



# imec

## SMART PRODUCT DEVELOPMENT: THE SHIFT LEFT

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CENTER FOR ELECTRONICS DESIGN & MANUFACTURING



Met steun van:



# CONTENT

View on Product Development Challenges

View on Product Development Life-Cycle

Smart Product Development in Practice

“White Box” Technology Qualification

Summary



# VIEW ON (SMART) PRODUCT DEVELOPMENT CHALLENGES

<https://www.mentor.com/pcb/resources/>



# VIEW ON PRODUCT DEVELOPMENT CHALLENGES

## A STUDY ON DFX: PRODUCT COMPLEXITY

Table 1: Increasingly Complex Products Demand a Multi-Domain Product Development Solution

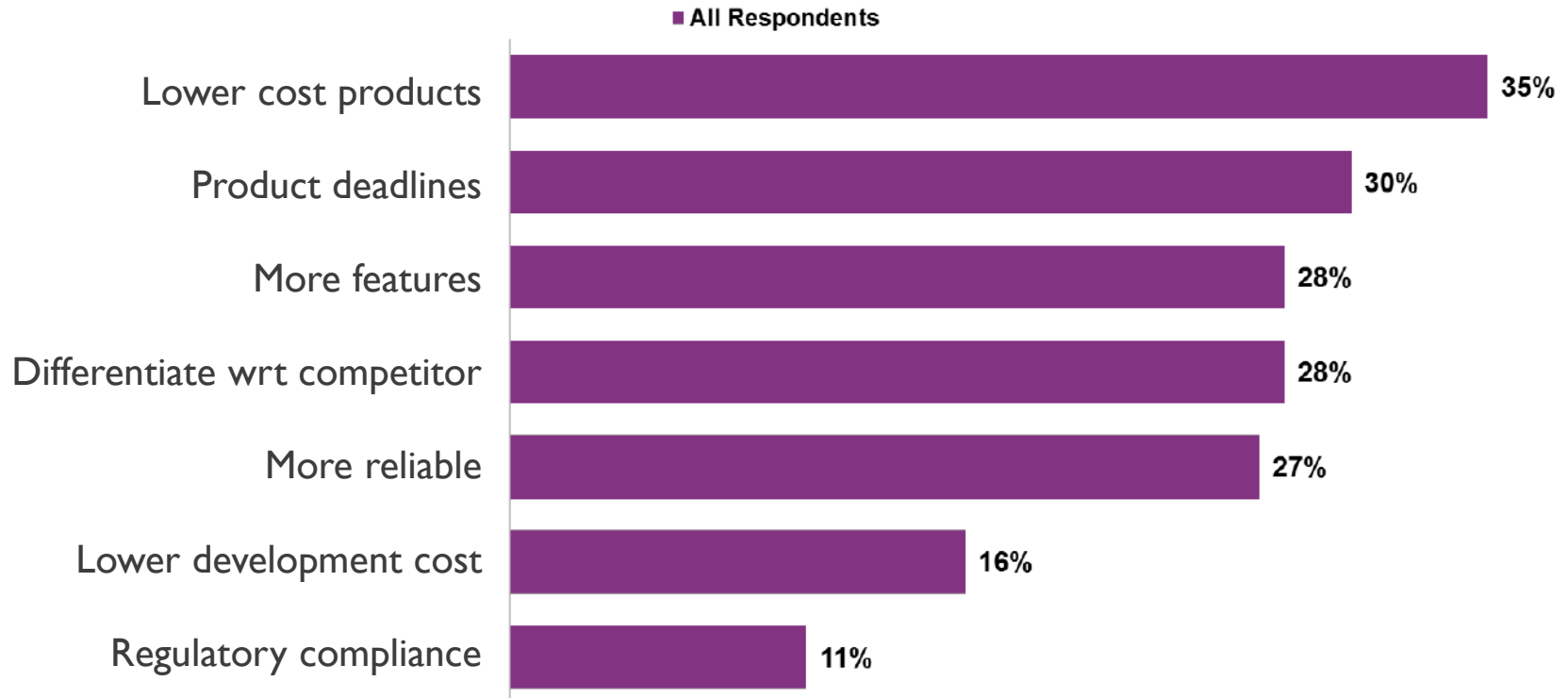
Product Element	% Increase — Past Two Years
Number of mechanical components	14%
Lines of software code	34%
Number of electrical components	21%

