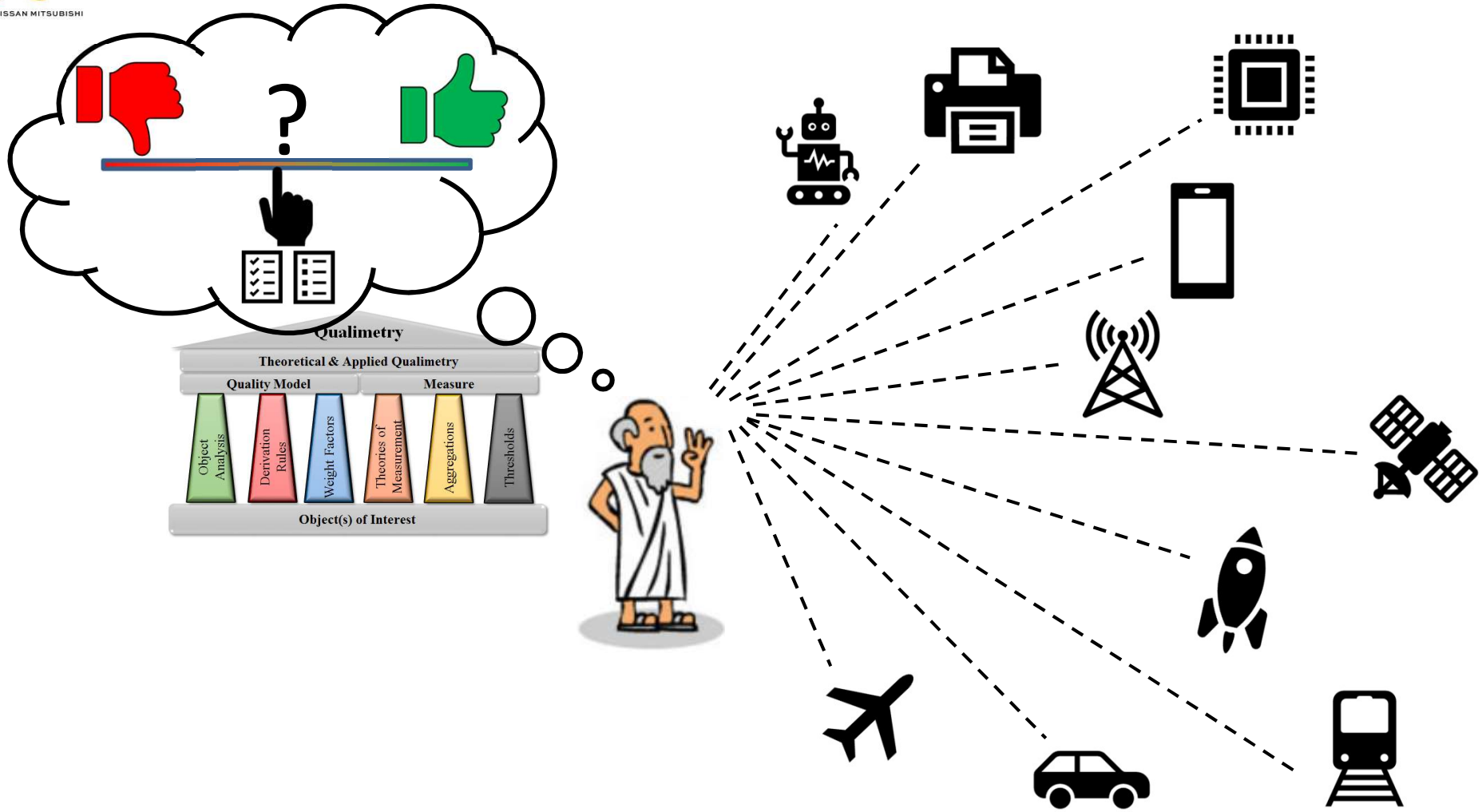
Quality Quantification Applied to Automotive Embedded Systems and Software

