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RELIABILITY DESIGNED & DELIVERED

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AUTOMATED DESIGN ANALYSIS™

2019
DESIGN FOR RELIABILITY
CONFERENCE

How to Implement a Proactive Approach to Identifying Reliability Risks …

March 26, 2019 | John Coates, ZF

Agenda

- Introduction
- Challenging Landscape in Automotive
- Increasing Value of Electronics
- Interconnections are critical!
- Physics of Failure (Phenomenon)
- ‘Trial & Error’ Testing is Insufficient!
- Simulation (FE) has an Important Role!
- Innovative Approach…
- Consistency in Manufacturing

Introduction

- Core Technology in ZF has responsibilities extending to all ZF Electronics & ADAS related product lines and developments
- And covering…
  - Manufacturing Technology
    - Interconnection & packaging technologies, associated manufacturing processes, plus qualification and release of assembly materials
  - Component Engineering
    - Qualification and lifecycle management of “off-the-shelf” electronic components as well as close engagement with suppliers
  - PCB Technology
    - Qualification and release of PCB suppliers, materials and technologies as well as associated documentation and design rules
  - Product Stewardship
    - Responsible for regulatory compliance throughout product lifecycle
- That is, the major areas which influence product industrialization and reliability

Challenging Landscape in Automotive

- Increasing value from Electronics
- Increasing quantity, complexity, ECUs and interconnections
- Increasing safety criticality
- Decreasing time to market
- New component suppliers
- New interconnection and packaging technologies
- Changing E/E architecture in vehicle
- Changing environmental stress conditions

Challenging Landscape in Automotive

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Connectivity

- Integration of 3rd-party services
- Updates over the air to deploy new features faster
- Operation of future cars partly in the cloud

Autonomous driving

- Rise of built-in sensors and actuators
- Higher demand for computing power and communication
- Unlimited need for reliability

Electrification

- Introduction of new electronics
- Reduction of energy consumption through advanced software algorithms

Diverse mobility

- Shared-mobility services and robo-taxis via app
- Customized driver experience

Source: Automotive Electronics Initiative; HAWK; IEEE, "This car runs on code"; McKinsey analysis

McKinsey&Company

Increasing Value of Electronics

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Then

Other Early Automotive Computer Controlled Systems

- 1969 - Ford introduces their first computer controlled anti-skid system.
- 1971 - General Motors introduces their first computer controlled transmission.
- 1978 - Cadillac introduces a computer controlled trip computer powered by a Motorola Microprocessor.
- 1986 - Carnegie Mellon University's "Navlab 1" becomes first self-driving, autonomous car.
- 1986 - Chrysler introduces multiplexing wire communication modules with chips supplied from Harris Semiconductor.
- 1987 - First automotive microcontroller chips produced to CAN vehicle bus standards by Intel and Philips Semiconductor.
- 2014 - First commercially available self-driving vehicle introduced - The Navia shuttle.
- 2015 - Daimler's "Freightliner Inspiration" becomes First self-driving, semi-autonomous, Semi-Truck.

