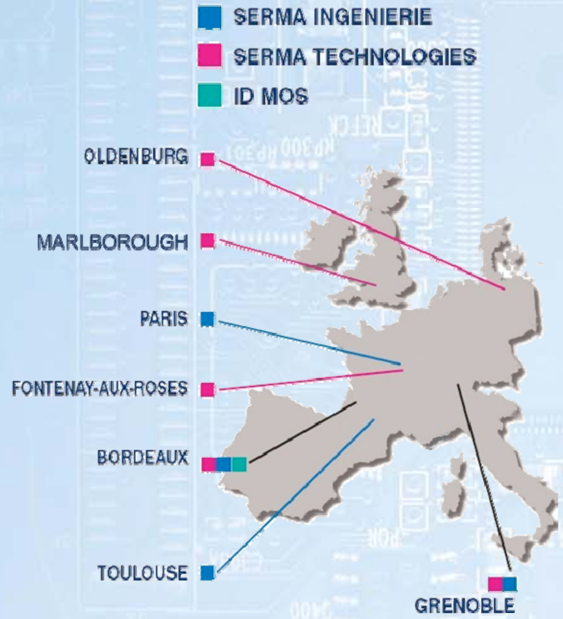
Impact of Package Choice on your System Reliability

Serma Technologies

TWI/NMI – 20090422

Groupe Serma Technologies

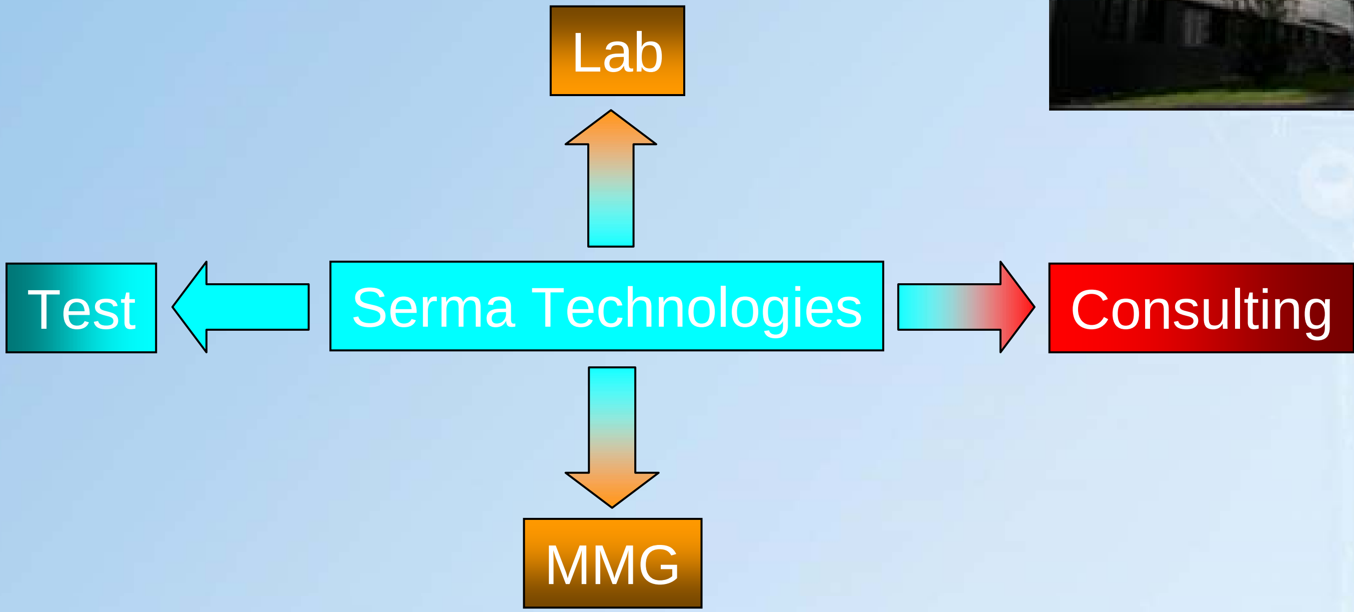
- Created 1991
- Listed on Alternext
- 400 people
- Turnover 2008 – 43 M€
- 6 locations in France



Groupe Serma Technologies → Serma Technologies → Serma Ingénierie / ID MOS / Surlog

