



imec

NEW PRODUCT INTRODUCTION METHODOLOGY FOR RELIABLE SMART PRODUCTS

GEERT WILLEMS – IMEC

CENTER FOR ELECTRONICS DESIGN & MANUFACTURING



Met steun van:



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THAT UNITES, INFORMS
AND SUPPORTS
COMPANIES ACTIVE IN
DESIGN,
MANUFACTURING AND
INTEGRATION OF
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Guidelines Tools Calculators Projects Agenda Library Membership RoHS Service

AGENDA

- Activities Calendar
- Workshops
- Webinars
- Events
- Technology Seminars
- Partner Events

Enter your keywords

cEDM Activities Calendar

cEDM Activities Calendar 2017

Subject	Date	Location	Invitation	Type of Meeting
Webinar 1 FMEA	Jan 12, 2017	Online	Public	Technical
Webinar 2 CB Marking	Feb 2, 2017	Online	Public	Technical
Improvoil Workmeeting 8	Feb 21, 2017	ON Semi (Oudenaarde)	Partners, Consortium	Technical
Training KULeuven	Feb 23-24, 2017	KULeuven (Oostend)	Public	Training
PCB technology session	Mar 10, 2017	ACB (Dendermonde)	Public	Training
Webinar 3 Virtual testing	Apr 6, 2017	Online	Public	Technical
Improvoil Workmeeting 9	Apr, 2017	tbd	Partners, Consortium	Technical
PBA technology session	Apr 7, 2017	Connect (Ieper) tbc	Public	Training
Webinar 4 System engineering	Jun 1, 2017	Online	Public	Technical
cEDM Management Meeting 18	Jun 9, 2017	Televic (Izegem)	Partners	Management
User Group Improvoil	Jun 9, 2017	Televic (Izegem)	Partner, Members, IWT	Management
cEDM Workshop 26 Smart textile	Jun 9, 2017	Televic (Izegem)	Public	Technical
Improvoil Workmeeting 10	Jun, 2017	tbd	Partners, Consortium	Technical
Sirris Seminar	Jun, 2017	tbd	Public	Technical
Webinar 5 Yield & Test coverage	Sep 7, 2017	Online	Public	Technical
cEDM Workshop 27 Reliable electronics	Sep 22, 2017	tbd	Public	Technical
Webinar 6 Plated through hole via failure	Nov 8, 2017	Online	Public	Technical
cEDM Management Meeting 19	Dec 8, 2017	imec	Partners	Management
User Group Improvoil	Dec 8, 2017	imec	Partners, Members, IWT	Management
cEDM Workshop 28	Dec 8, 2017	imec	Public	Technical
Reliability technology session	tbd	tbd	Public	Training

News

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Check out our job openings
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[New guideline](#)
Rigid Printed Circuit Board Qualification
[More](#)

[New guideline](#)
Reliability Quantification
[More](#)

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cEDM Offering

- Design guidelines
- Supporting tools
- [Pred-X](#) (PBA simulation tool)
- cEDM Workshops
- DXF Helpdesk
- [Industry Services, Failure Analysis & Simulation](#)
- Customer oriented training
[More info](#)

cEDM Mission Statement

To support the development of high quality, reliable and cost-effective electronic modules (PBA) in industry by means of knowledge creation and sharing, scientifically sound methodologies and collaboration throughout the electronic supply chain.

cEDM Objectives

- Development and maintenance of:
- Design Guidelines: Design-for-X
 - Qualification Guidelines
 - Design, qualification, production and test qualification tools
 - Quality screened knowledge
- Supporting:
- Design: better quality PBA at a lower cost
 - Qualification: more efficient, more effective
 - Assembly: better prepared
 - Test: more effective and better quantified
 - PBA operation: better quantified reliability



Our Partners



Become a member / partner

cEDM Membership
As a cEDM member you will be informed about the activities of the cEDM program.
[More info](#)

cEDM Partnership
Besides all benefits a cEDM member company receives, a cEDM partner can attend and participate in research projects and industrial workgroup meetings.
[More info](#)



CONTENT

Products for the “Smart World”