Now

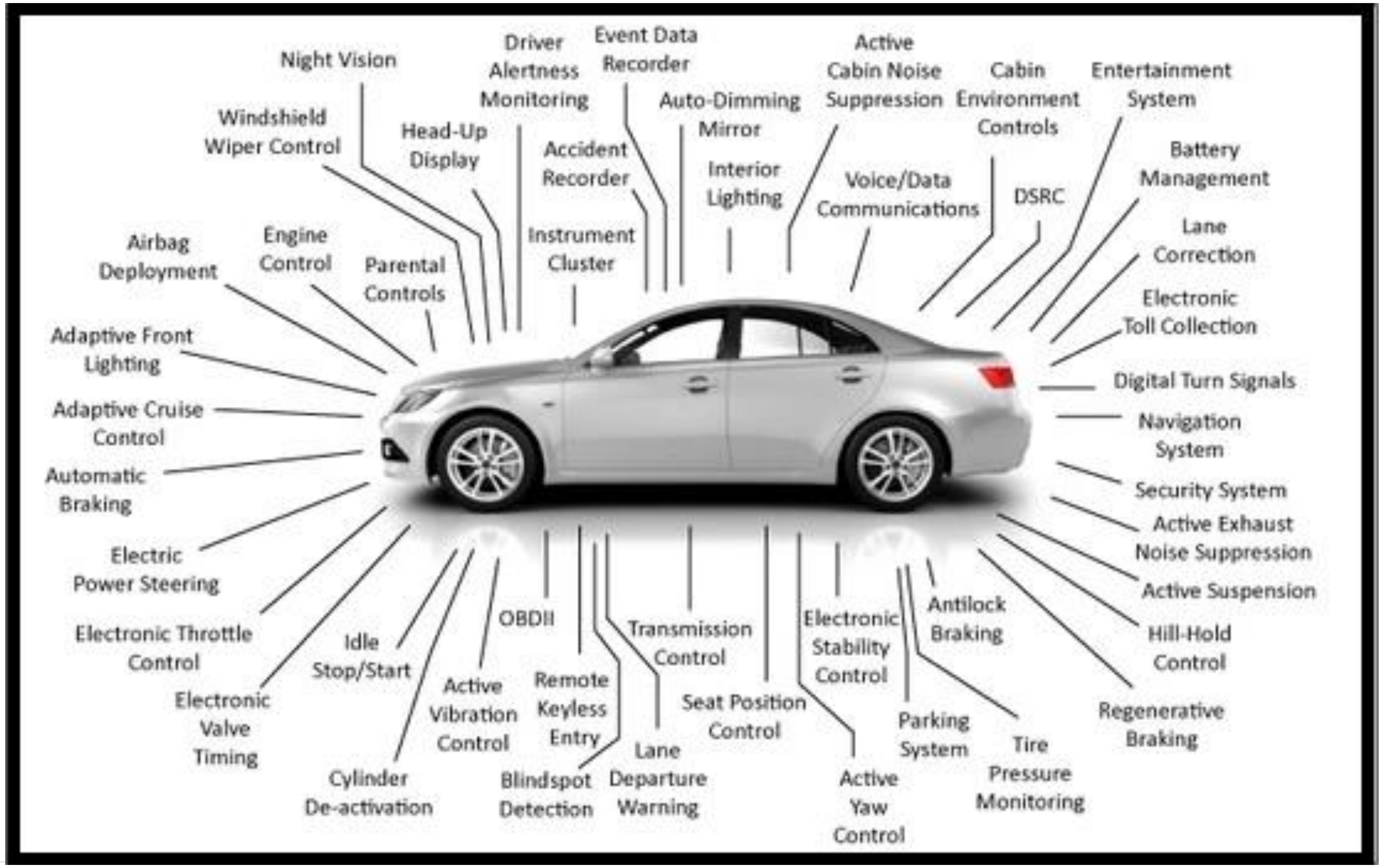

Image courtesy of chipsetc.com.