Serma Technologies

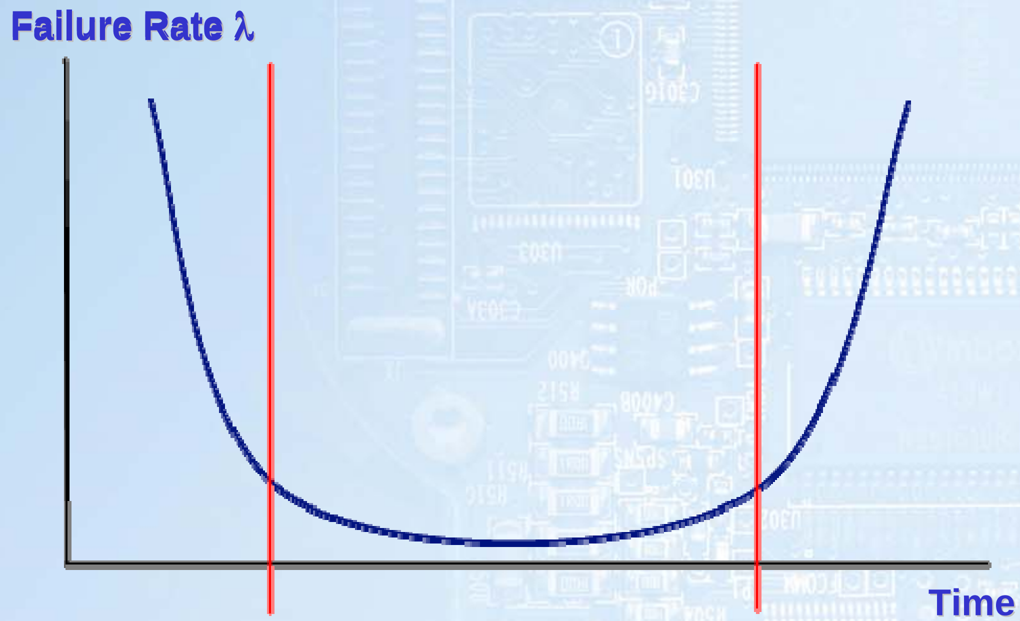
- 3 laboratories
- 170 people
- 6000 projects per year
- 17 M € – turnover 2008



Reliability

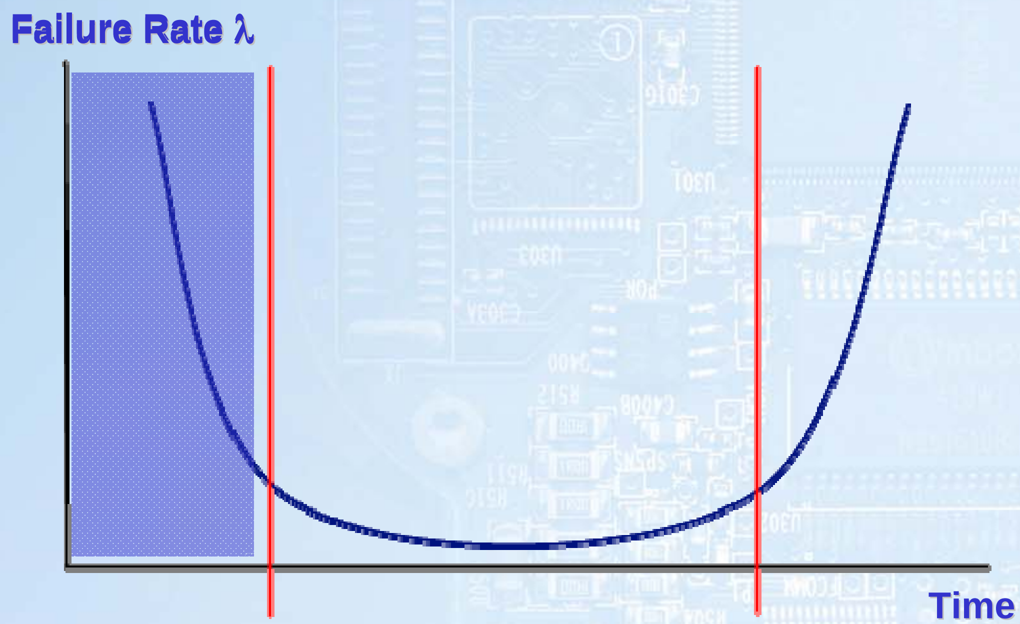
- Definition

  - Probability for an electronic system to perform a defined mission, in a defined environment, for a defined duration