Source: Aberdeen, November 2018

# VIEW ON PRODUCT DEVELOPMENT CHALLENGES

## A STUDY ON DFX: EXTERNAL CHALLENGES

Figure 1: External Business Pressures of Electronics Design

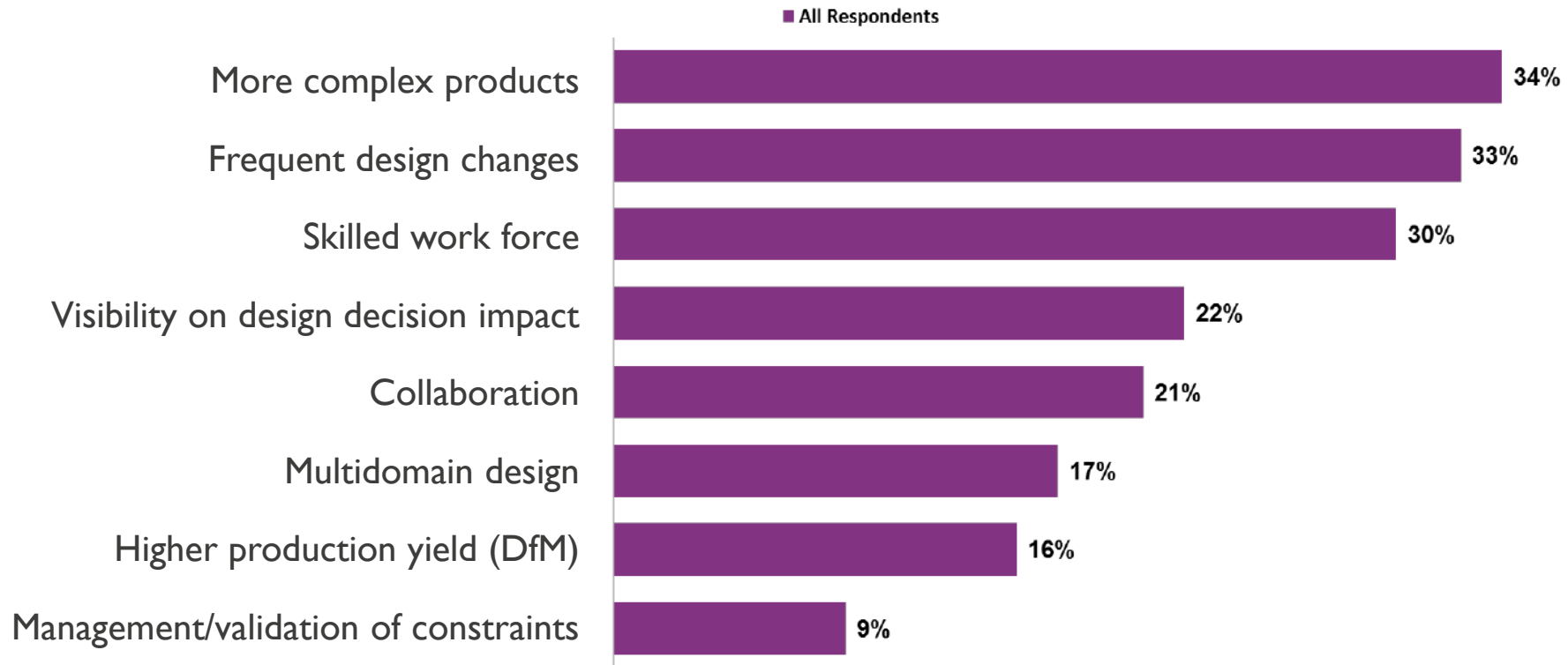


% of Respondents, n = 122, Source: Aberdeen 2018, November 2018

# VIEW ON PRODUCT DEVELOPMENT CHALLENGES

## A STUDY ON DFX: INTERNAL CHALLENGES

Figure 2: Internal Challenges of Electronics Design

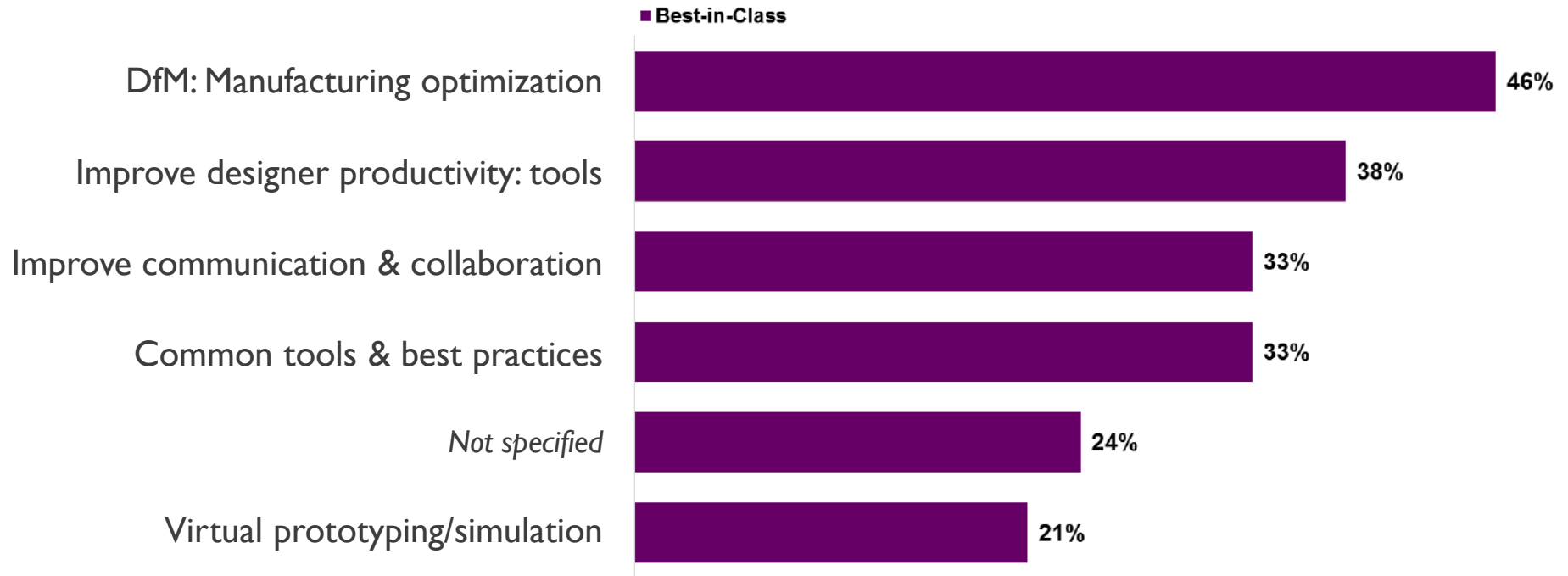


% of Respondents, n = 122, Source: Aberdeen, November 2018

# VIEW ON PRODUCT DEVELOPMENT CHALLENGES

## A STUDY ON DFX: FACING THE CHALLENGES

Figure 3: Best-in-Class Actions for Electronics Design



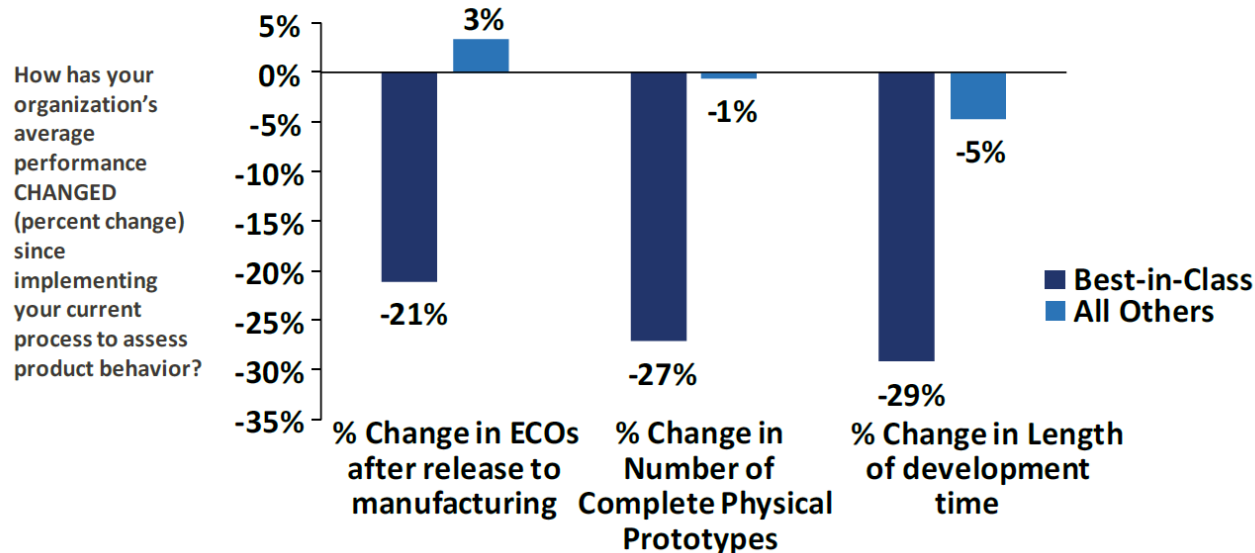
% of Respondents, n = 122, Source: Aberdeen, November 2018

# VIEW ON PRODUCT DEVELOPMENT CHALLENGES

## A STUDY ON DFX: THE SHIFT LEFT

Instead of waiting until a design is completed, the “Shift Left” methodology integrates manufacturing and performance validation in the design process.

Figure 4: Simulation-Driven Design Boosts Performance

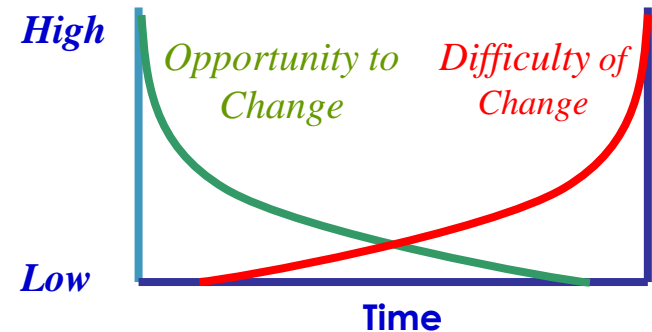
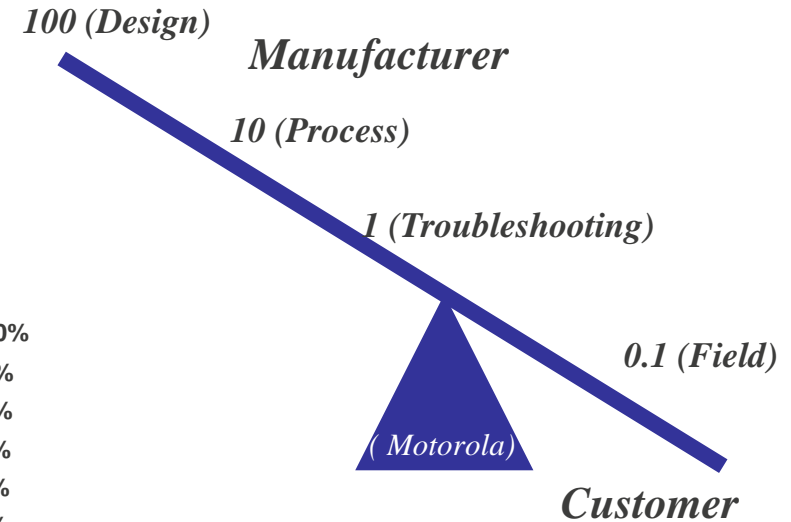
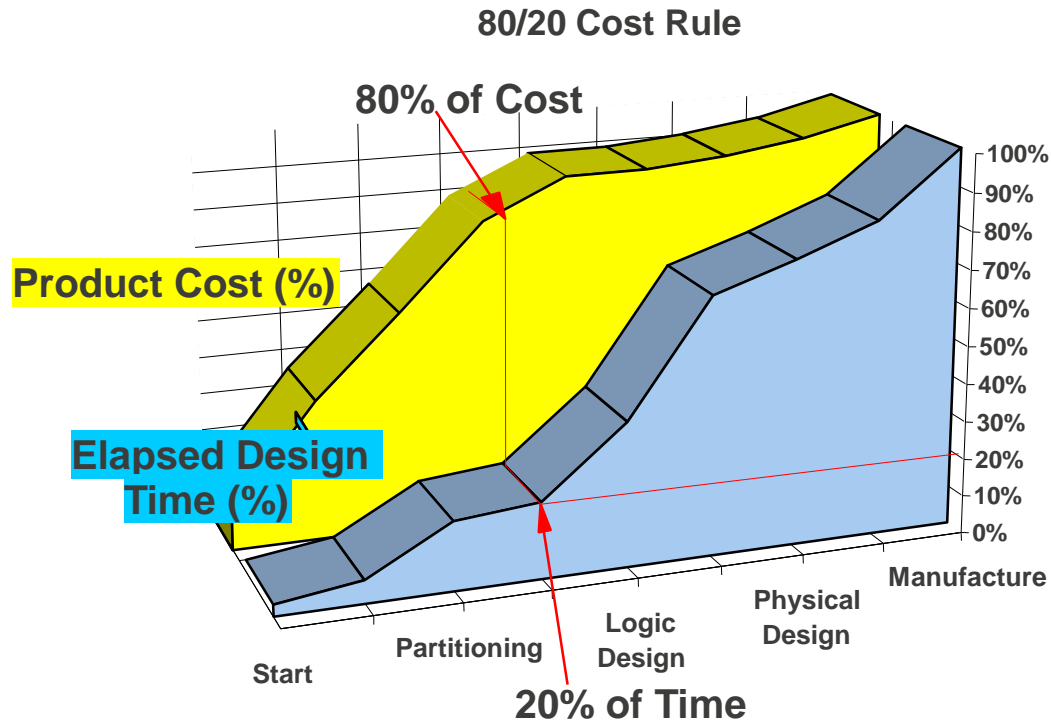