Advances with qualimetry science

Yann Argotti, Claude Baron, Philippe Esteban, Denis Chaton

Embedded Real Time Systems Conference 2020

INTRODUCTION

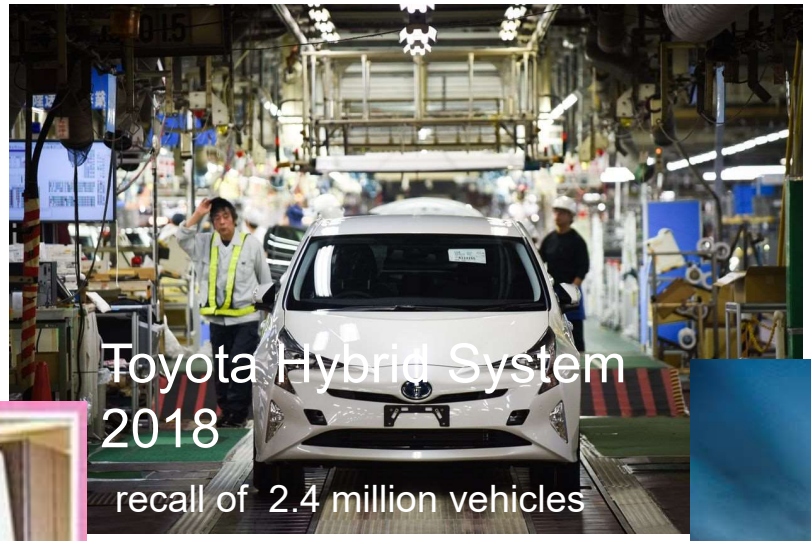


WHY DOES IT MATTER?

- **Conformance to standards and regulations**
  - eg. ARP4754, DO-178C, ISO26262, A-Spice, ISO/TS 16949, CE
- **Help to characterize / define adequately Quality**
  - Identify and organize multitude of characteristics
  - Quality model as central point
- **Help to control / optimize metrics flow**
  - Metrics are essential and everywhere
  - Outputs from many tools
  - Loopback & digitalization of characteristics / properties
- **Help on Cost / Delay / Quality trade-off**
  - Non-Quality costs companies 5% of total revenue
    [*Afnor group, 2017*]

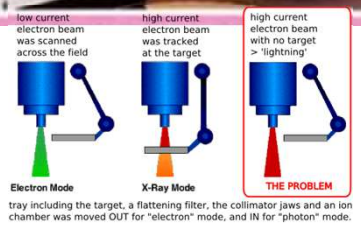
IMPORTANCE OF RIGHT QUALITY QUANTIFICATION

Source https://www.wsj.com/articles/toyota-recalls-more-than-2-million-vehicles-over-hybrid-system-fault-1538725425



Source https://www.flickr.com/photos/dlr_de/8967685954/ licensed under CC BY

Source http://haticomseguranca.blogspot.com/2014/02/seguranca-x-confiance-problemas.html licensed under CC BY



Source http://radonc.wikidot.com/radiation-accident-therac25 licensed under CC BY-NC-ND

Source https://commons.wikimedia.org/wiki/File:Ariane_5_1.jpg licensed under CC BY-SA

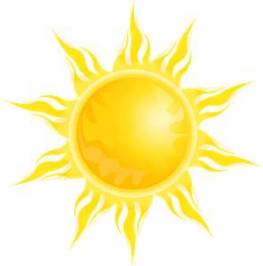
PROBLEM WITH CURRENT APPROACHES

- **Solution too general**
  - Wide scope with ambition to cover as much as possible
  - e.g. standard such as CMMI, ISO/IEC9126, ISO/IEC25010
    - 28% of companies use standards and 79% of these companies customized them [*Wagner et al., 2012*]
- **Solution too specific, focus is on applied aspect**
  - Reuse / adaptation of previous work cannot be or hard to generalize
  - McCall *et al.* with Factor / Criteria / Metric [*McCall et al., 1977*],
  - Basili *et al.* with Goal / Question / Method [*Basili et al., 1994*],
- **Solution set too large**
  - In literature, many quality models for SW product: no obvious right quality model
- **Few works about theory and applied quality quantification,**
  - ***SW product oriented***, Wagner on SW product quality control [*Wagner, 2013*],
  - ***General approach***, Azgaldov *et al.* on general quality assessment [*Azgaldov et al., 1968 & 2015*]