New Product Introduction for the Smart World

The Reliability Challenge

A Smart NPI (reliability) example

THE SMART WORLD



Article
June 2015

Manufacturing's next act

By Cornelius Baur and Dominik Wee

SMART WEARABLE

INTERNET of DATA

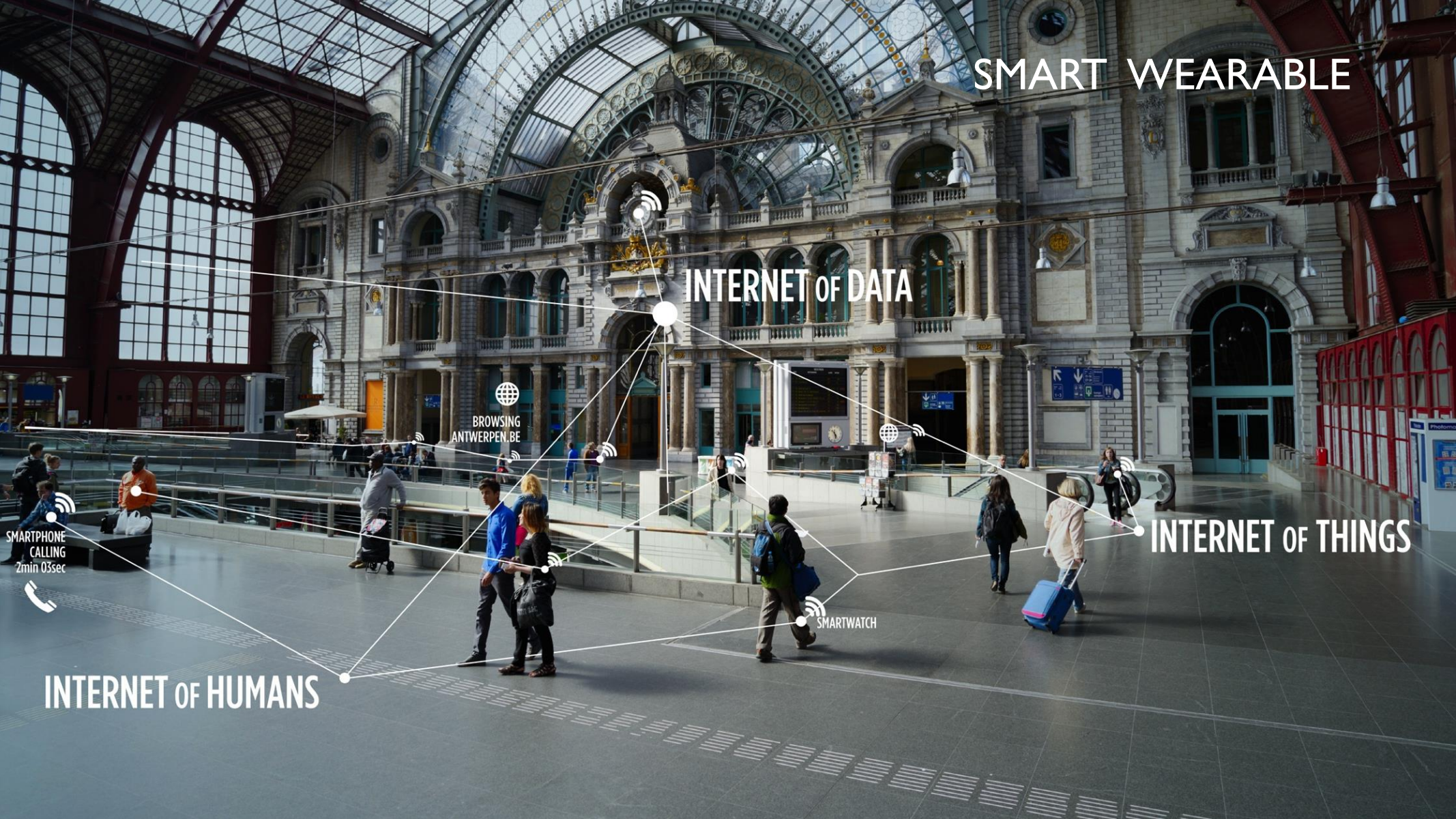
INTERNET of THINGS

INTERNET of HUMANS

BROWSING
ANTWERPEN.BE

SMARTPHONE
CALLING
2min 03sec

SMARTWATCH



SMART CAR

Knowledge base
&
Deep learning
in the Cloud

Real-time execution



SMART CITY

15 min BEFORE RAIN APPROACHES YOU

✈️ 05 min 37 sec BEFORE ARRIVAL

✈️ 08 min 07 sec SINCE DEPARTURE

🌿 1,214 KWH GAINED

☀️ 1,358 KWH GAINED

✖️ 04 TABLES LEFT

✖️ FULLY BOOKED



23 WATT USED

ENERGY SAVING MEDAL UNLOCKED

🛢️ 432 METER TO THE CHEAPEST DIESEL

🚦 04 RED LIGHTS ON YOUR WAY

🚶 YOU WALKED 1894 METER SO FAR

🚚 YOUR PACKAGE WILL ARRIVE IN 15 min

🚲 235 METER UNTIL BIKE PARKING

🍔 124 PEOPLE FAVORISED

🕒 17 HOURS PARKING LEFT

THE “SMART WORLD”

WHAT IS NEW ABOUT “SMART WORLD”?

- Closing the loop between control and operation:
(real time) feedback
- Exploitation of an increasing amount of information
- (Self-)Learning, dynamic, adaptable systems

Why now?

It has become affordable: low-cost, high-performance electronics.

THE “SMART WORLD”