**Shift Left is a major advance in electronics design, allowing users to ultimately eliminate many of the iterations used for manufacturability and performance analysis today, thus making the overall flow more efficient.**



# VIEW ON PRODUCT DEVELOPMENT CHALLENGES

**DfX Rule #1:**  
**The sooner, the better!**

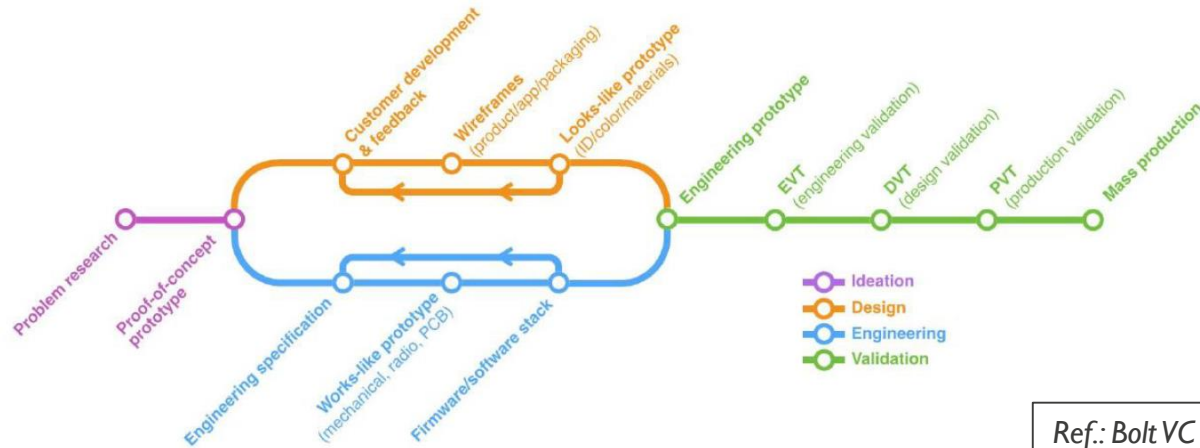


# VIEW ON PRODUCT DEVELOPMENT LIFE-CYCLE

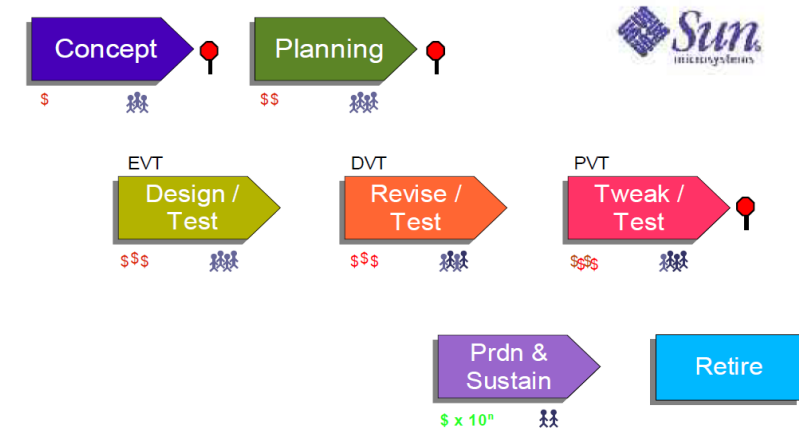
# VIEW ON PRODUCT DEVELOPMENT LIFE-CYCLE

## INDUSTRY'S PRODUCT DEVELOPMENT STAGE-GATING

Often proprietary – consultancy companies – large companies



## Product Development Phases

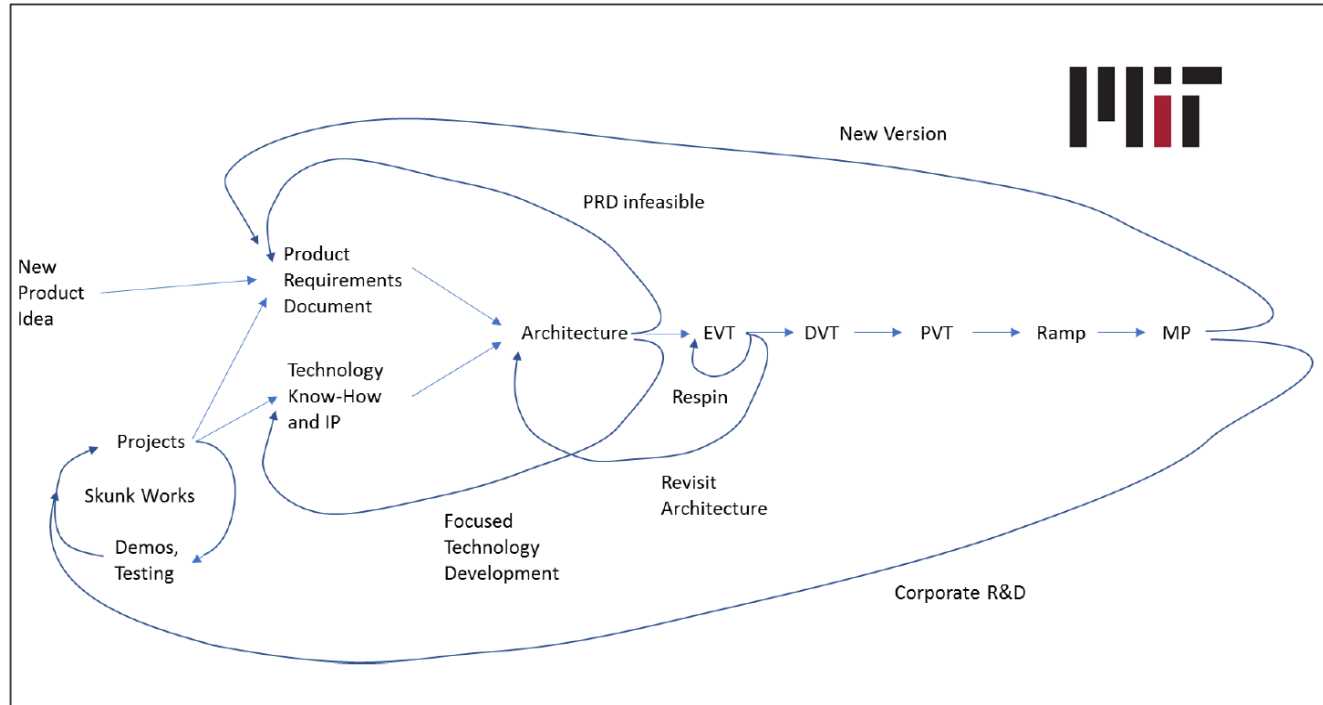


Fuzzy Front End (FFE)