→ ***Qualimetry***

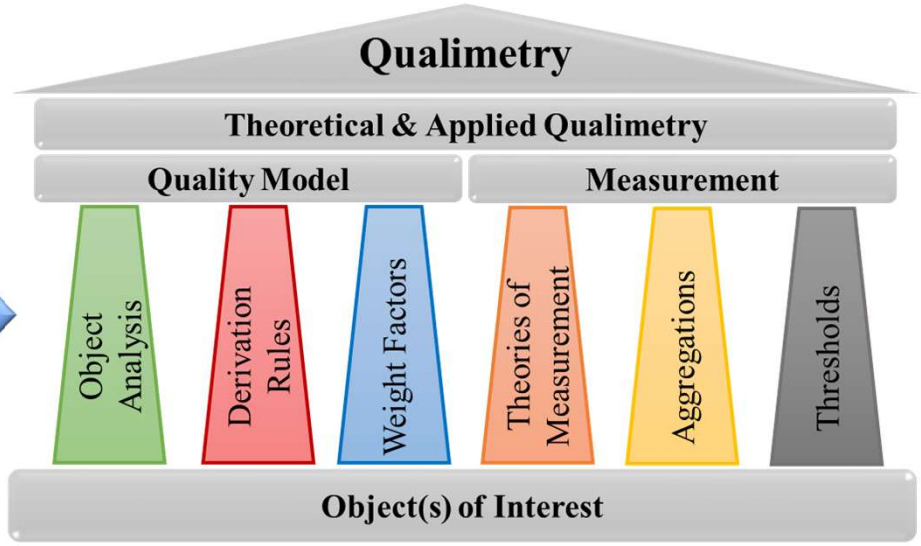
QUALIMETRY

> **Science of quality quantification**
- from the Latin qualis “of what kind”
- and the Greek μετρεω “to measure”



> **Science Id**
- Goal is to generalize quality quantification approach
- Born in former USSR in 1968 [*Azgaldov et al., 1968*]
- Theoretical & Applied aspect
- Scope: any fields

