Development Cycle

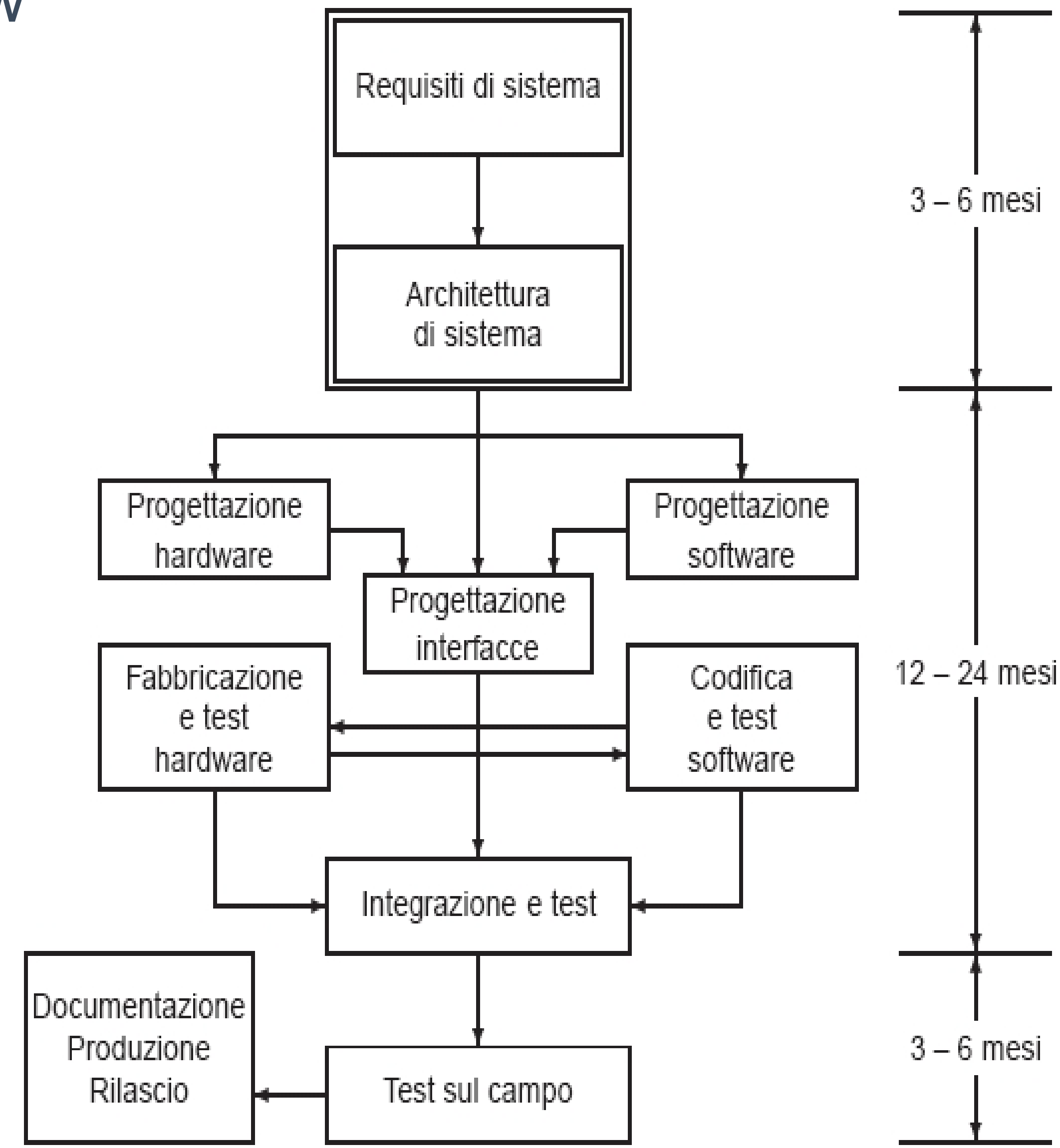
Development cycle

Ciclo di sviluppo

- The development of an embedded system, at least as far as the realisation of a finished product from which engineering towards mass production is concerned, is traditionally still an extremely uneven activity
  - Persistent lack of integration causes costs and delays

Development cycle

- Traditional flow
  - Uneven



Development cycle

- Structuring the project so as to control all phases
  - Analysis of a requirement
    - Understanding the need to be covered by the system, whether there is a market, and what the essential constraints and requirements are
  - Project Definition
    - Preliminary study of the system (feasibility), define resources, budget and development time in a quantitative manner to arrive at a contract proposal
  - Planning and organisation
    - Tasks, deadlines and checkpoints for progress and quality
  - Project Development
    - Realising the system with appropriate methodologies/technologies
  - Completion
    - Verify that the product actually complies with the objectives