# VIEW ON PRODUCT DEVELOPMENT LIFE-CYCLE

## INDUSTRY'S PRODUCT DEVELOPMENT STAGE-GATING

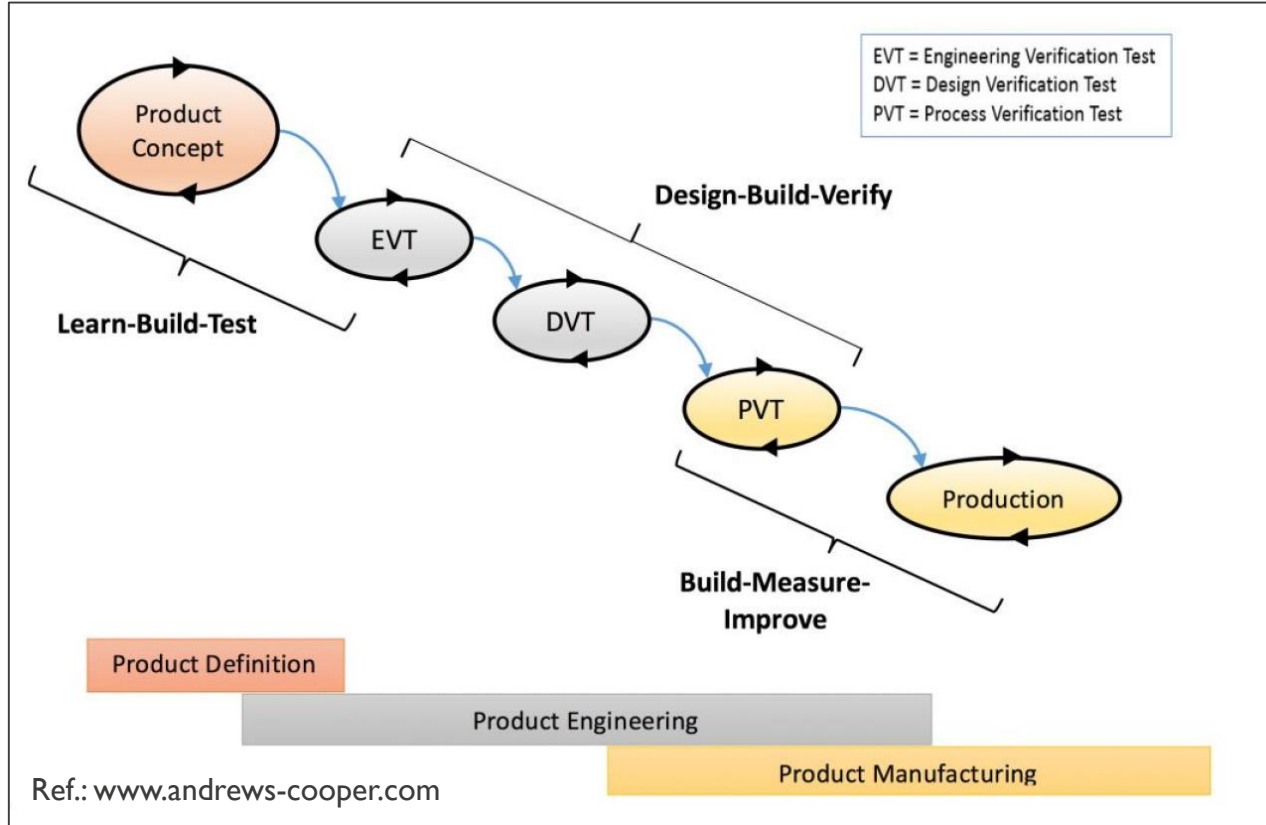


NTD, NPD, FFE,  
ideation, Problem  
Research, *prototype*,  
PoC, PRD, NPI,  
concept, design,  
architecture, EVT,  
*prototype*, DVT,  
*prototype*, PVT, ramp,  
industrialization, MP  
...

- A lot of inconsistently used terminology: what does it really mean?

# VIEW ON PRODUCT DEVELOPMENT LIFE-CYCLE

## VALIDATION FOCUSED STAGE-GATING: THE 20<sup>TH</sup> CENTURY APPROACH



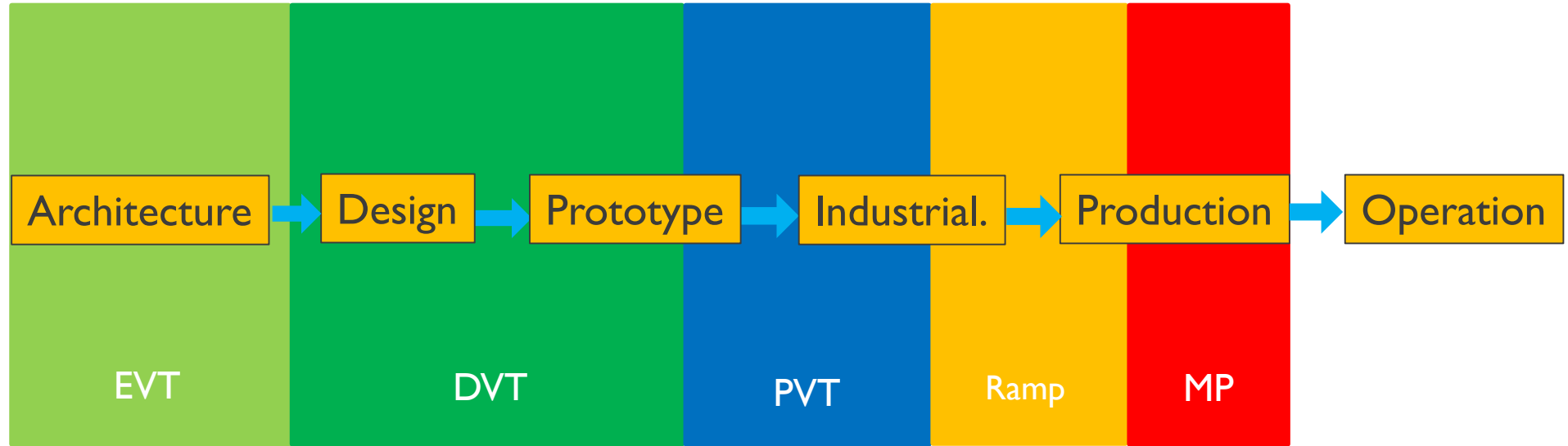
### EVT – DVT – PVT – MP

- Test focused
- Iterative Design-Build-Test approach
- Intrinsically not pro-active
- Design-for-eXcellence addressed too late (DVT, PVT)

**Not a viable approach  
for smart products!**

# VIEW ON PRODUCT DEVELOPMENT LIFE-CYCLE

## REALISATION ORIENTED NPI STAGE-GATING



**Architecture:** system concept design

**Design:** physical product design

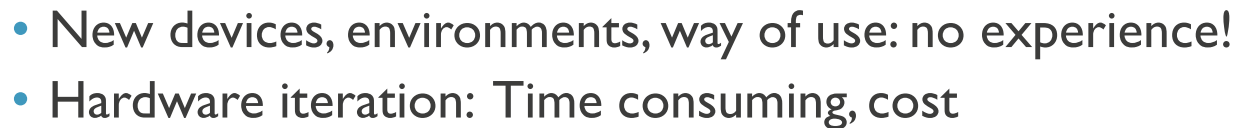
**Prototype:** product prototyping for test, qualification, certification and preparation of production (DfM)