> ***House of Qualimetry* and its 6 pillars**
- a synthetic view of Qualimetry



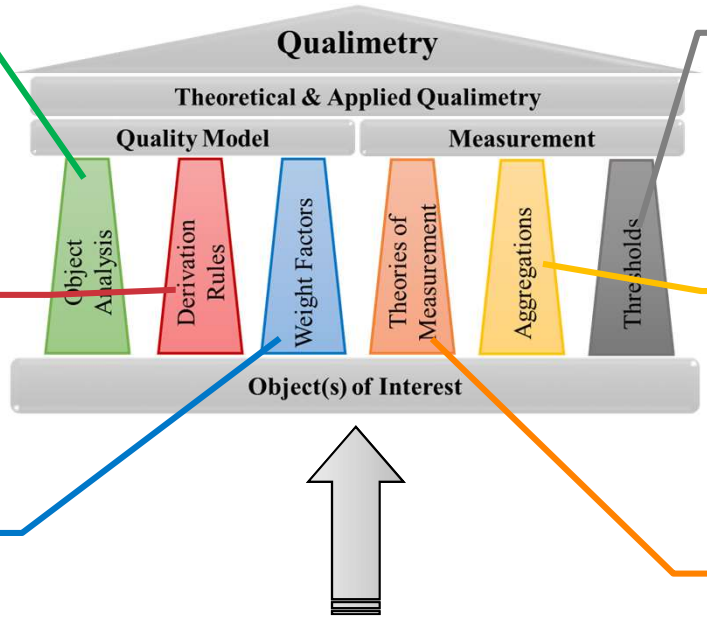
THE *HOUSE OF QUALIMETRY*

Quality Model

Quality characteristic identification

Rules to support quality characteristic organization

Importance of quality characteristics among others



Candidate object(s) for quality quantification

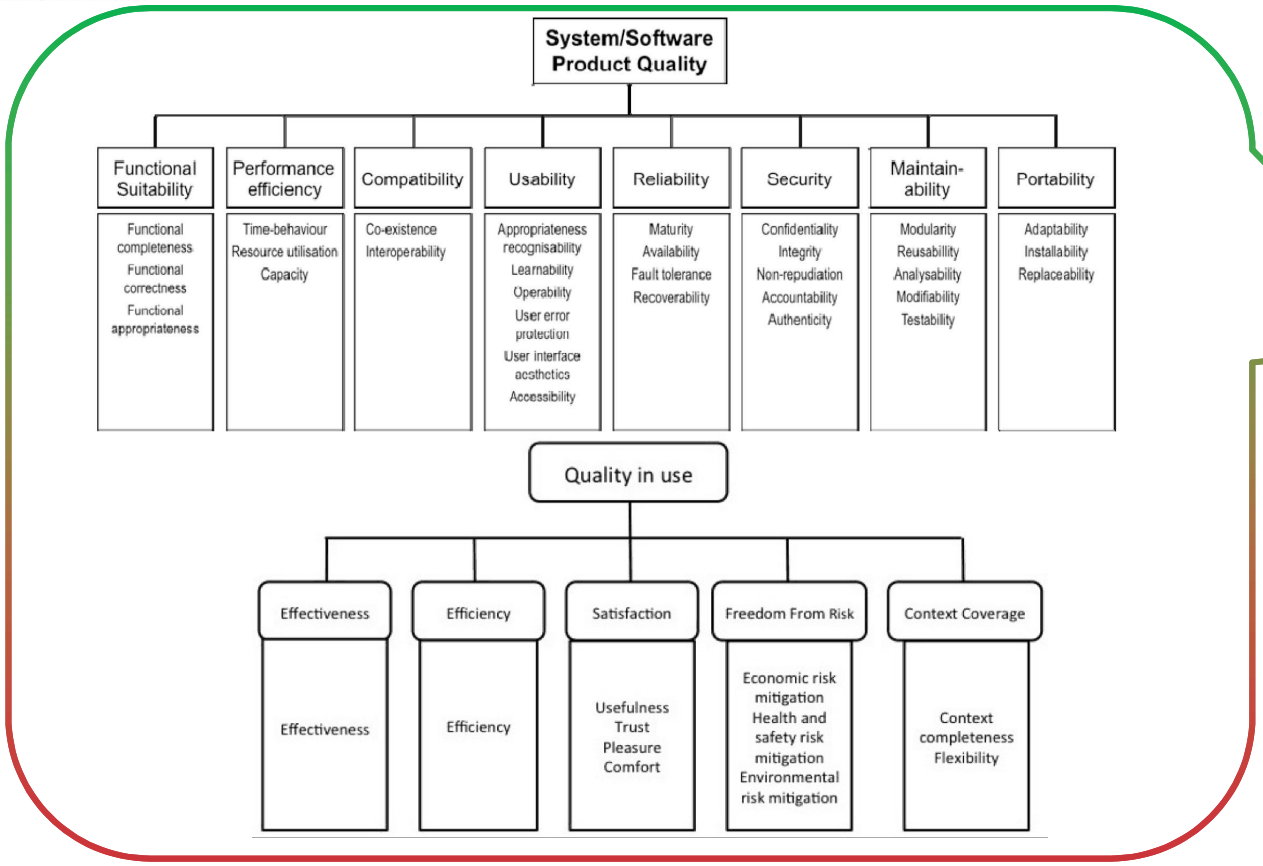
Measurement

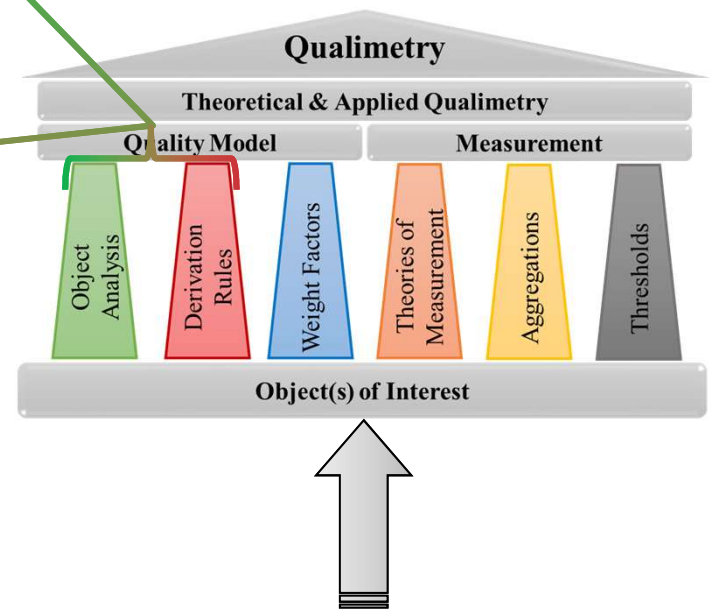
Reject, accept, target, reference (can be extended with “forecasted”)

Combining measurements (Logical scoring of preferences, mean, median, variance, …) weighted or not