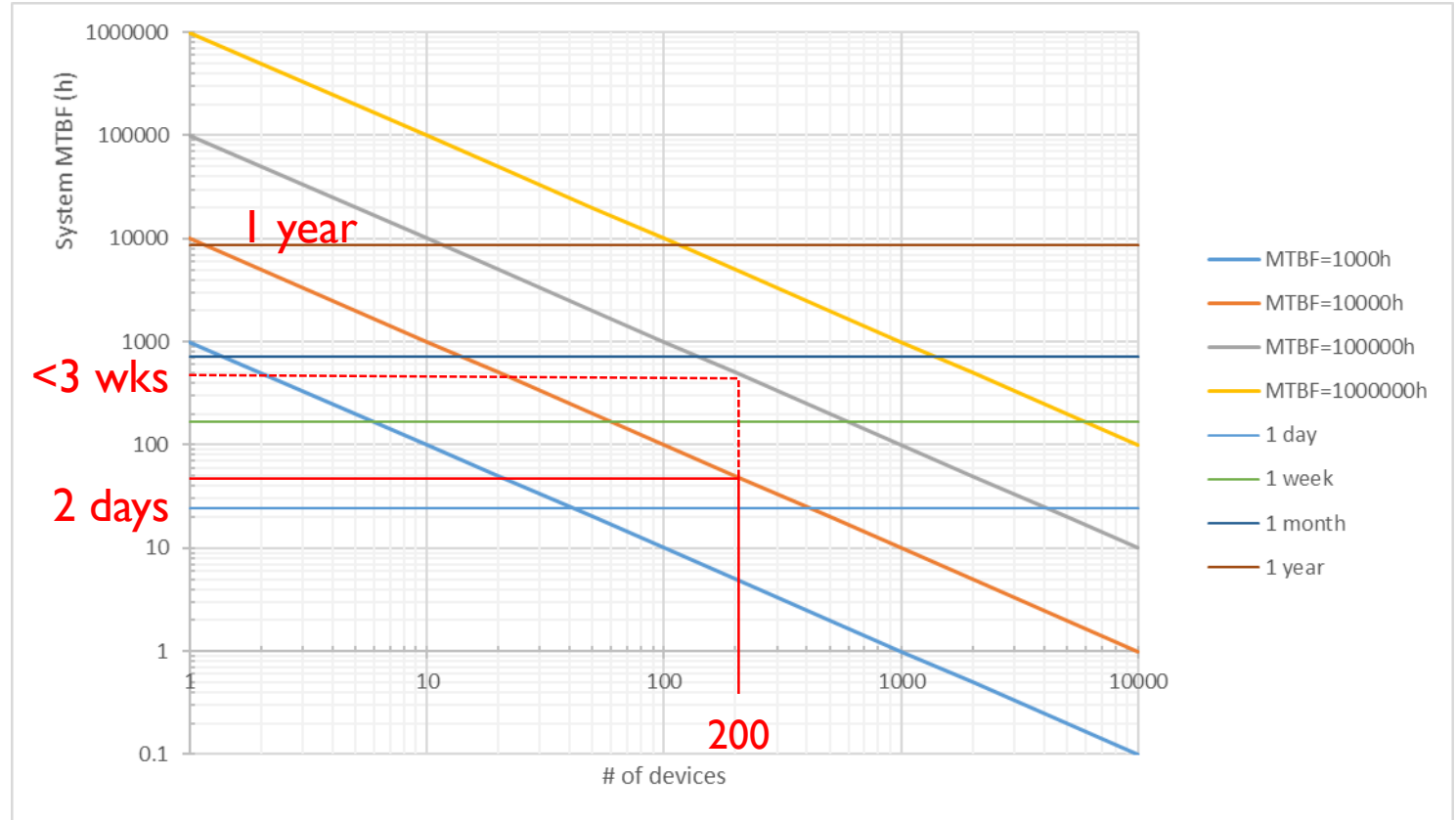
"SMART WORLD" SYSTEM CHARACTERISTICS

- **Software** (AI) using
- a high number of (wireless) **interconnected & distributed** innovative **electronic hardware** modules (sensing, computing, communication, power)
- New devices in different often hard-to-reach and/or harsh environments
- May be safety critical
- High severity at failure
- Dynamic: growing number of variable applications

THE “SMART WORLD”

QUALITY AND RELIABILITY: TIME BETWEEN FAILURE

In the
Connected
World
Reliability
is
Essential



THE “SMART WORLD”

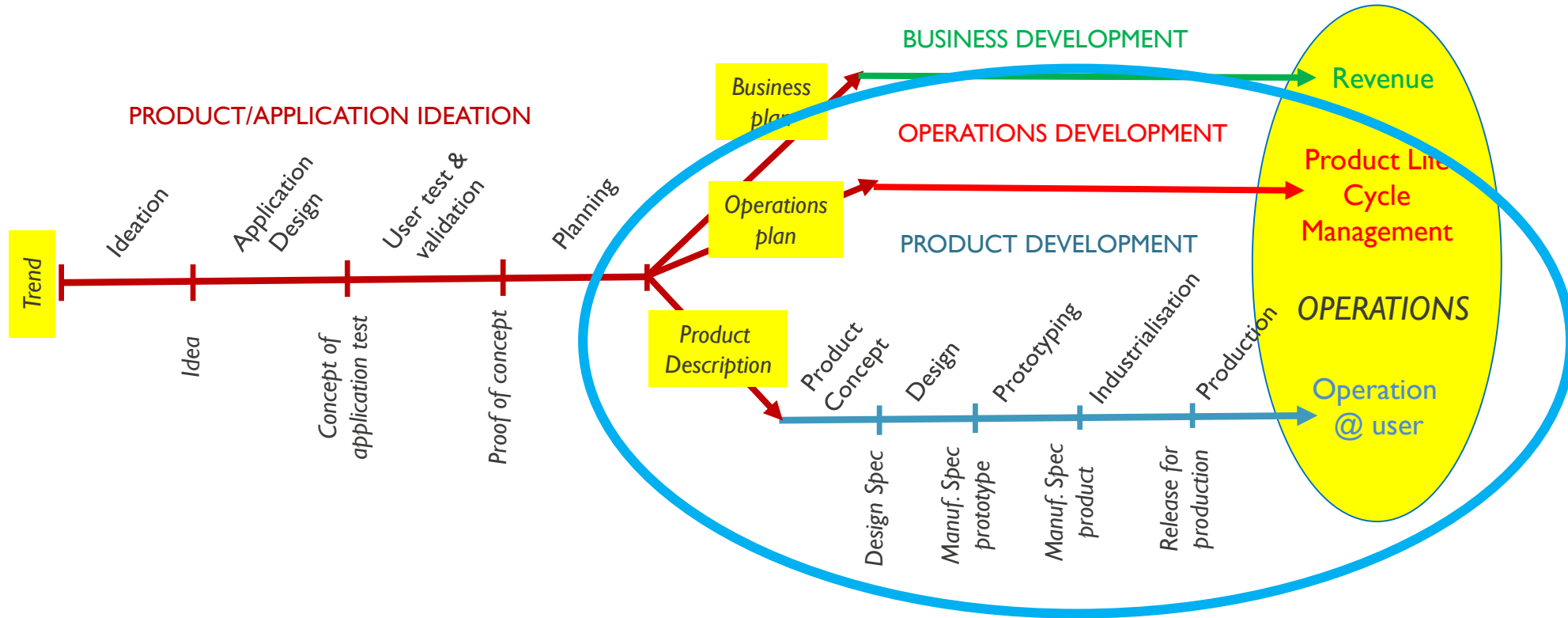
PRODUCT DEVELOPMENT REQUIREMENTS FOR THE “SMART WORLD”

- Use of new devices with little use history
- System adaptable to
 - Different applications
 - Different environments and mission profiles
 - Different volumes, markets (consumer, professional, safety critical), product life cycles
 - All this may be variable over time for the same product
- High quality, high reliability, low maintenance in often “hostile” environments
- Short time-to-market: fast development, scale-up and deployment
- Lowest possible cost

NEW PRODUCT INTRODUCTION FOR THE “SMART WORLD”