**Industrialisation:** preparation of (volume) production, qualification, certification

**Production:** production by regular supply chain

**Operation:** product operation

## THE TRADITIONAL DESIGN-BUILD-TEST APPROACH

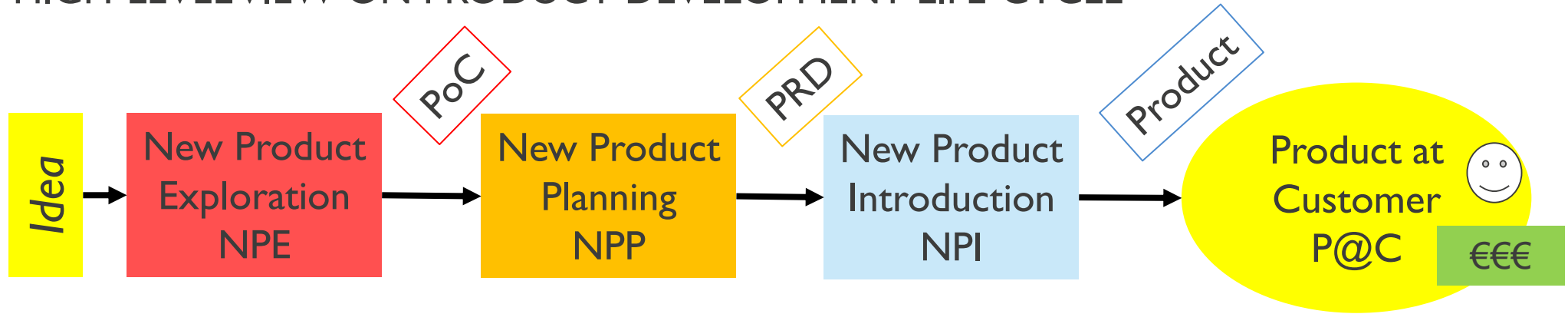


# SMART PRODUCT DEVELOPMENT SHIFT LEFT IN PRACTICE



# SMART PRODUCT DEVELOPMENT

## HIGH-LEVEL VIEW ON PRODUCT DEVELOPMENT LIFE-CYCLE



NPE - Problem research: user, market, business, technical/industrial feasibility

→ *Proof-of-Concept (PoC)*

NPP - Plan the product development, operations and business set-up

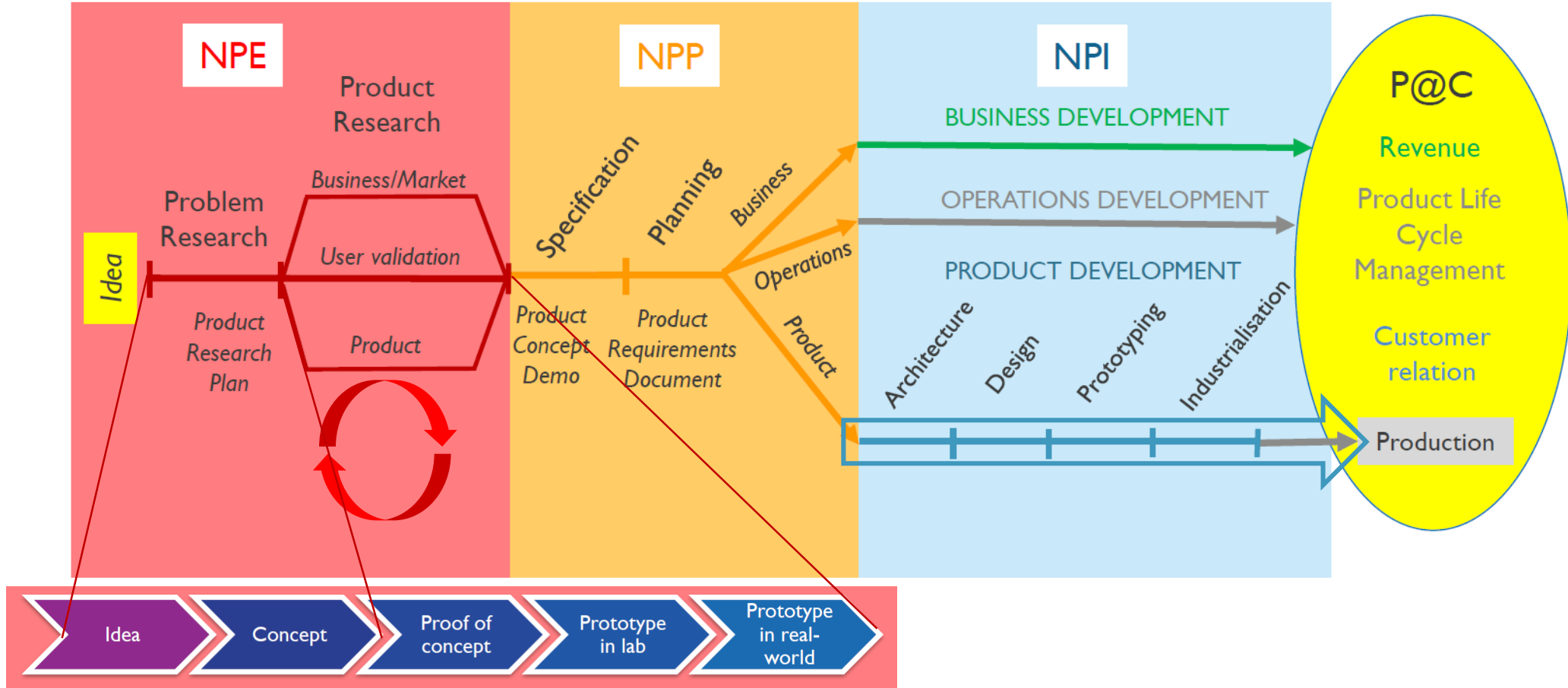
→ *Product Requirements Document (PRD), operation's and business' roll-out plans*

NPI - Execution of product development, industrialization, operations and business roll-out