- Operational, Representational and various minors (Diez 1997)
- Gives mathematical & statistical tools

THE *HOUSE OF QUALIMETRY:* quality model example - ISO/IEC 25010:2011



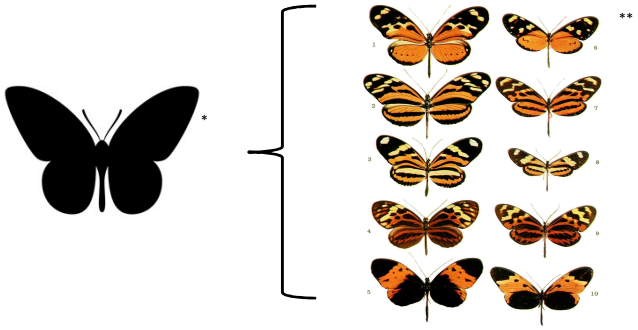


Automotive SW Product

QUALITY MODEL PILLARS: POLYMORPHISM CONCEPT

> Polymorphic quality model

1. For same type of objects, we may have
   - Common quality model characteristics or "interface" (*ie **Ad hoc polymorphism:** overloading & coercion,*),
   - Variations with heritage between quality models (ie ***Universal polymorphism***: *sub-classing, inheritance, or overriding, extension*)



2. Over a project or product life cycle, for example, quality model can change (e.g in design phase we have different focus than in maintenance one),

> Quality model distance: Degree of polymorphism (*from genetic*)

- The nucleotide diversity formula introduced by Nei and Li in 1979

$$\pi = \sum_{ij} x_i x_j \pi_{ij}$$

Note: nucleotide = leaf characteristics, gene = group of characteristics, x_i frequencies of the ith sequence

π_{ij} nucleotide difference between sequence i and j

Quality Model Pillars: Quality Model Distance Importance

Sources of Quality model change or adaptation

- Change of life cycle stage (e.g. from design to implementation),
- Evolution of product (e.g. addition of new features),
- Insufficient quality area coverage (e.g. gaps in safety or security),
- Change of targeted product (e.g. from car to truck),
- New or updated process or standard (e.g. from ISO/IEC 9126 to ISO/IEC 25010),
- …

> Benefits from Quality model distance

- Evaluate risk linked to quality model change
  - low distance = low risk, high distance = high risk,
- Evaluate change workload and cost,
- Identify most impacted areas and characteristics,
- Identify where quality quantification, assessment and control are changing,
- Identify and evaluate validation path finding change
  - Capture of different types of bugs possibly never found before
  - Discarding other areas and path
- Support decision and control change / update of quality model