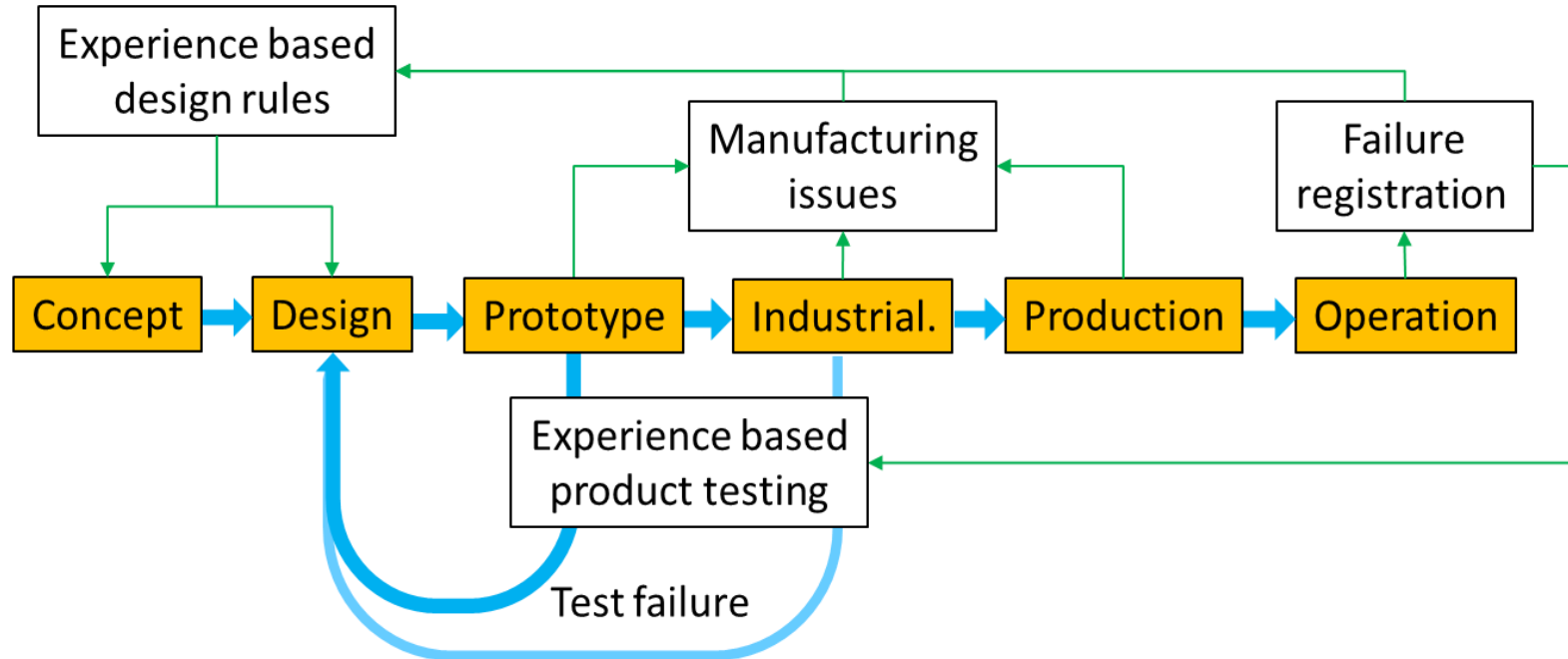
NEW PRODUCT INTRODUCTION FOR THE SMART WORLD

FROM IDEA TO SUCCESSFUL BUSINESS



NEW PRODUCT INTRODUCTION FOR THE SMART WORLD

THE TRADITIONAL WAY



New, fast, adaptable, reliable, low cost ... \leftrightarrow experience based time-consuming design iterations

NEW PRODUCT INTRODUCTION FOR THE SMART WORLD

WHAT DO WE NEED?

Product:

- Dynamical
- High Quality
- High Reliability
- Low Cost
- Time-to-market



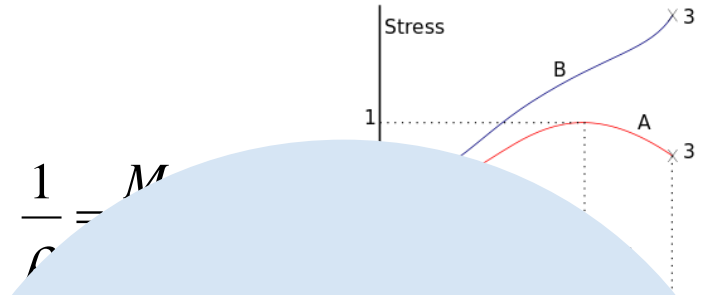
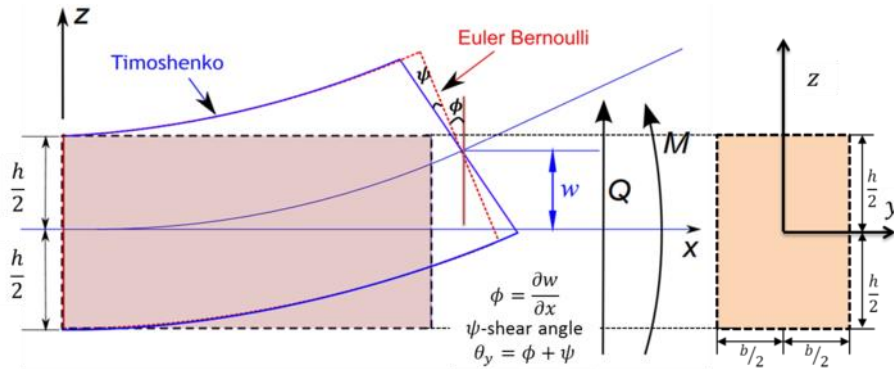
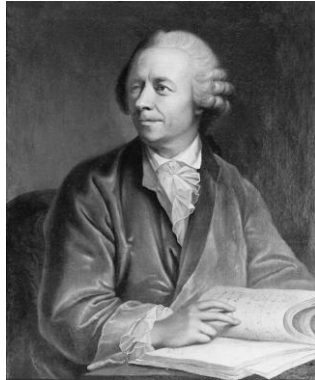
Trustworthy PREDICTION of all
Product Life Cycle aspects
without costly, time-consuming prototyping,
testing and design iterations

How do we do that?