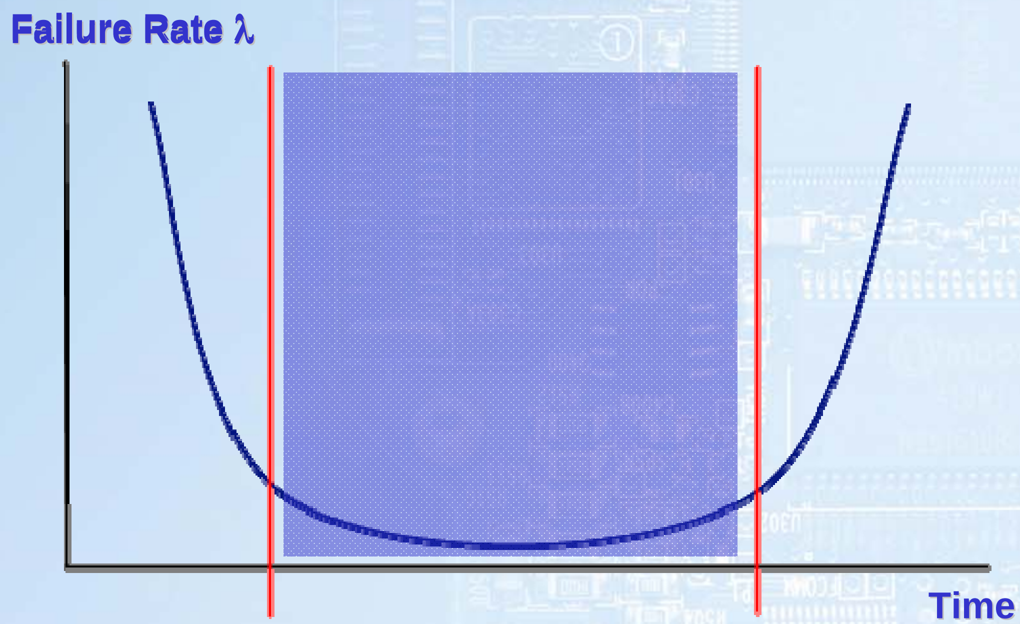
Reliability

- Early fails
  - Cause: process defects
  - Duration: several weeks



Reliability

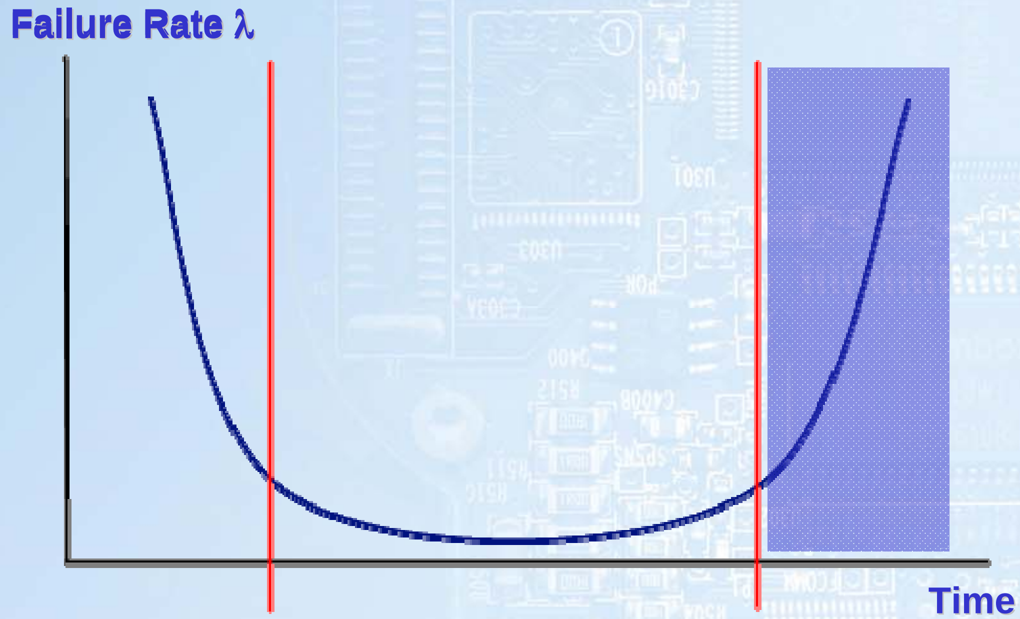
- Random failure
  - Cause: intrinsic failure
  - Duration: several months to several decades



Reliability

- Wear-out

  - Cause: end of product life



Predictive Reliability

- Purpose
  - Failure rate evaluation for a specified lifetime

- Methods
  - 1 – Theoretical calculation
  - 2 – Qualification procedure (standards, industry sector references)
  - 3 – Field return experience