Models

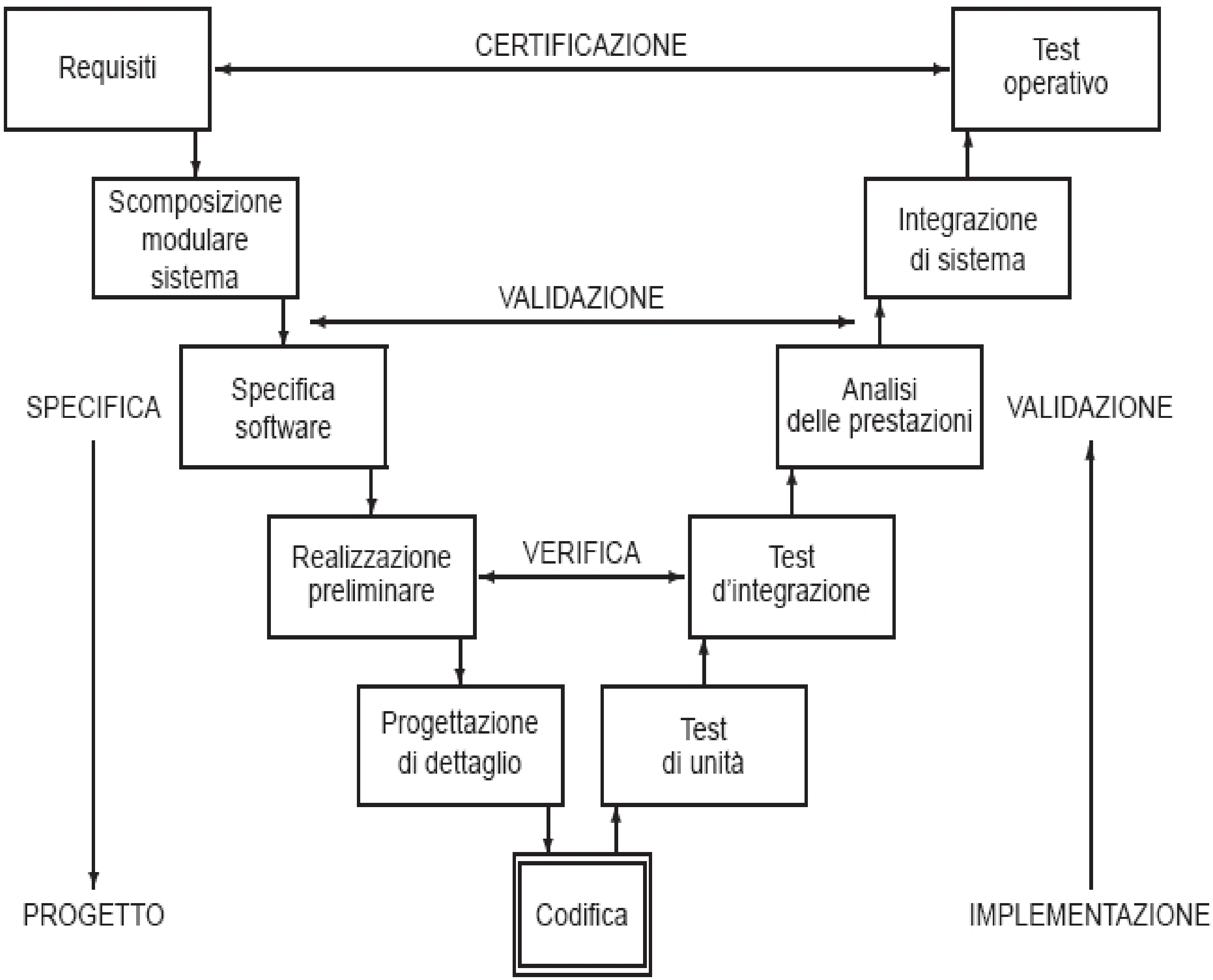
Models

- In recent years, several models have been proposed to represent the development of a project
  - In general, the various models involve at least five stages
    - Definition of specifications
      - Structured document describing the functions to be implemented, the interfaces and the constraints to be met in the implementation
    - Project
      - Particularly complicated phase, as it encompasses the simultaneous development requirements of a real-time system, hw and sw
    - Realisation, Production and Commissioning
      - Production often passes through the development of a prototype, in order to assess its characteristics and choose the appropriate industrialisation criteria
  - At the end of the cycle, maintenance activity, which may be: corrective, adaptive or preventive, must be foreseen

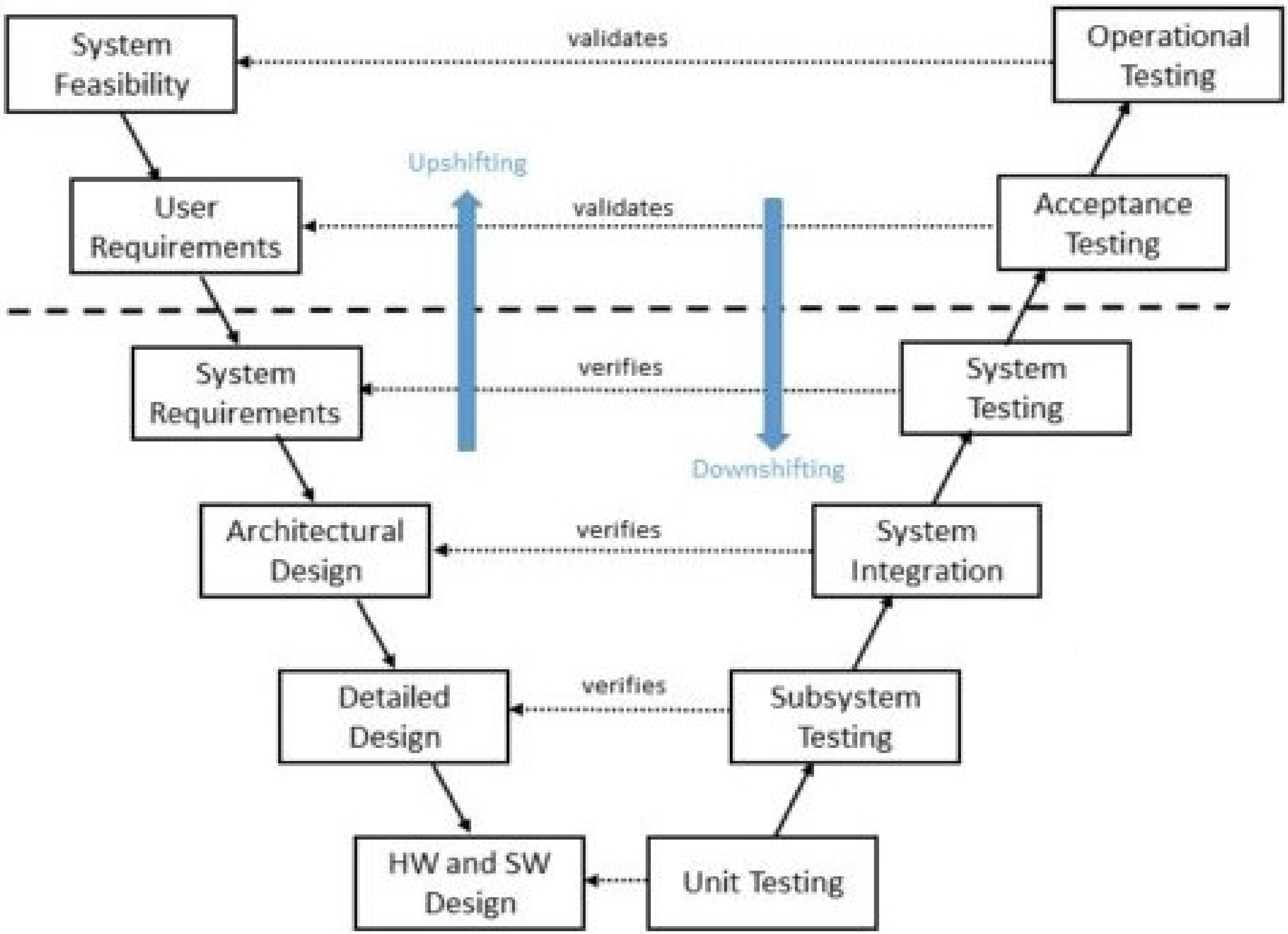
Models

- Cascade model
  - Feasibility study
  - Requirements planning and analysis
  - Product design
  - Detail design
  - Encoding
  - Integration
  - Realisation
  - Maintenance
  - Phaseout

