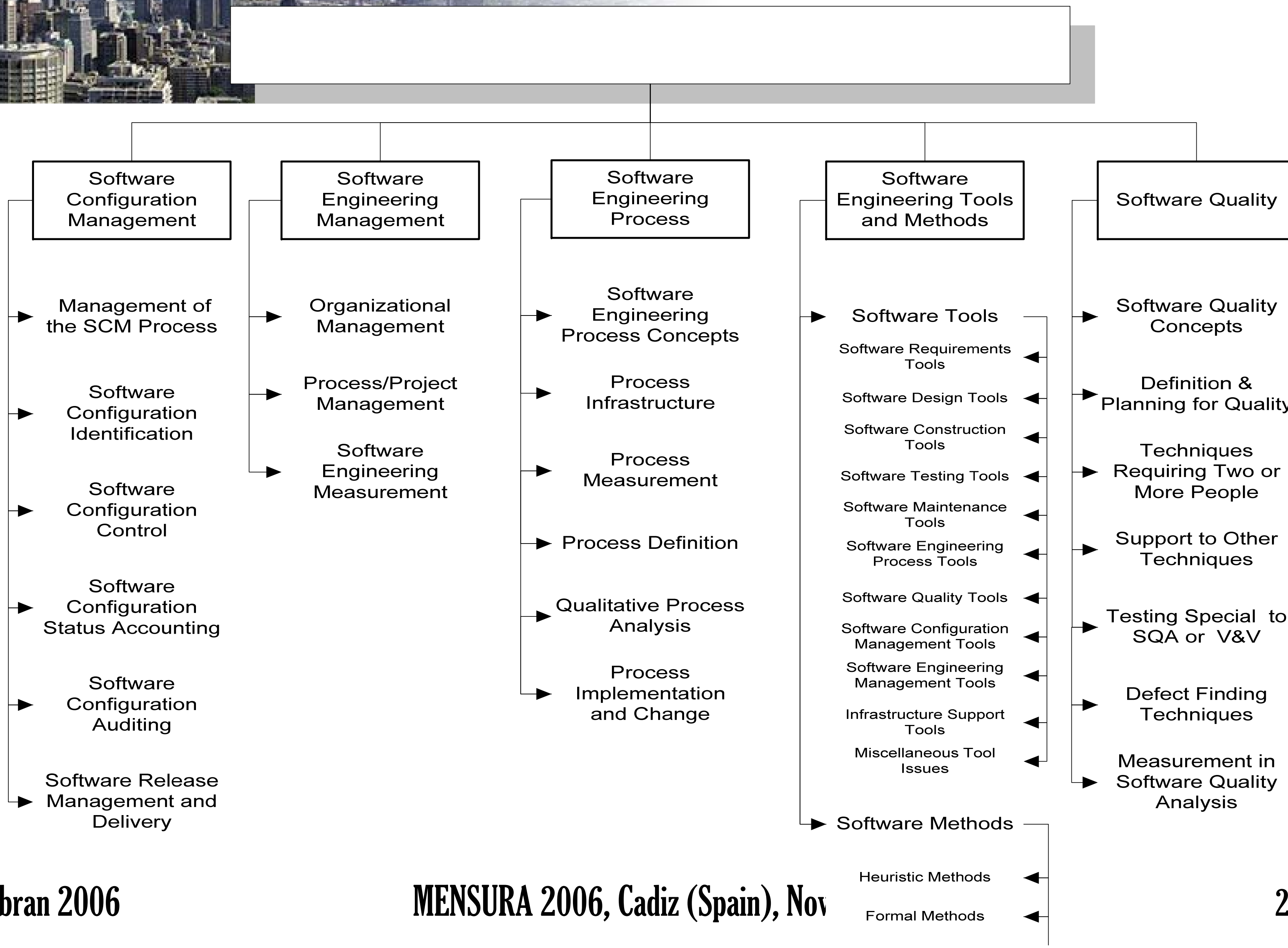
Generally Accepted

- *«Applies to most projects, most of the time, and widespread consensus validates its value and effectiveness»*
  - *Project Management Institute - PMI*

- *Bachelor + 4 years of experience*

Guide to the Software Engineering Body of Knowledge
(Version 0.95)

- Software Requirements
  - Requirement Engineering Process
  - Requirements Elicitation
  - Requirement Analysis
  - Requirements Specification
  - Requirements Validation
  - Requirements Management
- Software Design
  - Software Design Basic Concepts
  - Key Issues in Software Design
  - Software Structure and Architecture
  - Software Design Quality Analysis and Evaluation
  - Software Design Notations
  - Software Design Strategies and Methods
- Software Construction
  - Reduction in Complexity
  - Anticipation of Diversity
  - Structuring for Validation
  - Use of External Standards
- Software Testing
  - Testing Basic Concepts and Definitions
  - Test Levels
  - Test Techniques
  - Test-Related Measures
  - Managing the Test Process
- Software Maintenance
  - Basic Concepts
  - Maintenance Process
  - Key Issues in Software Maintenance
  - Techniques for Maintenance