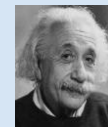


NPI FOR THE SMART WORLD

A PRACTICAL WAY



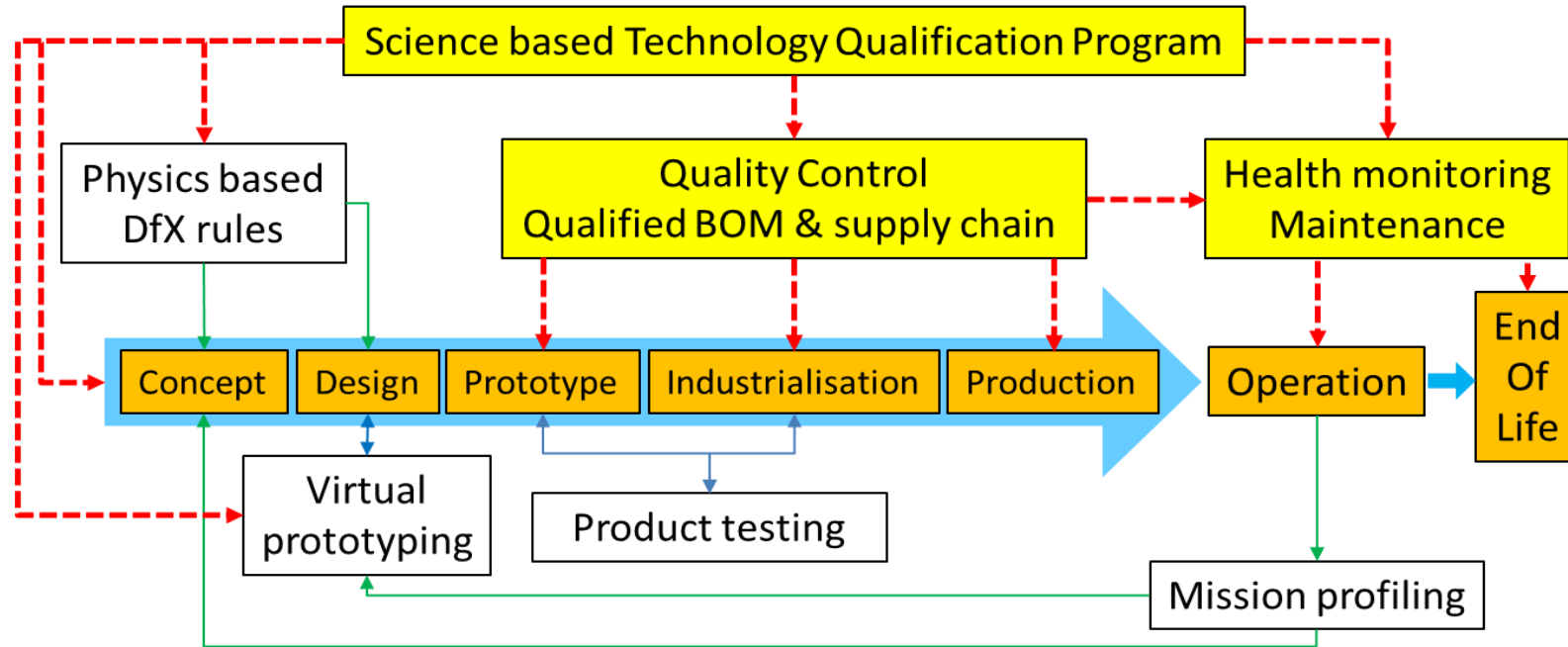
SCIENCE
*The next best thing
to a crystal ball*



The Mechanics of Electronics

NEW PRODUCT INTRODUCTION FOR THE SMART WORLD

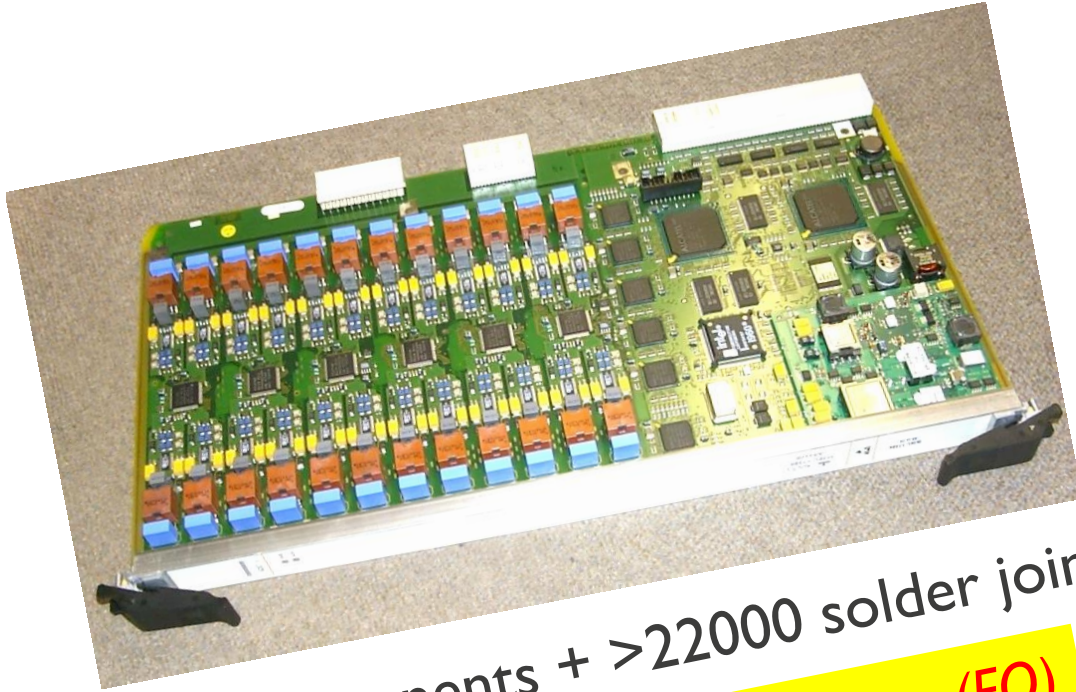
SCIENCE-BASED NPI: A PARADIGM SHIFT



THE RELIABILITY PREDICTION CHALLENGE

THE RELIABILITY PREDICTION CHALLENGE

SO MANY THINGS CAN FAIL ...



2500 components + >22000 solder joints

= >40000 failure opportunities (FO)

- Components
- Solder joints
- PCB
- PBA

$$I \text{ PBA} = (1\text{K to } 100\text{K FO}) \times n \text{ failure mechanisms/FO}$$

RELIABILITY PREDICTION

THE TRADITIONAL APPROACH: RELIABILITY PREDICTION STANDARDS

MIL-HDBK-217 - *the oldest, best-known most outdated (1995)*

Telcordia SR-332 - *previously Bellcore, telecommunication, US.*

IEC-61709/SN 29500 - *Siemens, industrial, Germany.*

IEC-TR-62380/Fides 2009 - *French industry, industrial-avionics, France.*

217plus – *Quanterion, commercial MIL-HDBK-217 update, US.*

GJB/Z 299C – *China.*

Describe how to determine the reliability of a **system of electronic components** using **constant failure rate statistics** and field failure data.