- V-shaped model

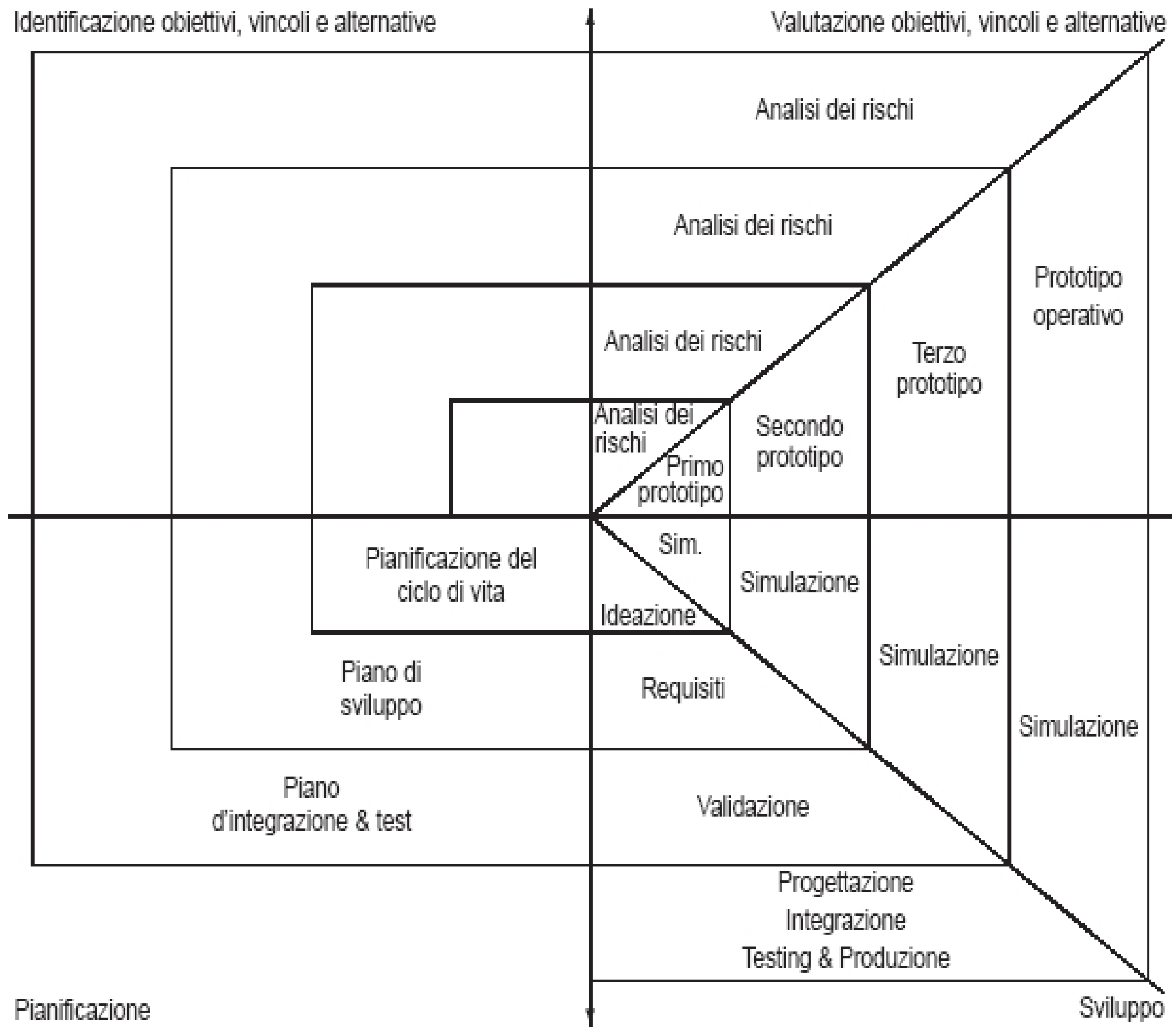


V-Model (EXTENDED)



Models

- Spiral model



- Contract model
  - Emphasises the interaction aspect between customer and client
    - Each phase is considered subject to a contract between the parties
    - Moving from the description level towards implementation, each release is validated by the customer which implies the fulfilment of contractual requirements
      - This model has the advantage of directly involving the customer in the validation phase throughout the development process
      - The disadvantage is that it is not always easy to have a sufficiently competent client for validation

Models

- A more realistic view
  - The models presented give the impression that all phases are clearly identifiable and separated
    - In reality, at the beginning of each new phase, decisions taken previously often have to be changed, which results in a partial overlap of the various phases
      - The design phase often begins when all specifications have not yet been fully and comprehensively defined
        - Many protocols evolved in terms of standards even in parallel with the release of the first commercial realisations
        - In the consumer field, the presence of software in the final architecture allows changes to be introduced even when the product is finished and sold

- A more realistic view
  - Entirely similar problems are generated by the client, who often requests variations that are seemingly insignificant in his opinion, but which risk translating into heavy architectural changes
    - In these cases, it is sometimes necessary to develop additional sections to add the required functionality
  - The cost of error correction and development time is reduced the more you can proceed in a top-down manner
    - Problems that emerge in production, or even worse after release, are the most difficult to correct

- A more realistic view
  - The distribution of project effort is uneven
    - This also poses an organisational problem, since ideally the number of people employed should be variable
      - In companies, on the other hand, it is common to have staff in fixed variable numbers slowly
        - " This is why design houses for design or body rental for designers are created
  - Several studies have been done on factors influencing productivity, especially with regard to software development
    - The ability of the project team has up to four times the influence of others
      - This observation justifies the investment in the professional growth of the project team, as opposed to merely minimising the cost for the individual project

Conclusions

Conclusions

- The development of an application, in addition to the obvious and never taken for granted technical skills, requires skills in economic analysis, planning and management
  - For embedded systems, where cost and development time requirements are crucial to the success of the product, it is of particular importance to structure the design process so that it is flexible and adaptable to the variability of the market and application requirements
    - Very important are the issues of identifying the role of the project manager, the metrics that can be used to estimate the development costs of the hw/sw parts that make up the system, and the effect of development time on product sales

Where are we in the company.....?