→ *Qualified, documented product delivered to customer.*

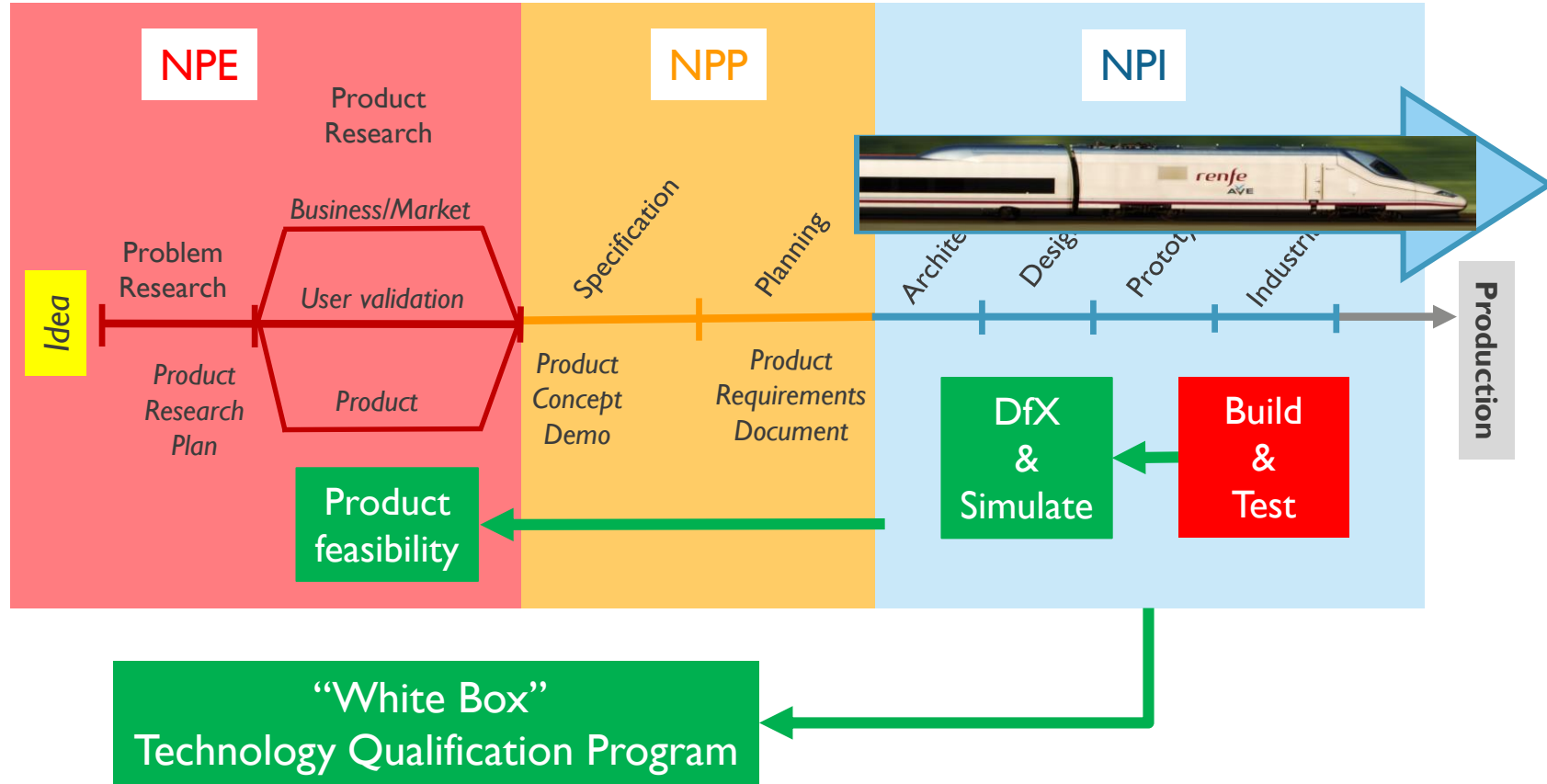
# SMART PRODUCT DEVELOPMENT

## PRODUCT DEVELOPMENT LIFE-CYCLE: A BIT MORE DETAIL



# SMART PRODUCT DEVELOPMENT

## SHIFT LEFT IN PRACTICE



# SMART PRODUCT DEVELOPMENT

## WHAT DO WE NEED?

### Product:

- Complex
- Co-development
- 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?

(focus on electronics HW DfX)

# SMART PRODUCT DEVELOPMENT

## TRADITIONAL DESIGN-BUILD-TEST: BLACK BOX TESTING

Vibration  
Shock  
Heat  
Cold  
Moisture  
Thermal cycling  
Voltage/Power  
EM pulse/radiation  
...



“Alive”



# SMART PRODUCT DEVELOPMENT

## TRADITIONAL DESIGN-BUILD-TEST: BLACK BOX TESTING

### What did we learn by passing the test?

- The prototype passes the test.
- Does this guarantee anything regarding product operation?
  - New devices
  - New environment(s)
  - New application(s)
  - New ways of use
- What if any of the above changes?



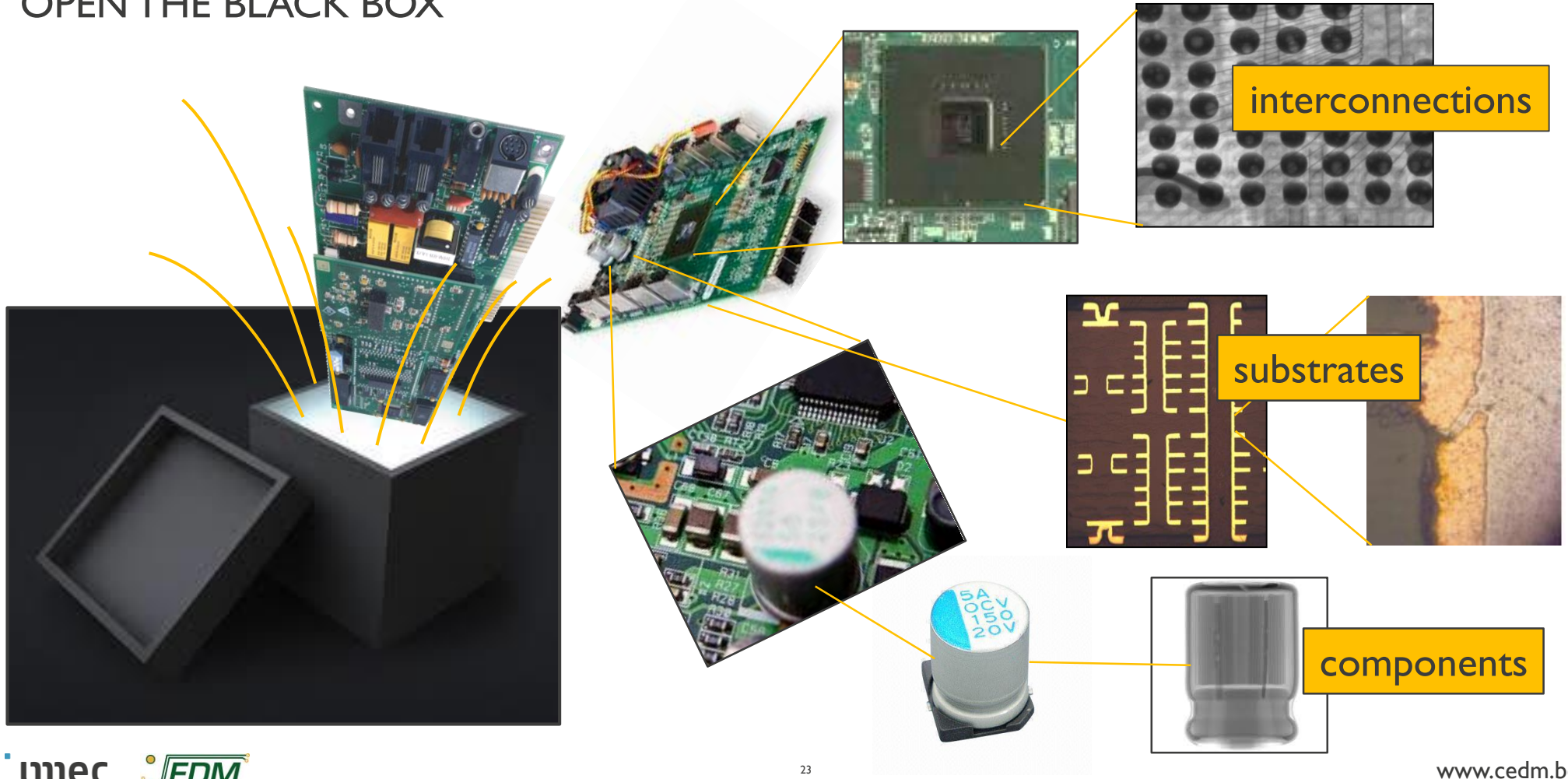
### What did we learn from a test failure?

- Test relevancy: did we discard a perfectly good solution?



# SMART PRODUCT DEVELOPMENT

## OPEN THE BLACK BOX





# SMART PRODUCT DEVELOPMENT

## THE WHITE BOX APPROACH: STRUCTURAL DESIGN AND ITS VALIDATION

Electronics are physical structures consisting of a set of components electrically and mechanically connected to a substrate.

**Understanding** the product **structure** and how the **building blocks** and their **interconnections** perform and **respond to loads**, allows to predict how the **system** will perform and respond.

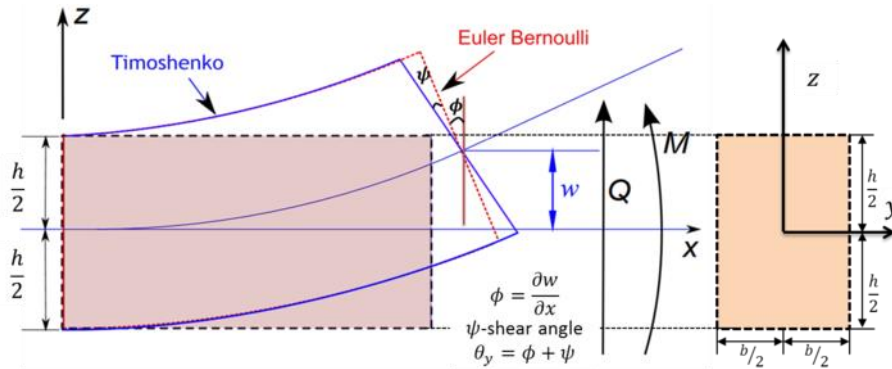
The **impact of changes** in building blocks, system build-up, environment, way of use, ... on performance, quality and reliability can be predicted.