Interconnections are Critical

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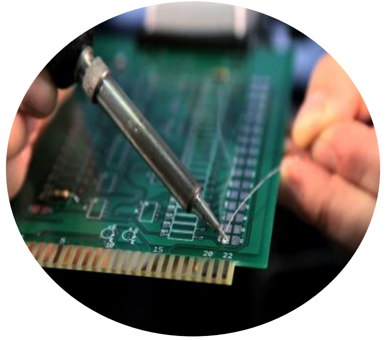
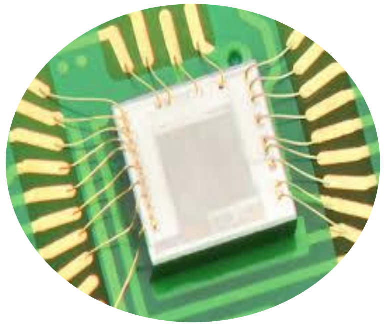
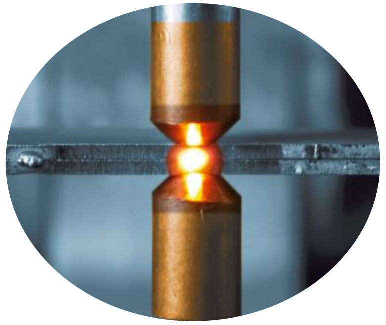
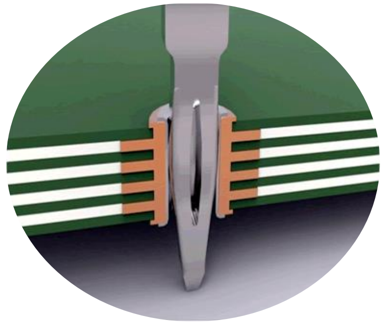
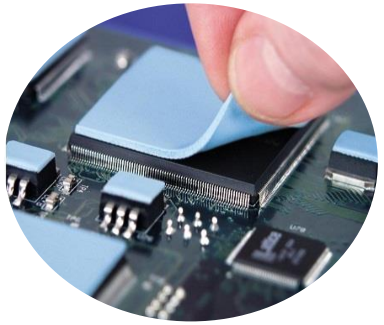
- Estimated **~30,000** electronic interconnections in a typical car, including mechanical, metallurgical, electrical and thermal interconnections
  - Continuing to increase in number, complexity and safety criticality!
- Many of these interconnections relate directly to the value and performance in the electronics system and as such in the vehicle
- As a result interconnections create innovative value in terms of Quality and Cost in the car
- Types of interconnections include…
  - soldering, wire-bonding, resistance welding, press-fit, adhesive, thermal interface, braze etc…





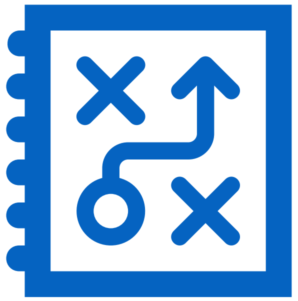






Interconnections are Critical

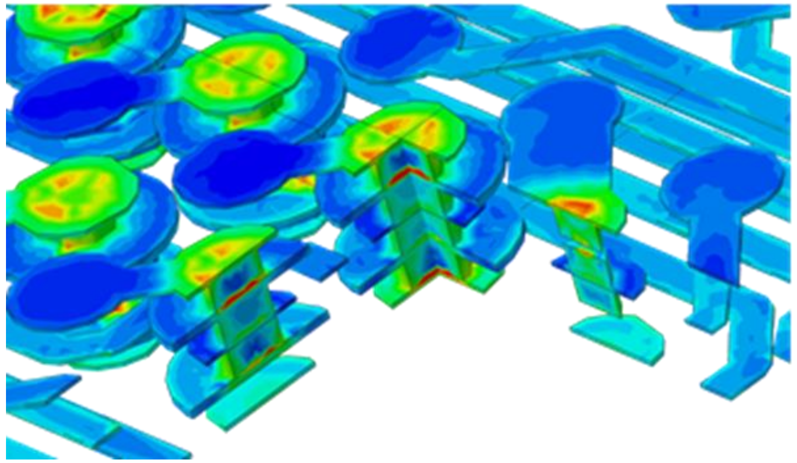
- Which are to be the critical interconnections now and in the future?
  - Continued trend to increasing complexity and miniaturisation with reduced pitch, increasing pin count, leadless packages, chip scale packages…
- Understanding the phenomenon is the start…!
- Simulation is the tool, but don't believe the output without questioning!
- It could provide benefit in terms of efficiency (time) and delivering an optimised solution (quality, performance)!