Example of assessment
R&D and New Product Development (NPD)

Assessment R&D (1)

- The performance of R&D and NPD (new product development) activities can determine not only the success and competitive advantage of a company, but also its very survival
- Today's market requires appliance manufacturers to compete with products based on increasingly innovative and high quality digital technologies

- Periodic performance appraisal and evaluation of R&D and NPD activities should be cornerstones for every innovative industrial company
  - identification and evaluation of parameters that highlight the quality level of the research, design and production
- For appliance manufacturers in particular, this becomes increasingly true for the electronic component (HW and SW) of their products

Assessment R&D (2)

- ➔ The electronic project assessment project is based on the use of a set of *key indicators* covering all key stages of the design and development of an electronic system
  - ➔ □□□ quantity and type of *key indicators* depends on the specific R&D and NPD scenario under analysis from time to time
- ➔ □ rating is given for each *key indicator:*
  - ➔□□□□□□□□□ and descriptive, also containing, where necessary, indications of improvement/corrective actions
  - ➔Synthetic
    - ➔E.g. a rating between 1 and 5
      - ➔ 1) below average; 2) average; 3) above average; 4) very good; 5) outstanding.
  - ➔On trend, to take into account the perceived evolution of the indicator over time
    - ➔For example: high worsening; worsening; stable; improving
- ➔ To facilitate analysis, evaluation and visualisation for top management, the point indicators can be grouped into 'macro' indicators
- ➔ At the end of the assessment project, the strengths and weaknesses of the design and development process and the corresponding end products are evident

Example of key indicators for a project with HW and SW components

HW Project Indicators

- ➔Analysis of requirements
- ➔Configuration Management
- ➔Documentation of requirements
- ➔Architecture of the electronic system
- ➔Circuit solutions
- ➔Component □□□□□□□□□ and sizing
- ➔Layout of boards
- ➔Security □□□□□
- ➔Planning of activities
- ➔Reliability
- ➔Validation □□□□
- ➔ Supplier □□□□□□□□□□
- ➔System □□□□□□□□□□□□□
- ➔Technical □□□□□□□□□□□□□□
- ➔Detailed technical □□□□□□□□□□□□□
- ➔Electrical and electronic □□□□□□□
- ➔Development □□□□□
- ➔Measuring □□□□□□□□□□□□□□□
- ➔ Configuration management □□□□□
- ➔ Staff □□□□□□□□
- ➔…

SW project indicators

- ➔Analysis of requirements
- ➔Configuration Management
- ➔Documentation of requirements
- ➔Software □□□□□□□□□□□□
- ➔Programming □□□□□□□□ and libraries
- ➔Correctness of the code
- ➔Reliability
- ➔Validation □□□□
- ➔Independence on the project team
- ➔Use of metrics
- ➔ Supplier □□□□□□□□□□
- ➔Definition of responsibilities
- ➔Documentation of architecture
- ➔Technical □□□□□□□□□□□□□□
- ➔Detailed technical □□□□□□□□□□□□□
- ➔ User manuals
- ➔Development □□□□□
- ➔Testing and debugging □□□□□
- ➔ Configuration Management □□□□□
- ➔ Staff □□□□□□□□
- ➔…

Note: this set of indicators is not exhaustive and does not refer to any specific project, but is for explanatory purposes only

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Product Life Cycle

- Initial market research conduc-tion
- Alterna-tives definion by R&D
- Market research refine-ment
- Product criteria and targets setting

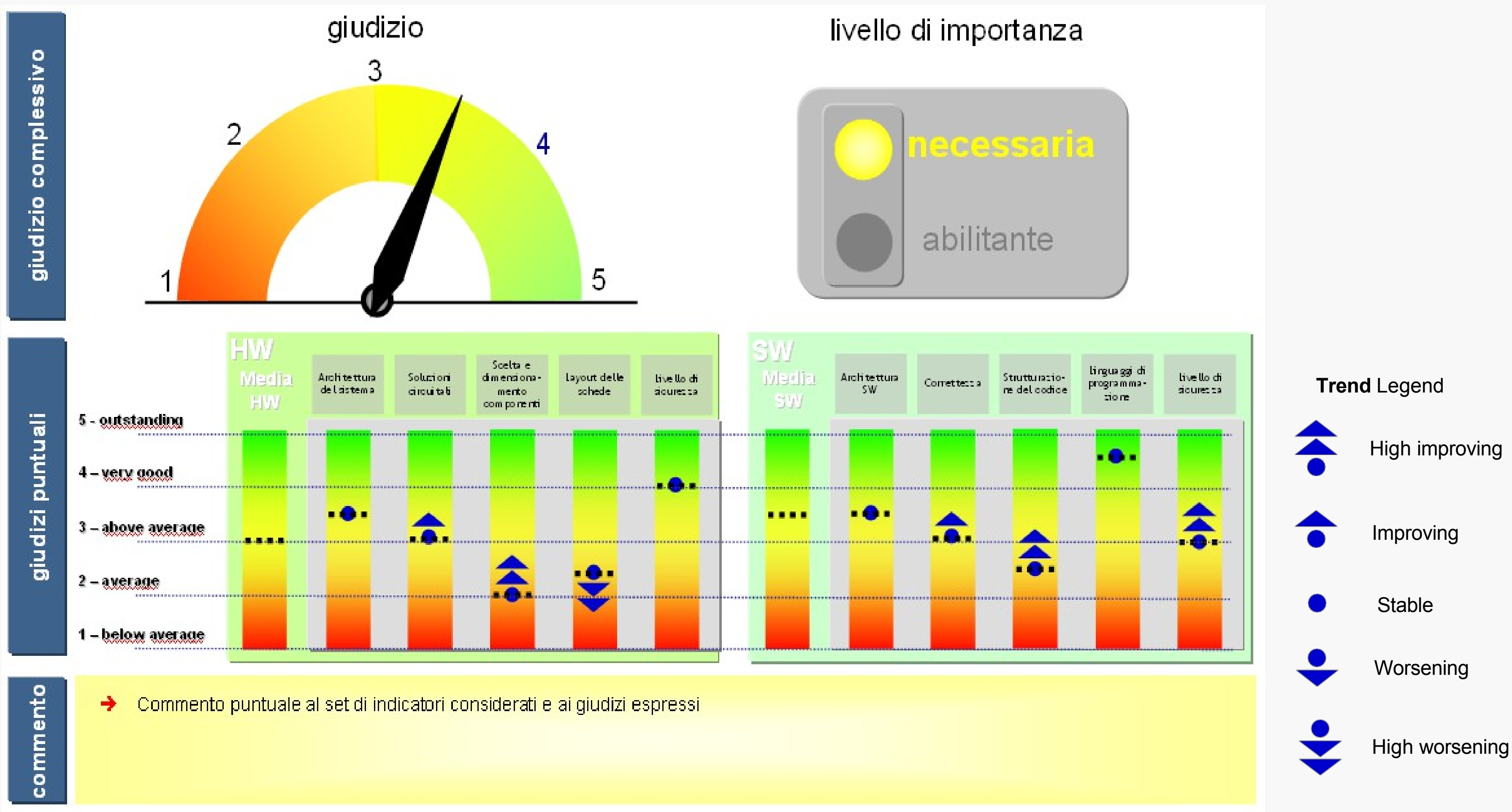
All phases of the product life cycle are taken into account in the assessment process, with particular reference to the design and development phases