Predictive Reliability – Method 1

- Method 1: Theoretical Calculation
- Main methods
  - MIL-HDBK217 (λ)
  - RDF2000 from CNET (UTEC-80810 / September 2000) for λ and life duration
  - FIDES
  - …
- Principle
  - Reliability handbook based on field return
  - Sum of the failure rates from components, connections and PCBs

Predictive Reliability – Method 1

- Method 1: Theoretical Calculation
- Advantages
  - Quick failure rate estimation
  - Determination of major contributor to λ
  - Useable with FMEA and FTA
  - Evaluation of technology sensitivity to stress factors (temperature, voltage, power…)
  - Dependence to thermal cycles and on/off cycles in UTEC-80810
- Drawbacks
  - Efforts needed (but software available for support)
  - No difference between suppliers (state-of-the-art hypothesis)
  - Generic mission profile no representative of application
  - Generally pessimistic calculation
  - Not adapted to new technologies (MIL-HDBK obsolete)
  - No account for industrial process
  - No life duration estimation through MIL-HDBK

Predictive Reliability – Method 2

- Method 2: Qualification Procedure
- Principle
  - Test plan according to defined conditions (standards, reference test plan)
- Advantages
  - Same evaluation process for all companies in a same industry sector
  - No additional cost for study (test plan definition)
- Drawbacks
  - Not exactly adapted to the application (constraints choice)
  - Stress conditions/parameters to adapt to application (lower/higher)
  - “Obsolete” standards when considering new technologies
  - Qualification tests but not really reliability estimation

Predictive Reliability – Method 3

- Method 3: Field Return Experience
- Principle
  - Collection and analysis of all field failures and during system integration / card assembly
- Advantages
  - Best reliability evaluation
- Drawbacks
  - Not preventive except for similar functions
  - Difficult logistics for data collection
  - Data integrity difficult to confirm (use duration, failure context, quantity of parts used, data “pollution” by maintenance team)
  - Really a reliability estimation?

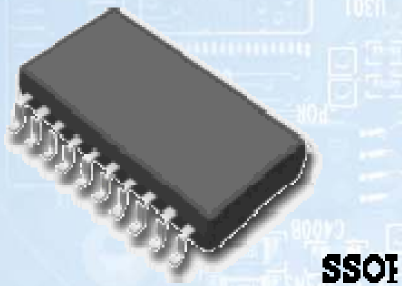
Predictive Reliability – Conclusion

- No completely adequate method
- Necessity for good characterisation taking into account
  - Mission profile for final user
  - Industrial process, from component storage to transportation and equipment storage before use
  - Used technology with associated failure mechanisms and sensitivities to external constraints

- Note
  - Most failure mechanisms caused today by extrinsic component root causes (degradations, use of technologies not adapted to application)

Reliability through Technology Analysis

- Method developed by Serma Technologies
- Based on experience on the complete product life
  - Components & PCBs
    - Process management
    - Latent failures
    - Technology sensitivity
    - Design (derating, weakness determination)
    - Component reliability
    - Obsolescence management



Reliability through Technology Analysis

- Method developed by Serma Technologies
- Based on experience on the complete product life
  - Process
    - Process management
    - Technology sensitivity
    - Solder joint reliability
    - Interconnection reliability
    - Component risk
    - Outsourcing
    - Regulation

Reliability through Technology Analysis

- Method developed by Serma Technologies
- Based on experience on the complete product life
  - End-user
    - Mission profile
    - Derating in regards to application
    - Environment
    - Electrical conditions
    - Systems reliability

RtTA – Method

- Qualification
  - Analysis/definition of mission profile
  - Risk analysis (FMEA on parts/processes)
  - Conception and realisation of evaluation plan
  - Result application
    - Result analysis and synthesis
    - Burn-in definition if needed
    - Component purchasing policy