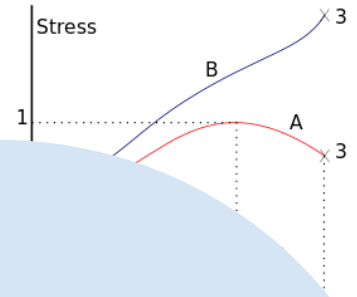
# SMART PRODUCT DEVELOPMENT

## THE WHITE BOX APPROACH: UNDERSTANDING THE BASICS

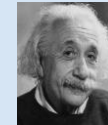


## The Mechanics of Electronics

$$\frac{1}{C} = \frac{M}{\sigma}$$



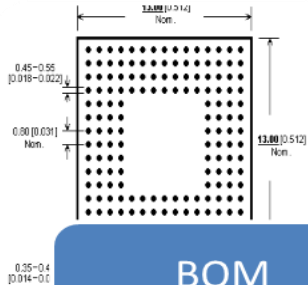
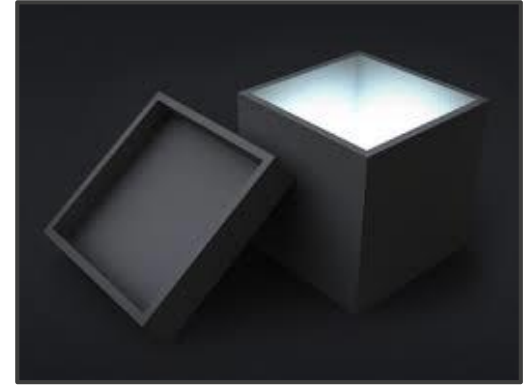
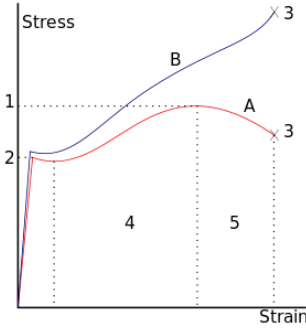
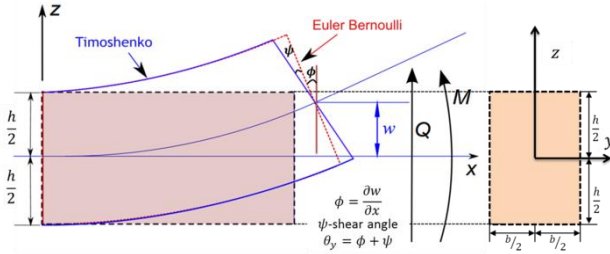
*Physics*  
*The next best thing*  
*to a crystal ball*



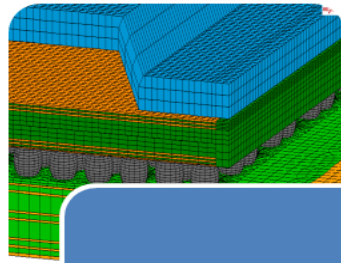
$$u_0 + \frac{\partial u_0}{\partial x} \Delta x$$

# SMART PRODUCT DEVELOPMENT

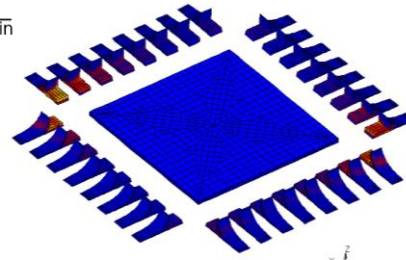
## OPEN THE BOX: SOLDER JOINT FAILURE PREDICTION



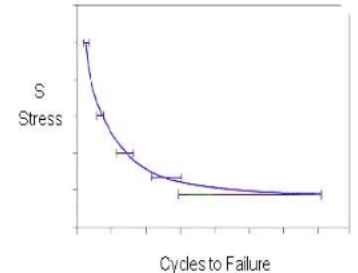
BOM  
+  
Mission profile



Modelling /  
Quantification  
/ Simulation



Cyclic strain in  
solder joints



Life time model

# ECU mounted in cab

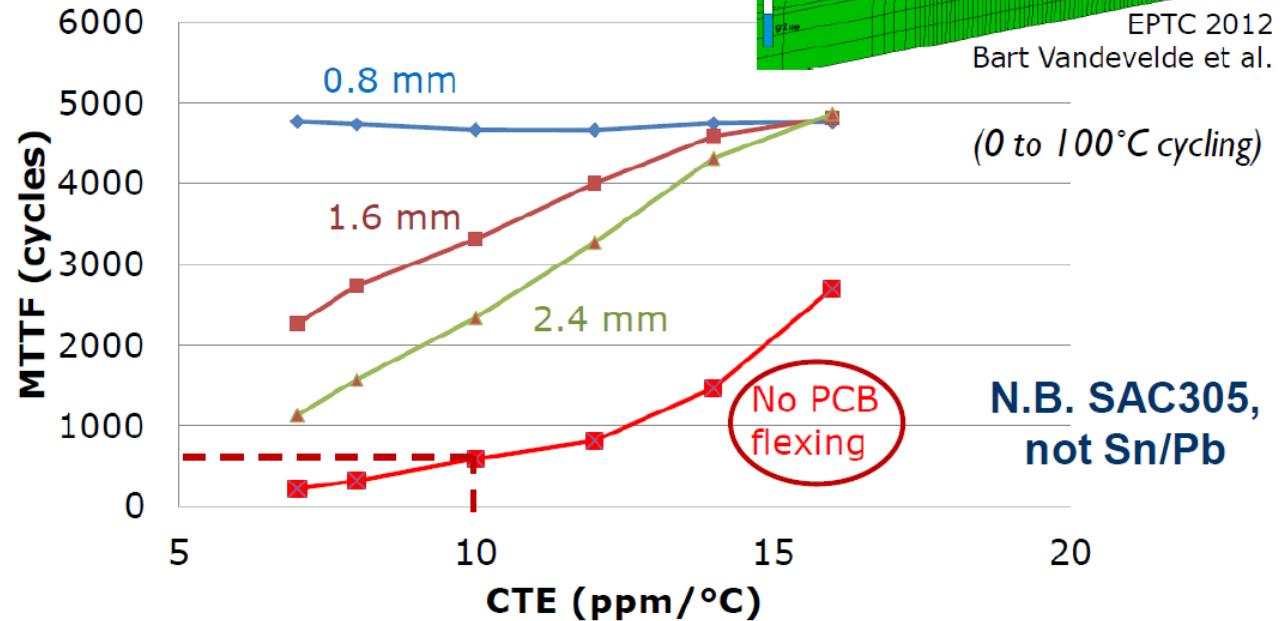


Truck manufacturer acknowledges our prediction of 2012.