- Feasiblety
- Design
- Integrated on and testing
- Industryl deploy

- Manufac-turing ramp-up
- Product Launch
- Hordesr
- Customer satisfa-ction
- Technical support
- New version

Assessment R&D
an example of an evaluation dashboard

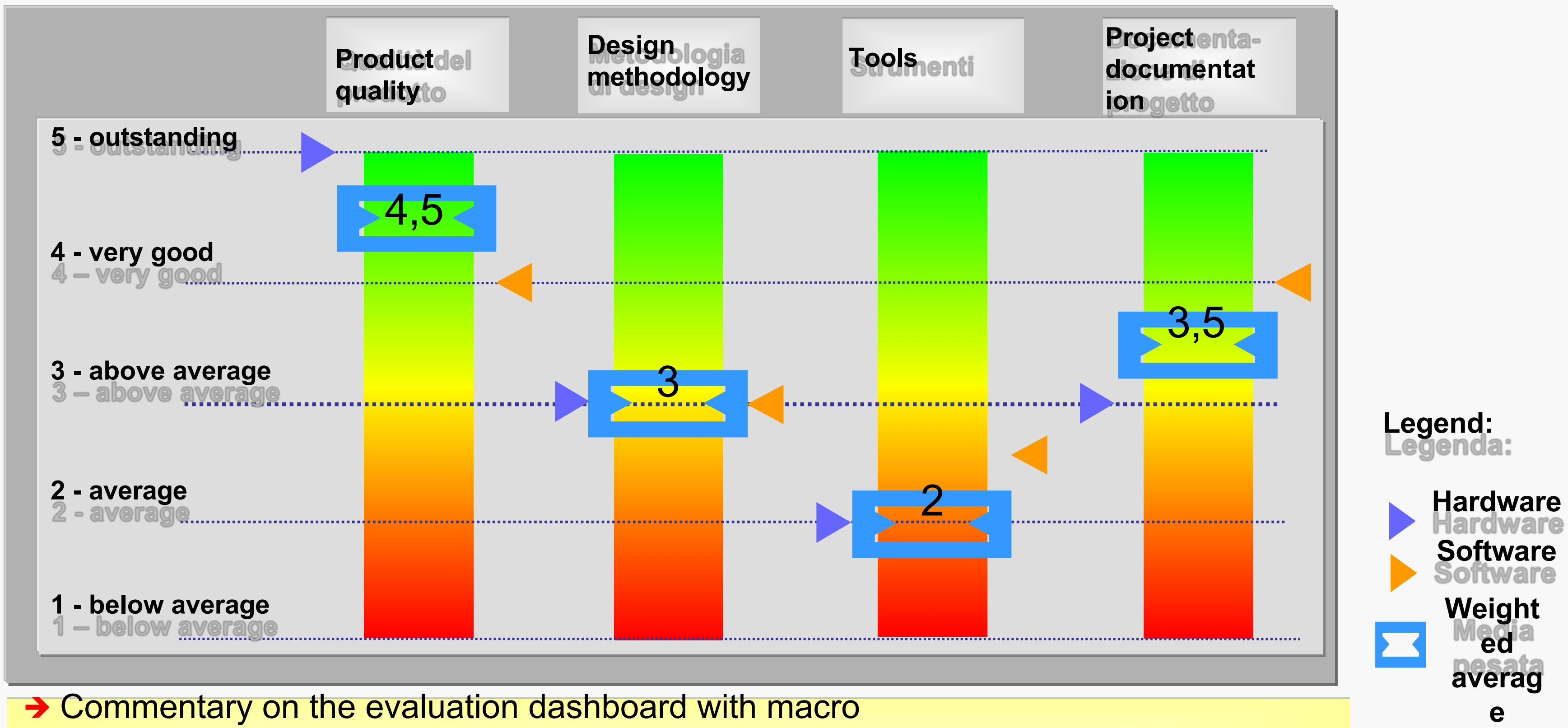
The results of the assessment are summarised in a series of graphical 'evaluation dashboards' for ease and immediacy of use



Assessment R&D
an example of a synthetic evaluation dashboard

Concise evaluation dashboard (based on macro indicators) suitable for presentations to top management