Basic principle: $\lambda_{\text{sys}} = \lambda_1 + \lambda_2 + \lambda_3 + \dots + \lambda_n + \lambda_{\text{PCB}}$

RELIABILITY PREDICTION

CONSTANT FAILURE RATE: WHAT DOES IT MEAN?

Buy NEW



Buy USED

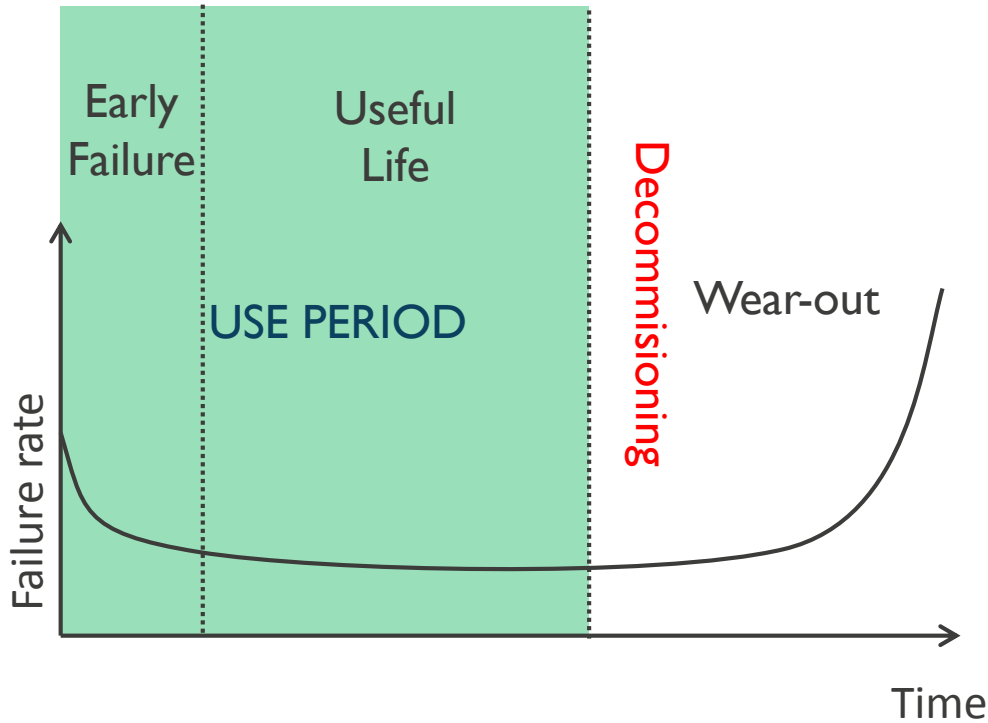


Do you expect the same failure rate for a used car as for a new one?

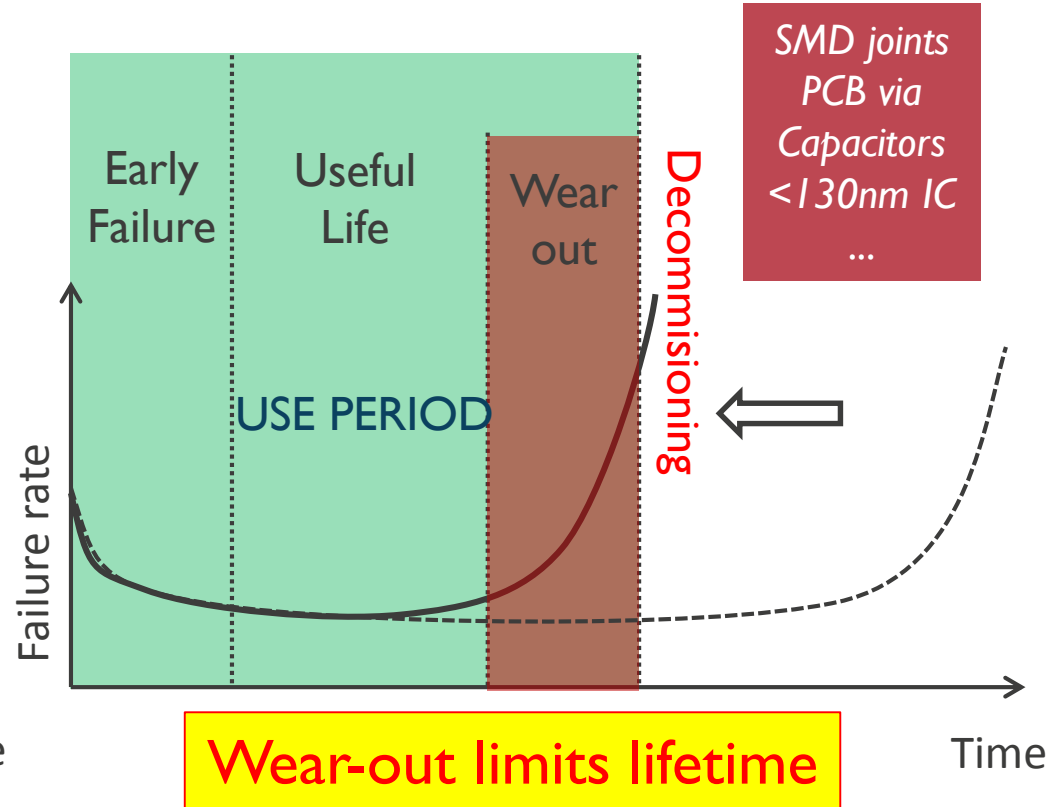
RELIABILITY PREDICTION

THE REAL WORLD

What it was (before the '80s)



What is now!