Prevention is possible w/o high testing costs

## 6. Reliability of BGA Impact of board thickness

PBGA 27x27 area array  
1.27mm pitch



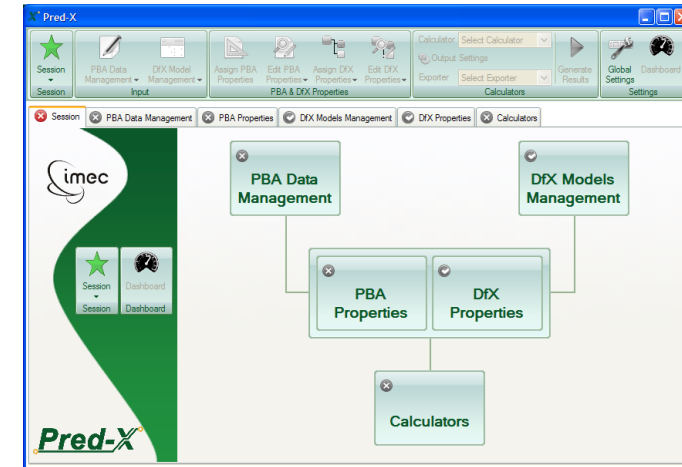
# SMART PRODUCT DEVELOPMENT

A PBA ASSEMBLY “DIGITAL TWIN”



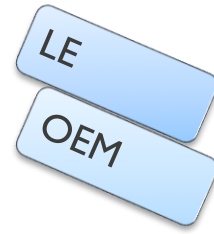
$$Q = \prod_{i=1}^{DO} Q_i$$

- Generic D-f-Manufacturing supporting tool
- Can be used very early in design phase (concept)
- Quantified prediction of PBA DfM properties
- V1.0: Quality (yield) and test coverage prediction
- V2.0: Assembly capacity use and DfA analysis



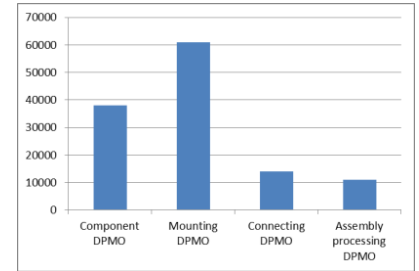
# SMART PRODUCT DEVELOPMENT


## QUALITY PREDICTION AND IMPROVEMENT



### New Quality method achievements

- 4 to 6 times better PCBA quality in 3 years
- Manufacturing Risks have become transparent



 Workshop 20, December 9, 2014

After decades of constant PCBA quality we have been able to improve it at our suppliers by a factor 4 to 6 in 3 years time by deploying the new Quality Quantification methodology embedded in imec's **Pred-X** tool in **ASML's** New Product Introduction process. Further quality improvement using this method at system level is the aim of ASML's ZHDR project.

[www.movip.nl](http://www.movip.nl) – [www.cedm.be](http://www.cedm.be)

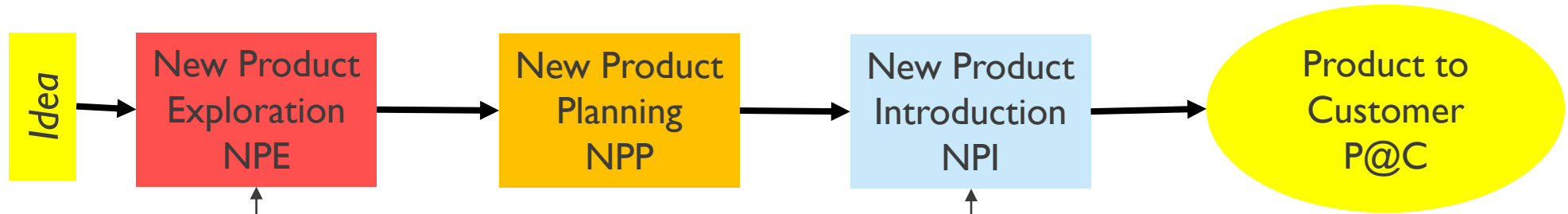


ASML  
Dick Van Hees

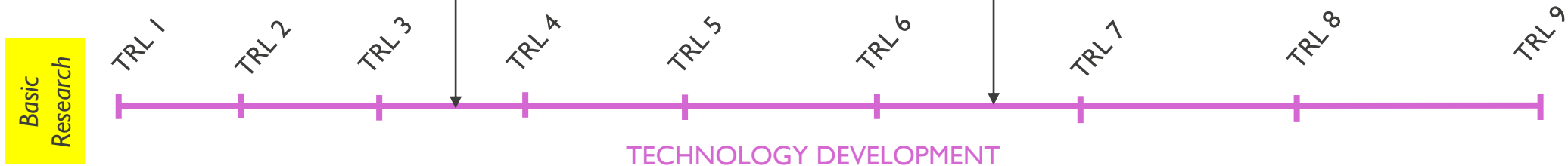
# “WHITE BOX” TECHNOLOGY QUALIFICATION

# TECHNOLOGY QUALIFICATION

## HIGH LEVEL VIEW: WHERE IS TECHNOLOGY DEVELOPMENT?



- Technology is a **product independent** solution for a specific functional/realization problem of a product's building block.
- A product is a collection of a large number of preferably proven (TRL9) technologies.
- Technology development should not be part of product development.





# SMART PRODUCT DEVELOPMENT

## TECHNOLOGY QUALIFICATION

### Technology qualification

is the methodology applied to evaluate if a predefined sub-set of a technology fulfils all requirements to be considered **fit-for-purpose** for a **specific set of applications, operational conditions and lifetime** while fulfilling additional **Design-for-eXcellence requirements** related to cost, manufacturability, quality, robustness, reliability, repairability & maintenance, environmental impact, etc.

### Technology Qualification is not product specific

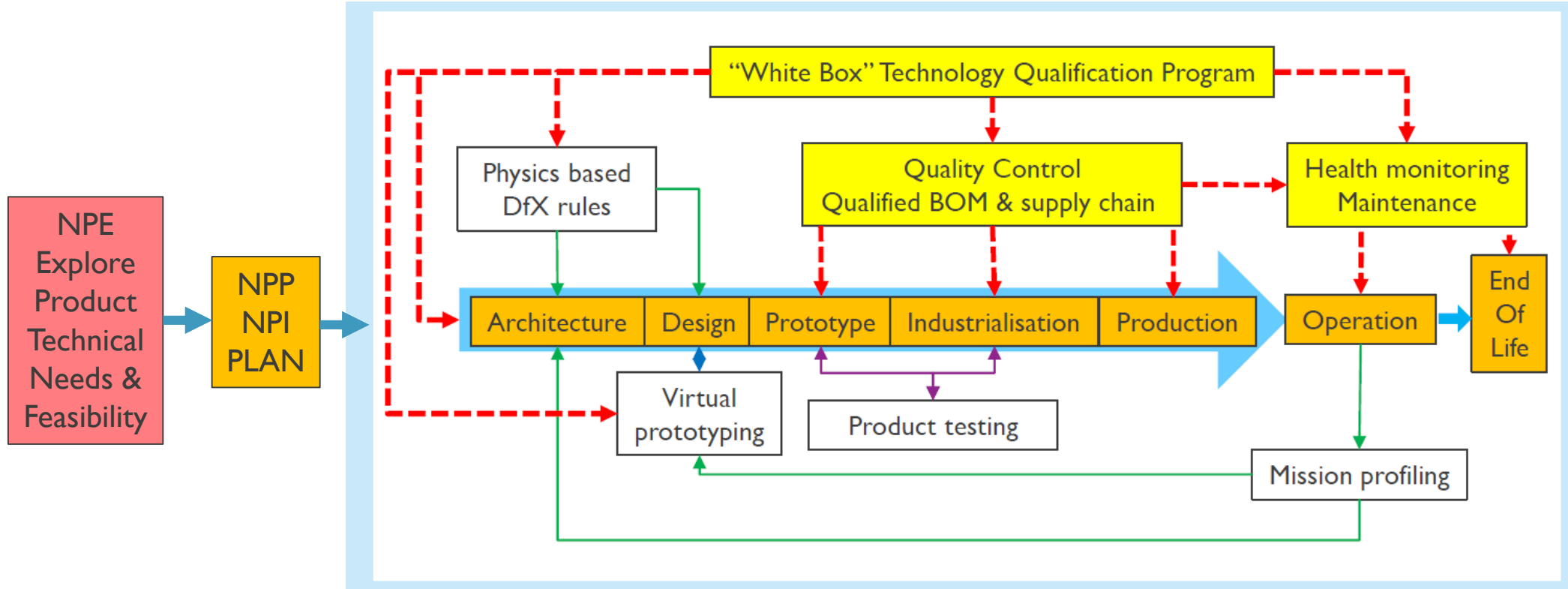
The added value of the Technology Qualification Program is that it provides **qualified building blocks** for product (Electronic Assembly) development and integration leading to a Qualified-by-Design product for all aspects (DfX elements) that are not product functionality specific.



# SUMMARY

# SUMMARY

## SMART PRODUCT DEVELOPMENT (NPI) STAGE-GATING



Collaboration: common stage-gating terminology

# THANK YOU



embracing a better life



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