overall judgement

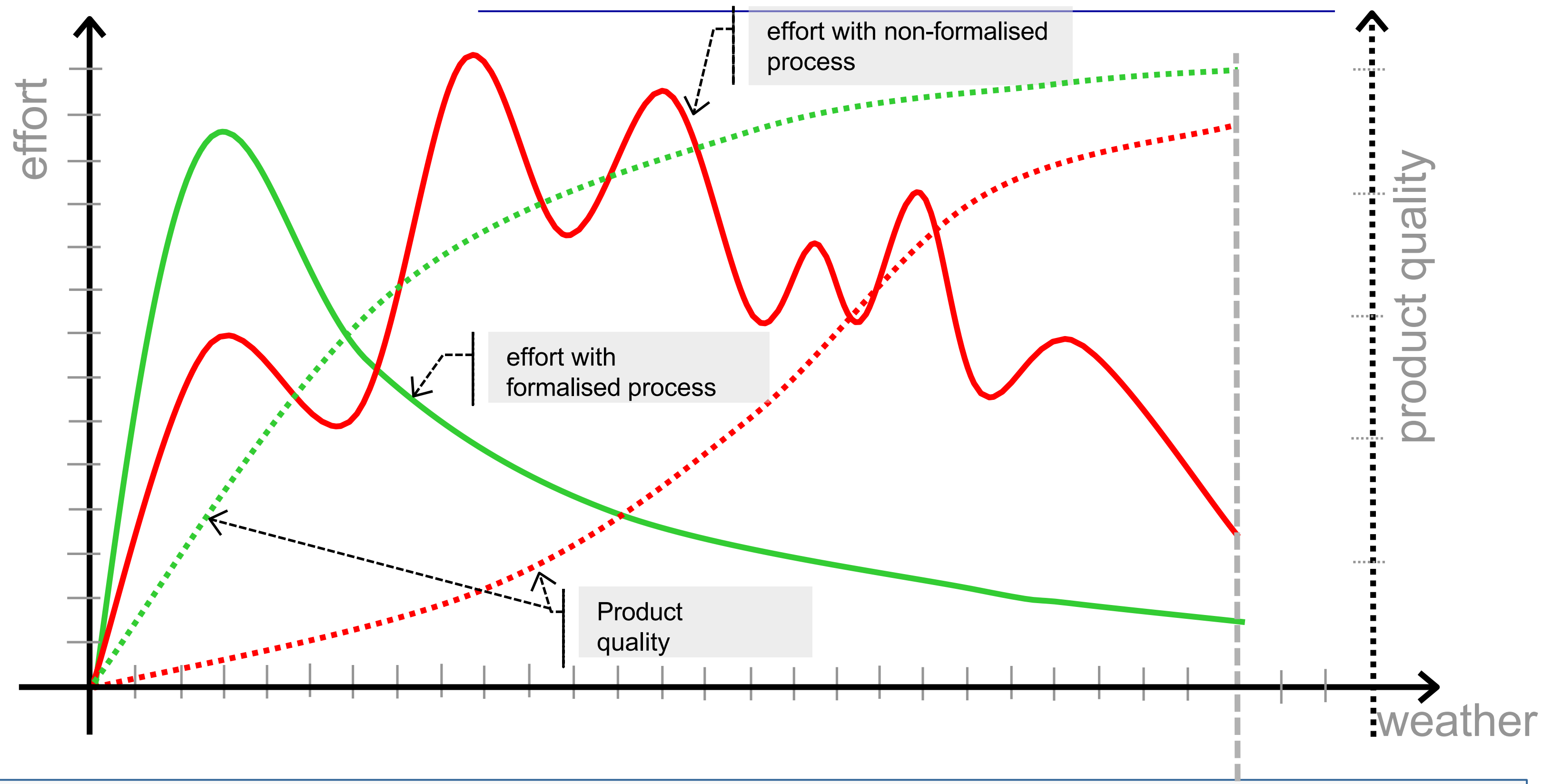


comment

→ Commentary on the evaluation dashboard with macro indicators

Research and development process
Punctual effort

trend in effort required/product quality over time



considerations

- Chaotic' development processes (CMMI level 1)
    - are based on common sense
    - are defined from time to time
    - are difficult to predict and govern
    - produce appropriate qualities according to the individual capabilities of the professionals
- The adoption of a rigorous development process
    - reduces the effort and time required to achieve product quality consistent with business requirements
    - increases the probability of product success

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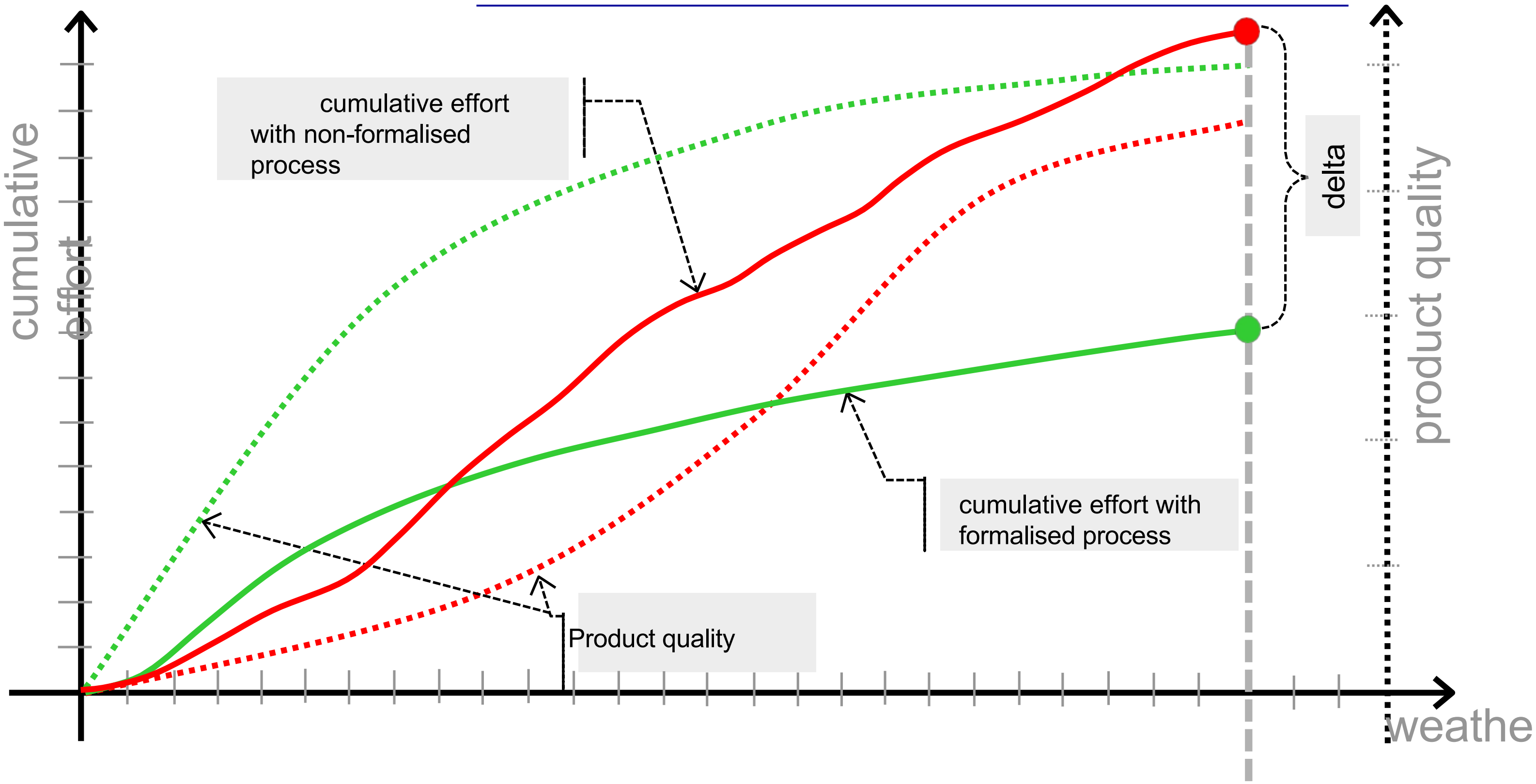
Research and development process
Cumulative effort