Army 1995 Memo Prohibiting Further Use of MIL-HDBK-217 Actuarial Reliability Prediction Methods



DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
RESEARCH DEVELOPMENT AND ACQUISITION



General Motors Reliability Policy

“... GM concurs and will comply with the findings and policy revisions of Feb. 15, 1996 by the Assistant Secretary of the U.S. Army for Research, Development and Acquisition. ... Therefore: Mil-Hdbk 217, or a similar component reliability assessment method such as SAE PREL, **SHALL NOT BE USED.**”

GM North American Operation,
Technical Specification Number: 10288874, June 4, 1996.

and reliability
handbook
reliability is not to
or handbook
ver using the
ards. In particular,
is not to appear in
in lead to erroneous

vide guidance to the
Standardization
Maintainability
ement of guidance

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EB73

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Predictions Methods in the 1990s.

define the quantitative reliability requirements. The extent to which failures and usage conditions are defined should be determined on an acquisition-specific

17

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U. S. Military View of Mil-Hdbk-217

“... Mil-Hdbk-217, Reliability Prediction of Electronic Equipment, **and progeny**, is not to be used as it has been shown to be unreliable and its use can lead to erroneous and misleading reliability predictions.”

October 1994

Decker, Assistant Secretary of the Army (Research, Development, and Acquisition), Memorandum for Commander, U.S. Army Material Command, Program Executive Officers, and Program Managers

More than 20 years ago
but still used!

RELIABILITY PREDICTION

THE PHYSICS-OF-FAILURE APPROACH

A science-based approach to reliability that uses modeling and simulation to design-in reliability.

It helps to understand system performance and reduce decision risk during design and after the equipment is fielded. This approach **models the root causes of failure** such as fatigue, fracture, wear, and corrosion.

An approach to the design and development of reliable product to prevent failure, based on the knowledge of root cause failure mechanisms. The Physics of Failure (PoF) concept is based on the **understanding of the relationships** between requirements and the physical characteristics of the product and their variation in the manufacturing processes, and the **reaction of product elements and materials to loads (stressors)** and interaction under loads and their influence on the fitness for use with respect to the use conditions and time.

RELIABILITY PREDICTION

THE BASICS OF RELIABILITY PHYSICS

1. Quantitative physical model of the failure mechanism.
 - Fatigue failure: solder joints, PCB via's & tracks.
 - Diffusion and evaporation of liquids: degradation of Al-capacitors.
 - Electro-migration (electric field driven) and corrosion.
 - And many more...
2. Calculation of the stress level dependent “damage factor” determining the lifetime.
3. Apply (empirical) lifetime model: $\text{lifetime} = F(\text{“damage factor”})$
(e.g. Wöhler curve)

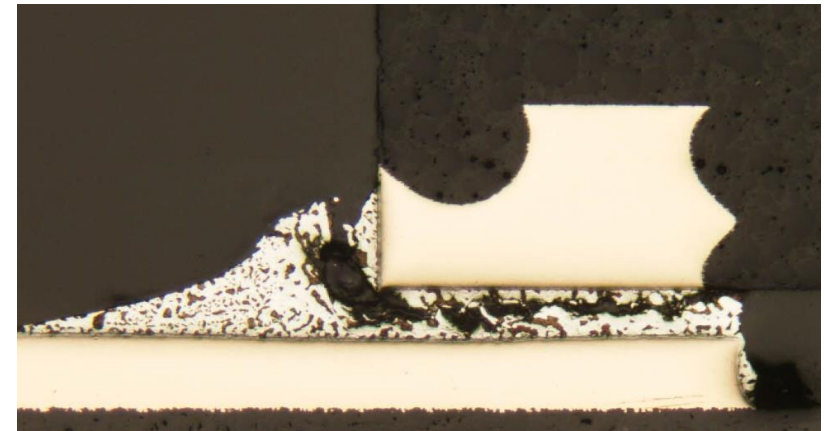
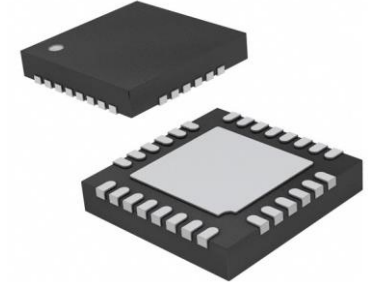
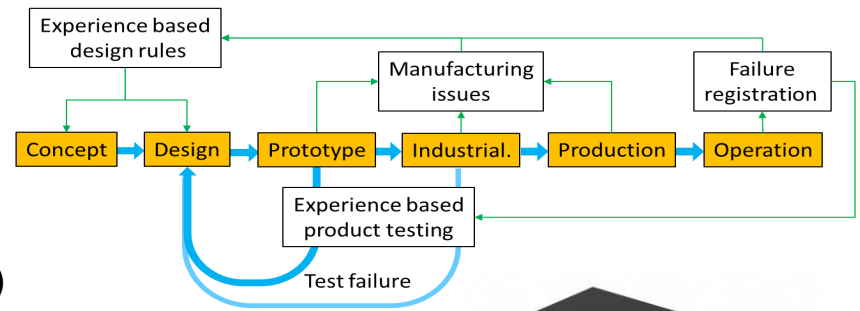
A SMART NPI (RELIABILITY) EXAMPLE

SMART NPI: QFN IN AUTOMOTIVE

TRADITIONAL NPI APPROACH

- First PBA design with 7mm x 7mm QFN (1 month)
- Build PBA (12 weeks incl ordering)
- Qualification: 1500 cycles -40°C to 150°C (1 month)
PBA failure: QFN solder joints
- Redesign PBA with other package type (2 wks)
- Build new PBA prototype (12 weeks)
- Qualification (1 month)
Hopefully it passes...