Software Configuration Management
Management of the SCM Process
Software Configuration Identification
Software Configuration Control
Software Configuration Status Accounting
Software Configuration Auditing
Software Release Management and Delivery
Software Engineering Management
Organizational Management
Process/Project Management
Software Engineering Measurement
Software Engineering Process
Software Engineering Process Concepts
Process Infrastructure
Process Measurement
Process Definition
Qualitative Process Analysis
Process Implementation and Change
Software Engineering Tools and Methods
Software Tools
Software Requirements Tools
Software Design Tools
Software Construction Tools
Software Testing Tools
Software Maintenance Tools
Software Engineering Process Tools
Software Quality Tools
Software Configuration Management Tools
Software Engineering Management Tools
Infrastructure Support Tools
Miscellaneous Tool Issues
Software Methods
Heuristic Methods
Formal Methods
Software Quality
Software Quality Concepts
Definition & Planning for Quality
Techniques Requiring Two or More People
Support to Other Techniques
Testing Special to SQA or V&V
Defect Finding Techniques
Measurement in Software Quality Analysis

Software Measurement

- Basic Concepts
  - Foundations
  - Definitions & Concepts
  - Software Measurement Models
  - Entities to be measured (STAR)
    - Organization
    - Project
    - Resource
    - Process
    - Product
- Measurement Process
  - Establish and Sustain Measurement Committment
  - Plan the Measurement Process
  - Perform the Measurement Process
  - Evaluate Measurement
- Measurement Standards
  - By Entity
    - Resource
    - Process
    - Product
  - By Type
    - De Jure
    - De Facto
- Measures by SLC phase
  - Primary Processes
    - Sw Requirements
    - Sw Design
    - Sw Construction
    - Sw Testing
    - Sw Mainteinance
  - Supporting Processes
    - SwEng Management
    - SCM
    - SwEng Process
    - SwEng Tools
    - Sw Quality
    - Sw Measurement
- Tools & Techniques
  - Tools
  - Techniques
- Quantitative Data
  - By Entity (STAR)
    - Organization
    - Project
    - Resource
    - Process
    - Product

Zelkowitz & Wallace taxonomy of empirical support methods

Category / Empirical support method	Description	Weaknesses	Strengths
A. Observational			
A1. Project Monitoring	Collect development data	No specific goals	Provides baseline for the future; inexpensive
A2. Case Study	Monitor project in depth	Poor controls for later replication	Can constrain one factor at low cost
A3. Assertion	Use ad-hoc validation technique	Insufficient validation	Serves as a basis for future experiments
A4. Field Study	Monitor multiple projects	Treatments differ across projects	Inexpensive form of replication
B. Historical			
B1. Literature Search	Examine previous published studies	Selection bias; treatments differ	Large available database; inexpensive
B2. Legacy	Examine data from completed projects	Cannot constrain factors; data limited	Combines multiple studies; inexpensive
B3. Lessons Learned	Examine qualitative data from completed projects	No quantitative data: cannot constrain factors	Determine trends; inexpensive
B4. Static Analysis	Examine structure of developed product	Not related to development method	Can be automated; applies to tools
C. Controlled			
C1. Replicated	Develop multiple versions of product	Very expensive; Hawthorne effect	Can control factors for all treatments
C2. Synthetic	Replicate one factor in lab setting	Scaling up; interactions among multiple factors	Can control individual factors; moderate cost
C3. Dynamic Analysis	Execute developed product for performance	Not related to development method	Can be automated; applies to tools
C4. Simulation	Execute product with artificial data	Data may not represent reality; Not related to development method	Can be automated; applies to tools; evaluation in safe environment

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Discussion

Key challenge for the designers of software measures:

- *Innovation or consensus building?*
  - *Promoting:*
    - *our 'own new metrics' or*
    - *robutsness in terms of metrology related properties?*
- *How to figure out the key design aspects out of a bunch of alternative 'metrics' designs?*
  - *How to get to a consensus?*

Discussion

- *How do we build an infrastructure for software measures?*

- *What is the process to define an 'étalon' for a software measurement standard?*
  - *What are the design issues?*
  - *How do we tackled them?*
- *How to set up an 'étalon' for a specific software measure?*
  - *And how do we make it evolve?*

The roadmap to software maturity?

- *We must ensure that the fundamentals are right.*
- *We have to build upon centuries of knowhow on how to build measures*
- *We have to contribute to the building of a software measurement infrastructure*

Thank You !

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