Quality Model Pillars: Application to Automotive

> As embedded Systems

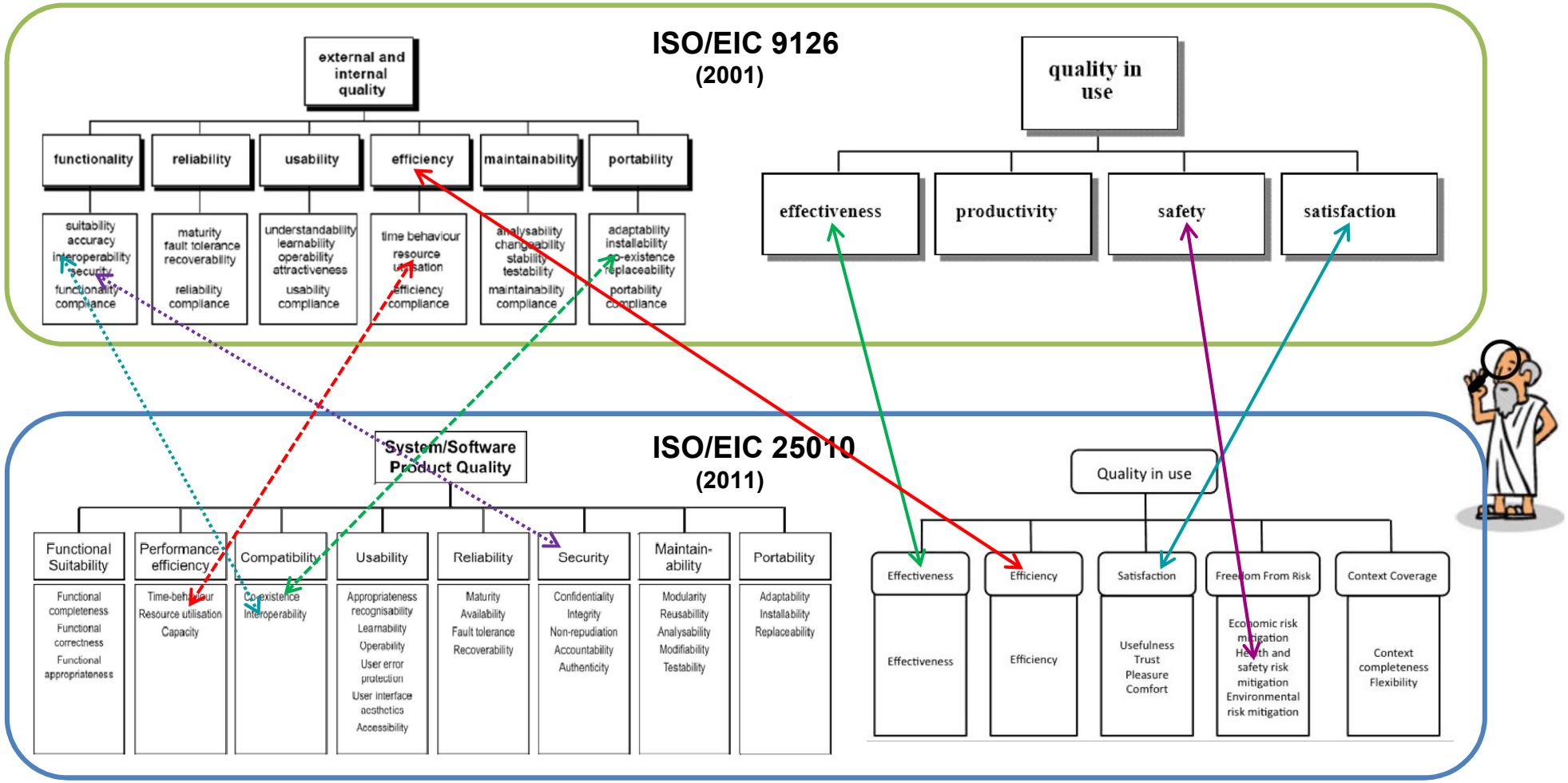
- **Vehicle platform**
  - **Variants:** mini-compact, crossover, supercar, convertible, commercial, sport, van ….
  - **Complex system**, composed of more than 40 systems, distributed over more than 60 Electronic Control Units (**ECU**): hardware + software
- **Each ECU has**
  - **Common characteristics** with other ECUs: e.g. diagnostic, connection interface, power,
  - A set of **specific characteristics**: e.g. HMI, communication, safety,
  - A **context**: e.g. door control, engine control, telematic control, seat control.