RtTA – Method

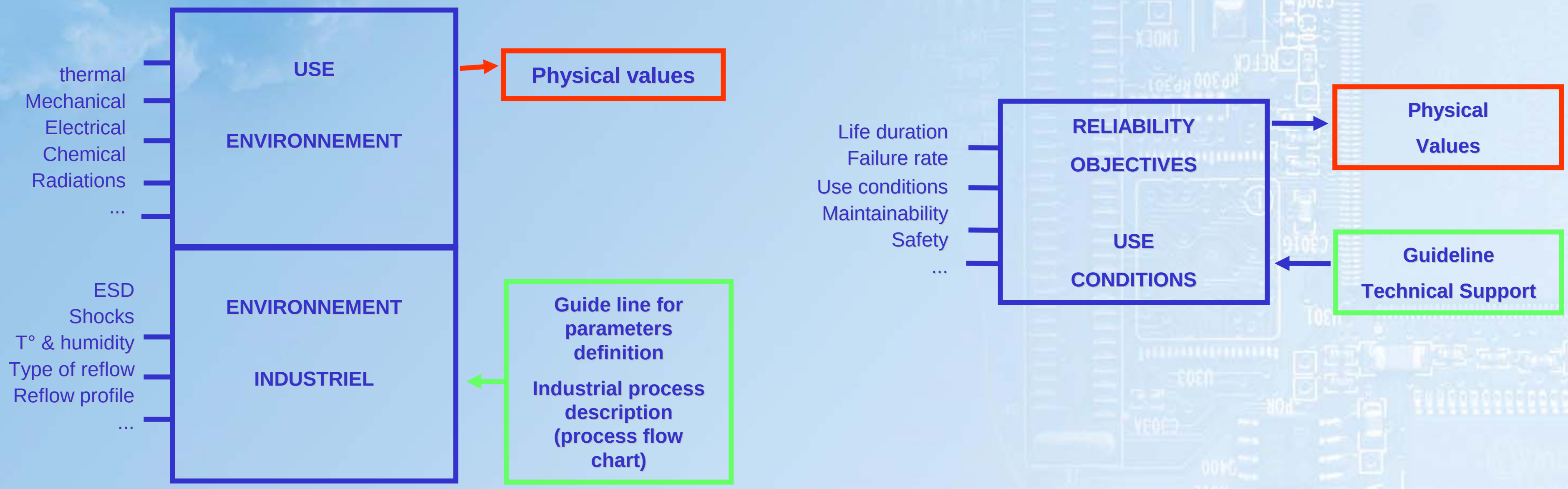
- Qualification
  - Analysis/definition of mission profile
  - Risk analysis (FMEA on parts/processes)
  - Conception and realisation of evaluation plan – 4-Axis Method
    - Qualification (performance)
    - Robustness (constraints)
    - Durability (ageing process)
    - Process (variability)
  - Result application

RtTA – Mission Profile

- Identification and dimensioning of all parameters impacting the technology

- Need for good knowledge of
  - use mission
  - Industrial mission profile (assembly process, storage conditions)

RtTA – Mission Profile (User)



- Mission profile definition for
  - End-user
  - Industrial process (from purchase to product delivery)

RtTA – Mission Profile (Process)

Investigation by Serma Technologies
Components technologies knowledge
Failure mechanism knowledge
Suppliers data (data-sheet , reliability)

Regarding
use mission profile

List of critical parts
Technological sheet
Actions for risk reduction

Component databas from Serma Technologies
Caps XPERT, PCN alert
...

Regarding
Obsolescence
& Perenity

Physical values
Bill of materials
Process flow chart description

Boards and components technologies knowledge
Failure mechanism knowledge
Tests and process management knowledge
...

Regarding
Card assembly
process
and system

- Status analysis towards life profile (mission and process) and used technologies

RtTA – Evaluation Plan

- 4-Axis Method
  - Qualification (performances)
  - Robustness (constraints)
  - Durability (ageing process)
  - Process (variability)