trend in effort required/product quality over time



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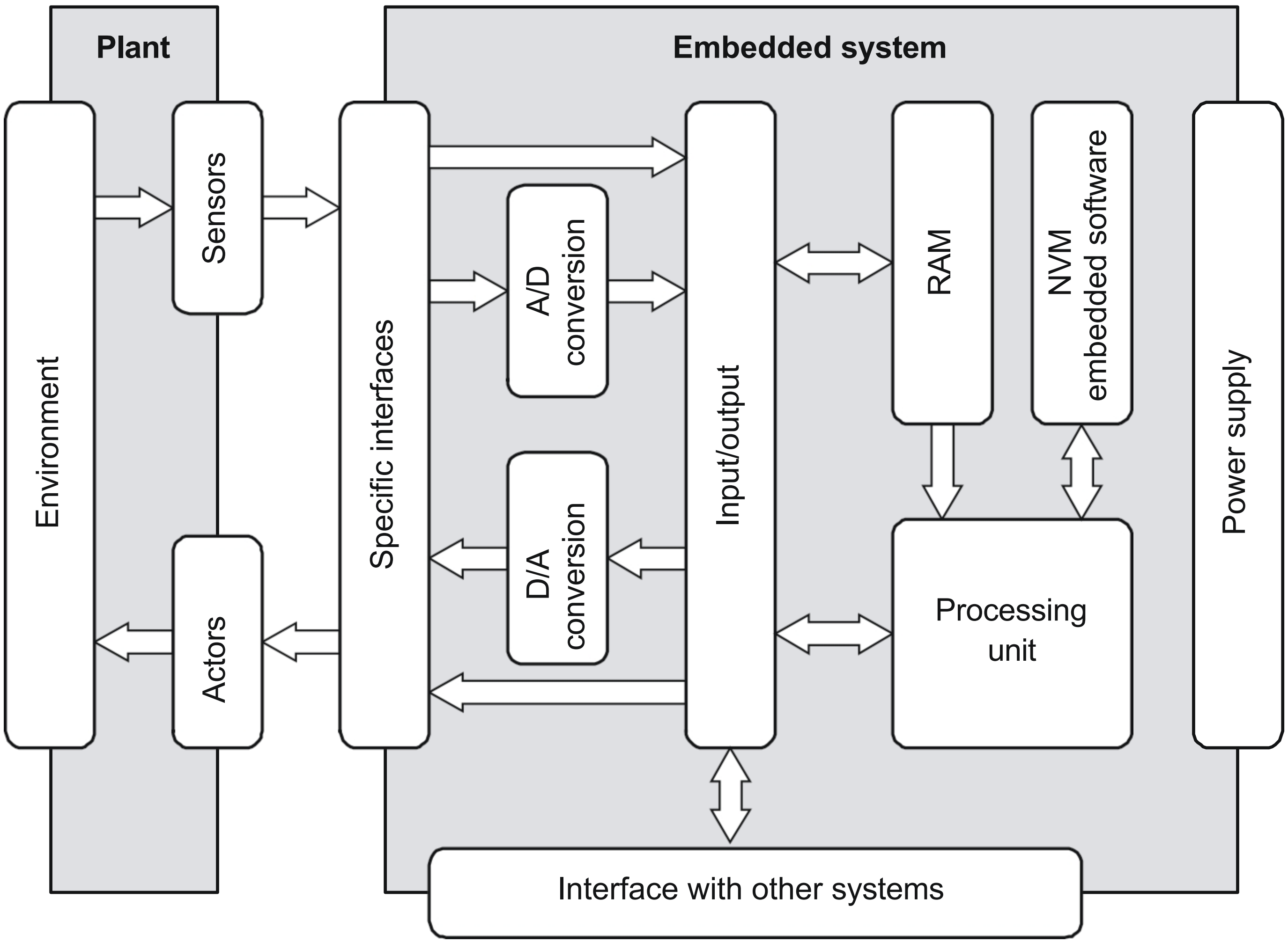
Nice one!.....but does it run correctly?

What is the meaning of testing for an Hw-Sw Embedded System

How to test?

- Attention, you don't just test a programme
  - often it is the entire embedded system that is verified



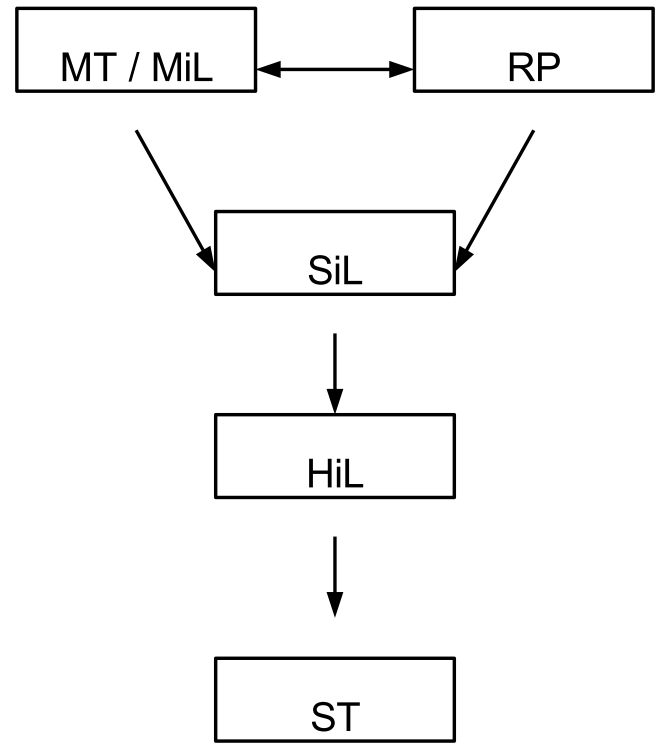
Stages in Embedded Systems Testing

Presenter
2020-11-19 19:34:26
- if I identify a pb 'before' I save...

- Simulation
  - all elements of the system are simulated
- Prototyping
  - some elements of the system are simulated
  - some elements of the system are prototypical (real, but not designed for production, only for prototyping)
  - some elements of the system are real
- Pre-production
  - all elements of the system are real
- Post production
  - all elements of the system are real

Test: transition from the simulated system to the real system

- MT: Model Test - (simulation)
- MiL: Model in the Loop - (simulation)
- RP: Rapid Prototyping
  - unreal' model (with many resources), real environment
  - (simulation)
- SiL: Software in the Loop
  - real sw tested on simulated hw
  - (prototyping)
- HiL: Hardware in the Loop
  - real hw (one or more components) tested in a simulated environment
  - (prototyping)
- ST: System Test
  - real hw and real sw



– (pre-production)

How to proceed

- Simulation
  - One-way
  - Feedback
  - Rapid prototyping
- Prototyping
  - Simulatable components
  - Type of test
- Pre-production, Post-production

Simulation

- aka: Model Testing, Model in the Loop
- Objectives
  - Design
  - Conceptual verification
- It is not a 'compulsory' stage
- Types
  - One-way simulation (S1)
  - Simulation with feedback (SF)
  - Rapid Prototyping (RP)
- Best practice:
  - **First** build the Environment model
  - **Then** the Embedded System model