> As embedded Software

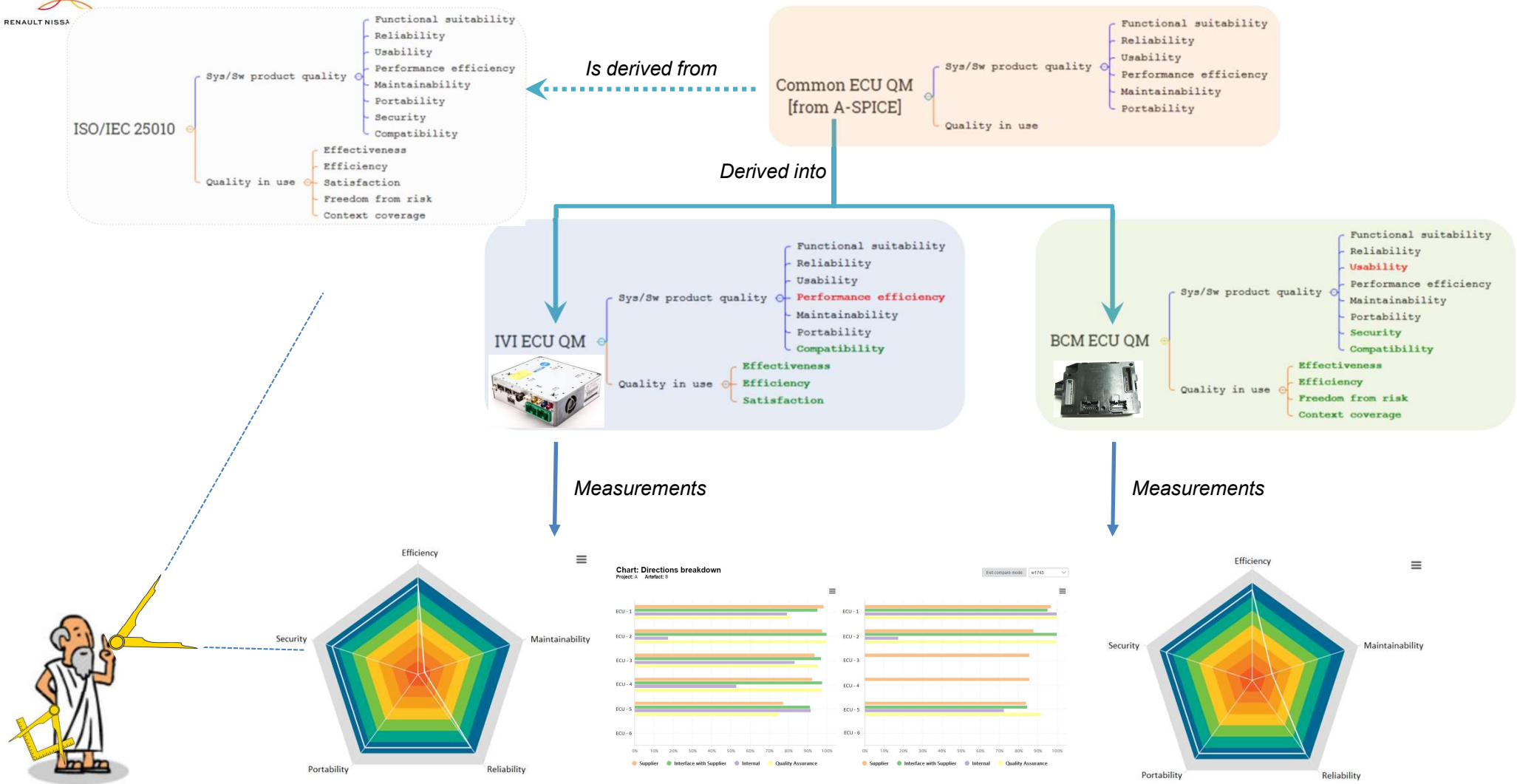
- **Automotive-SPICE Process Assessment / Reference Model guidelines**
  - **In v2.5:** reference to ISO/IEC 9126
  - **In v3.0/1:** reference ISO/IEC 25010
- **Distance between ISO/IEC 9126 and ISO/IEC 25010**
  - **Degree of polymorphism = 0.6792** (0 = identical; 1 = 100% disjoined)

    [53 leaf characteristics, 32 unique, 8 similar]

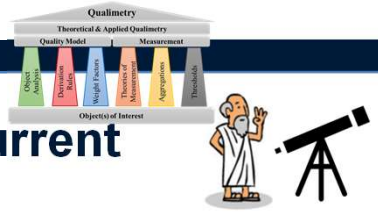
Example of some differences between ISO/IEC 9126 & ISO/IEC 25010



Quality Model & Measurement Pillars: Polymorphism applied to Automotive



CONCLUSION



- **Review why quality quantification is important and gaps with current approaches**
- **Strengthen current quality quantification relying on Qualimetry by**
  - Introducing synthetic view of the "***House of Qualimetry***",
  - Introducing ***polymorphism*** to capture quality model evolution, adaptation and replication aspects,
  - Introducing ***degree of polymorphism*** to setup intrinsic distance between quality models,
  - Explaining the ***importance*** of quality model distance,
- **Open new perspective with regards to quality quantification in systems engineering**
  - Bring homogeneity, consistency and compatibility to quality characteristics and quantification
  - Helps specify a joint "vocabulary",
  - Define a derivable quality model (e.g. ECU or car platform one)
  - Allow smooth incremental change management which is key in agile development methodology
- **Our next steps focus**
  - quality model consolidation and deployment for all ECUs & aggregation at vehicle platform level
- **Contacts**

YANN ARGOTTI
yann.argotti@laas.fr
yann.argotti@renault.com

CLAUDE BARON
claude.baron@laas.fr

PHILIPPE ESTEBAN
philippe.esteban@laas.fr

DENIS CHATON
denis.chaton@renault.com

THANK YOU !

Back-up