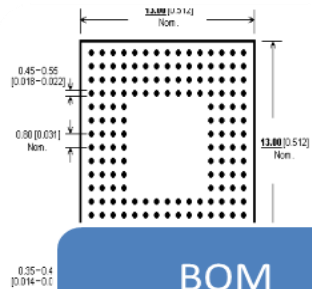
Penalty: +19 weeks time-to-market
+50KEuro material, labor, test



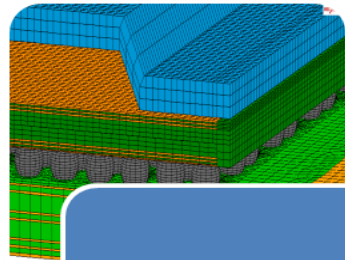
SMART NPI: QFN IN AUTOMOTIVE

SOLDER JOINT FAILURE PREDICTION

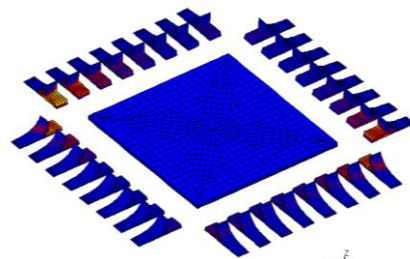
Quantification



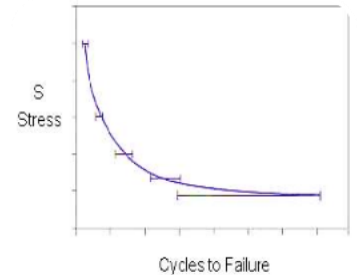
BOM
+
Mission profile



Modelling /
Quantification
/ Simulation



Cyclic strain in
solder joints



Life time model

SOLDER JOINT RELIABILITY EXAMPLE: QFN IN AUTOMOTIVE

SCIENCE BASED NPI APPROACH

- **Qualification of QFN packages for automotive:**

QFN max. 5 x 5mm² and mold CTE > 8ppm/K

Thermo-mechanical simulation required for QFN > 3mm

- @Design an automotive qualified package is selected

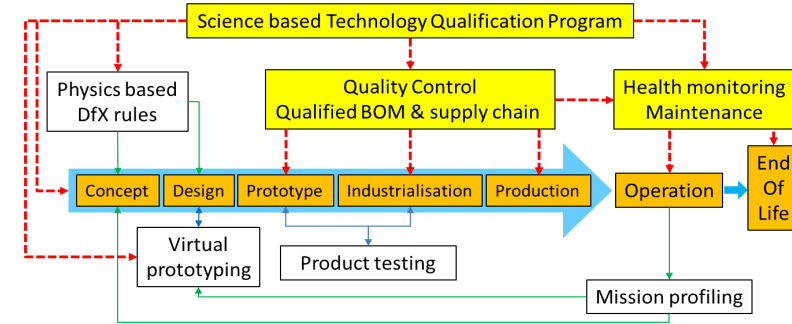
- Virtual prototyping 1500 cycles -40°C to 150°C (2 d)

Improve design if necessary (1d – 2 wks) (<10%)

- Build prototype (12 wks)

- Product Qualification test (1 month):
pass (for Solder Joint)

- Go to industrialization



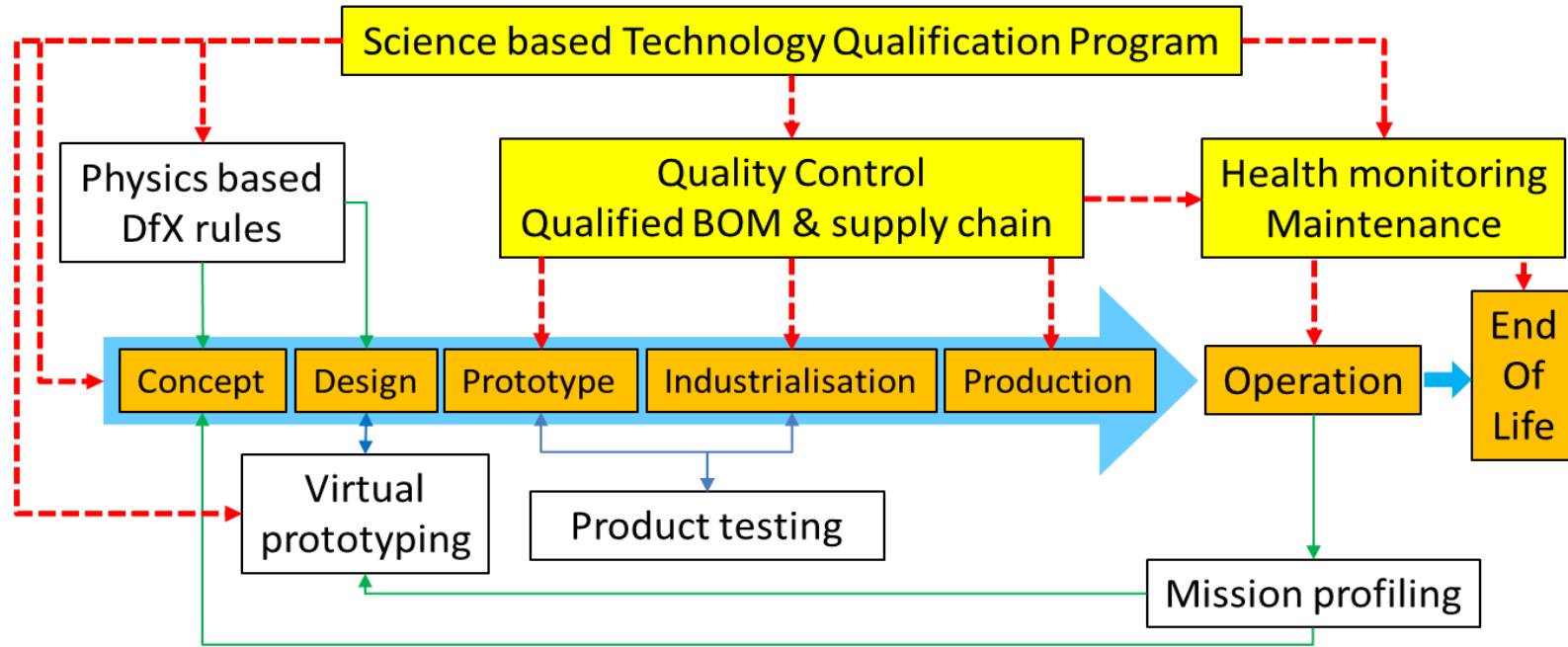
Fail at virtual prototyping penalty (<10%):

- 1 d to 2 wks design effort
no extra ordering/test delay
- 1 to 5KEuro extra labor
no extra material nor test cost

10x faster & 10x lower cost
Higher reliability level

NEW PRODUCT INTRODUCTION FOR THE SMART WORLD

CONCLUSION



A Smart World requires **Science-based = Smart Design-for-eXcellence**,
New Product Introduction and Product Life Cycle Management

THANK YOU



embracing a better life



Geert.Willems@imec.be

++32-498-919464

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