RtTA – Axis 1

- Qualification

- Advantages
  - Validation of performances

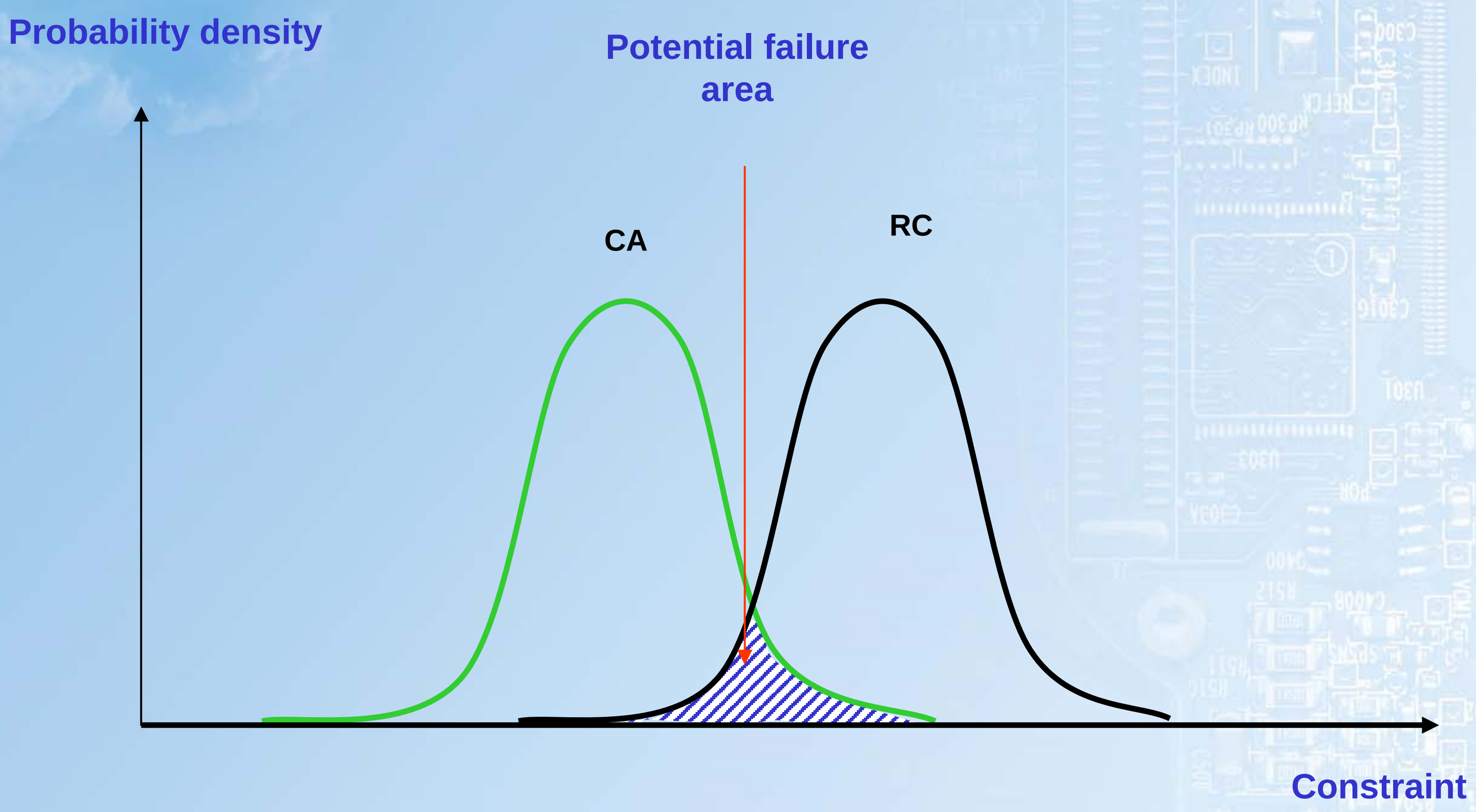
- Drawbacks
  - No consideration for
    - System robustness (electrical, environmental, other)
    - Time aspect for slow failure mechanisms (*e.g.* solder joints, intermetallic growth, metallic migrations…)

RtTA – Axis 2

- Robustness
- Principle
  - Stressing (environmental and/or operating) the product or part thereof
    - Step method to values far in excess specified conditions
    - Up to operating and/or destruction limits
  - Addressed failures
    - Design margin
    - Manufacturing process
    - Layout issues