Simulation

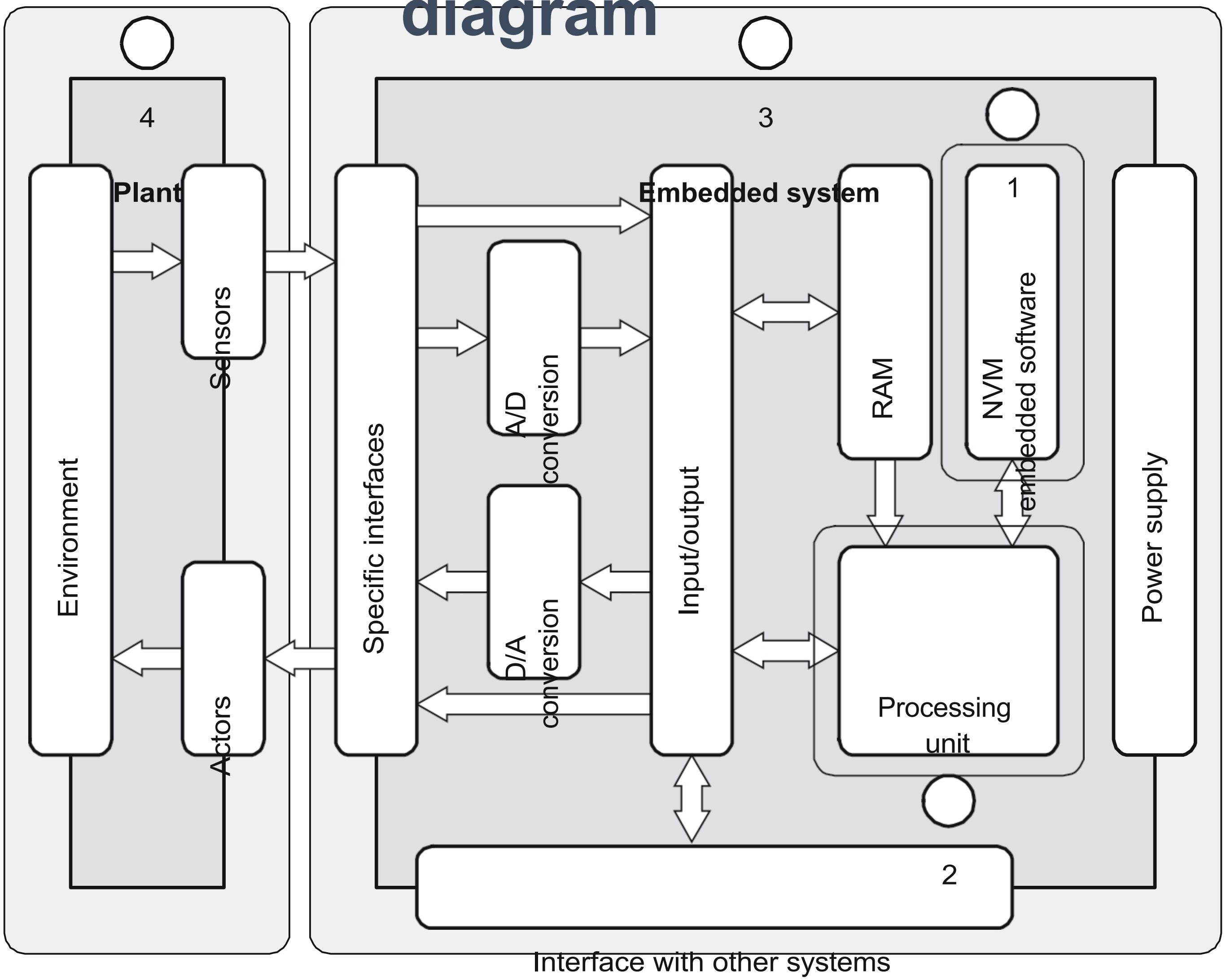
		SW	Processor	Embedded system	Environment - Plant
S1	MT	fictitious	-	-	-
SF	MiL	fictitious	-	-	fictitious
RP	RP	experimental	experimental	experimental	real

Prototyping

- aka: Model Testing, Model in the Loop
- Objectives
  - Verification of the simulation model (if any)
  - Check that the system meets the requirements
  - Release of the pre-production unit
- Process
  - In the prototyping phase real hw and sw gradually replace simulated components
  - Many iterations
- Comments
  - Need for interfaces between hw and sw (simulated and not)
  - Some signals available in simulated models may not be available in real models.
    - Instrumentation: signal collectors, transducers, signal recording instrumentation...
    - Instrument calibration: automatic, repeatable, documented

Simulatable components: diagram

Componenti simulabili: schema



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Simulatable components: description

1. Embedded Software

   The sw can be simulated:
   - on a host platform, compiled for the host platform
   - on an emulator of the target platform executed by the host computer, compiled for the target platform
2. Processor

   The processor can be replaced by a higher power processor. The higher power processor can emulate the target processor.
3. Remaining embedded system

   The remaining embedded system can be simulated through:
   - emulator on the host platform
   - construction of an experimental hw configuration
   - construction of a prototype plate with each of its components
4. Environment
   - Static simulation: signal generation
   - Dynamic simulation: interfacing with a simulation platform (computer)

Prototyping: types of tests

- Software Unit Testing (SW/U)
  - Testing of individual sw components
- Software Integration Testing (SW/I)
  - Testing of sw component interactions
- Hardware/software integration tests (HW/SW/I)
  - Testing of interactions between sw and hw components
- System Integration Test (SI)
  - Check that the system is behaving as specified
- Environmental test (E)
  - System testing under specific environmental conditions

Prototype test

		SW	Processor	Embedded system	Environment - Plant
SW/U SW/I 1	SiL	experimental / real (host)	host	fictitious	fictitious
SW/U SW/I 2	SiL	real (target)	emulator (target on host)	fictitious	fictitious
HW/SW/I	HiL	real (target)	real (target)	experimental	fictitious
SI	HiL	real (target)	real (target)	prototype	fictitious
E	HiL / ST	real (target)	real (target)	prototypical, mature	fictitious

Pre-production

- Objectives:
  - demonstrate that the requirements are met
  - demonstrate compliance with standards (imposed, quality, law...)
  - demonstrate the construction of the system in the development environment with planned effort and timing
  - demonstrate the reliability of the system in the use environment (mtr: mean time to repair, ...)
  - presenting the product to end users
- Predetermined test scenarios.
- Testing: acceptance, system, security, qualification against standards, inspections...

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Post production

- Production chain development and testing
  - product quality inspection
  - verification of production time and costs
- First Product Inspection
  - inspection and testing of the first artefact produced by the chain
- Production and maintenance testing
  - quality inspection tests
    - summaries on each manufactured article
    - in-depth studies on random samples chosen from manufactured products