- Note
  - Similar to constraint/resistance theory

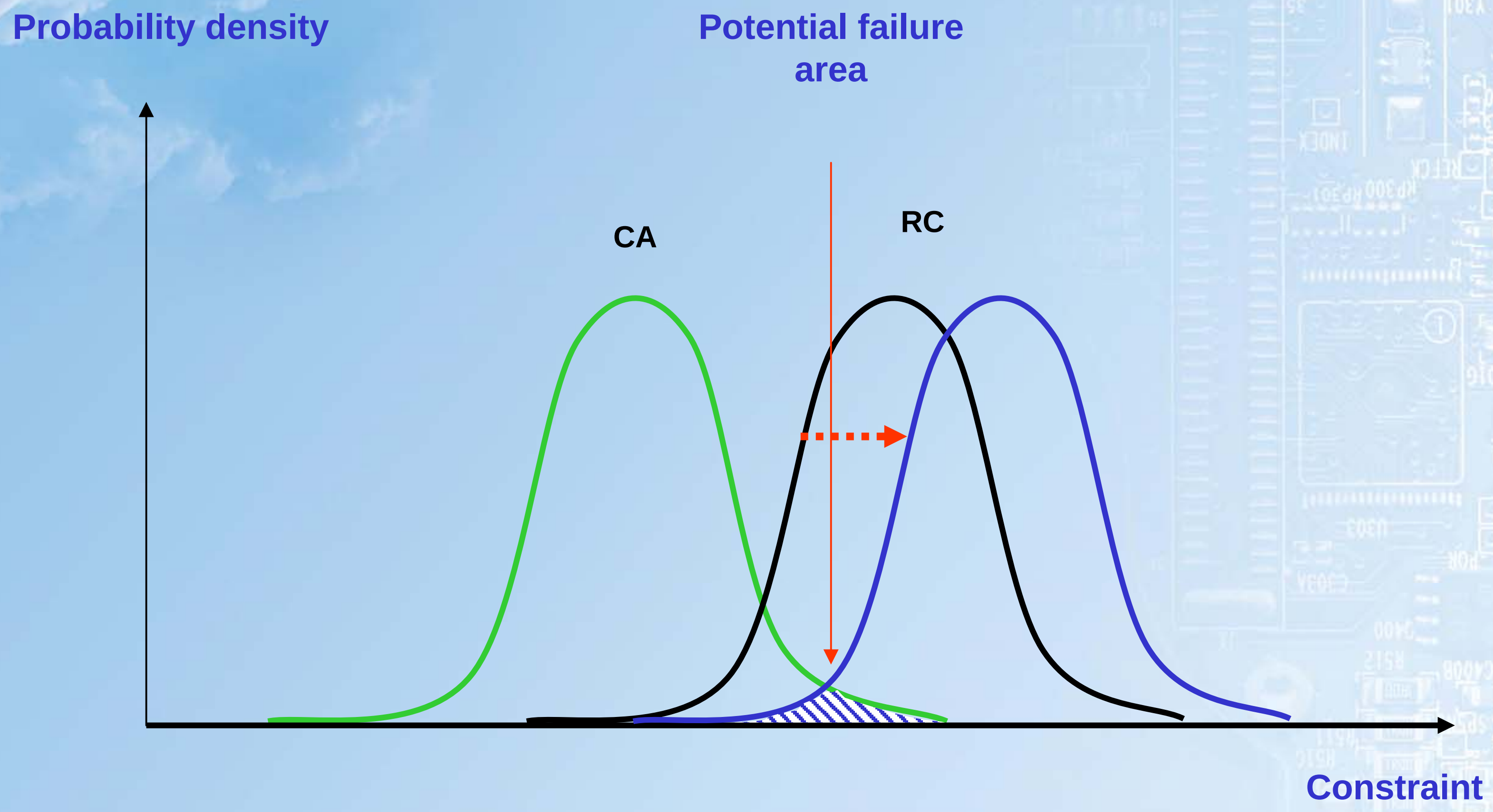
RtTA – Axis 2



CA = Applicable constraint

RC = Resistance to this constraint

RtTA – Axis 2



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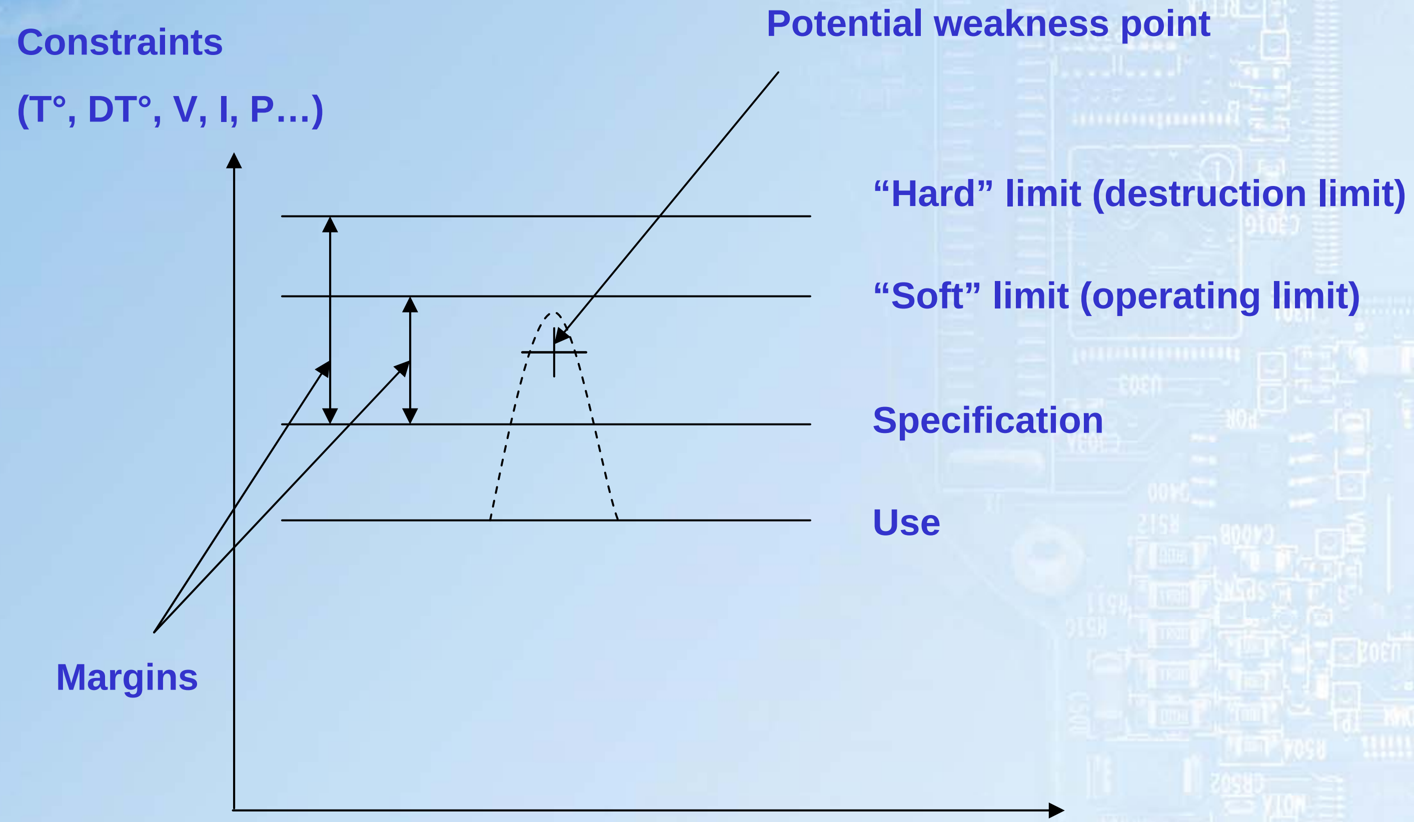
RtTA – Axis 2


Constraints
(T°, DT°, V, I, P…)
Potential weakness point
“Hard” limit (destruction limit)
“Soft” limit (operating limit)
Specification
Use
Margins

RtTA – Axis 2

- Robustness
- Objectives
  - Short-time product maturity improvement (before shipment
  - System robustness improvement and sensitivity reduction to constraints outside specifications
- Based on
  - Identification before use of potential failures (design errors or bad process management at manufacturing specifications)
  - Knowledge of system operating limit and available margin towards specifications
- Note
  - Dynamic process (proactive) needing failure analysis and root cause determination
  - Proactivity of method by encouraging engineering actions at earliest development stages

RtTA – Axis 3

- Durability
- Principle
  - Different than Robustness axis
  - Reliability/life test (accelerated ageing test and/or environmental test) performed inside/at specification limit
  - Time aspect considered (slow failure mechanisms regarding ageing and life duration)
  - Acceleration of failure mechanisms using known acceleration factors
- Objectives
  - Revealing potential failures faster than through simple use
- Parameters
  - Temperature, temperature variation, voltage/current/power, humidity/temperature

RtTA – Axis 4

- Process
- Principle
  - Determination of potential issues induced by manufacturing processes
- Most recurring causes
  - Component degradation (delamination, cracks, other)
  - Process drift (bad management on solder paste height, reflow profile management, other)

RtTA – Axis 4

- Process
- Associated tools
  - Process Optimisation through Analysis
    - System-level method developed by Serma Technologies
    - Involving SAM, X-Ray, cross-sectioning, optical inspection, SEM
    - Evaluation of manufacturer process management
  - Technical audit
    - Before or after physical analysis
    - Verification of manufacturer process management

RtTA – Result Application

- Definition of
  - Action plan
  - Parameters for burn-in if needed
  - Specific policies (if needed) for
    - Component incoming inspection
    - System maintenance

RtTA – Conclusion

- Advantages
  - Adapted method towards different risks (component, process, design…) with associated tools
  - Reliability process adapted to application (use conditions)
  - Good risk evaluation thanks to consideration for
    - Use environment
    - Industrial process
    - Extrinsic component defects
    - Technologies

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