Physics of Failure (Phenomenon)

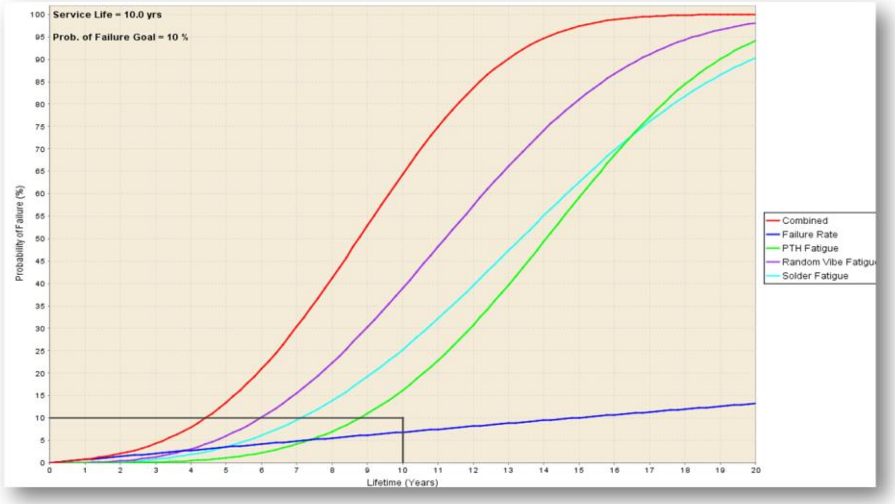
Physics of Failure

The process of using modeling and simulation based on the fundamentals of physical science (physics, chemistry, material science, mechanics, etc.) to predict reliability and prevent failures.



Reliability Physics

An engineering product development methodology that applies the knowledge produced by PoF research to predict reliability and produce failure free product and systems.



‘Trial & Error’ Testing is Insufficient!

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Most OEMs in Automotive and Aviation **hate** demonstrating reliability through testing

01 It takes too long

02 It costs too much

03 It is too late in the process

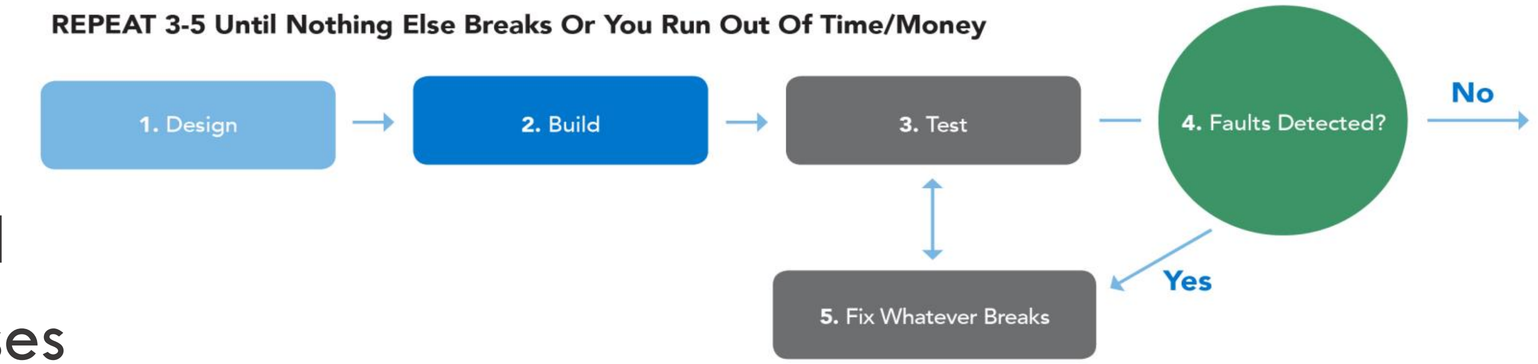
04 Suppliers rarely fail

05 Failures are not always relevant

06 It stymies innovation and modification (no one wants to retest)

‘Trial & Error’ Testing is Insufficient!

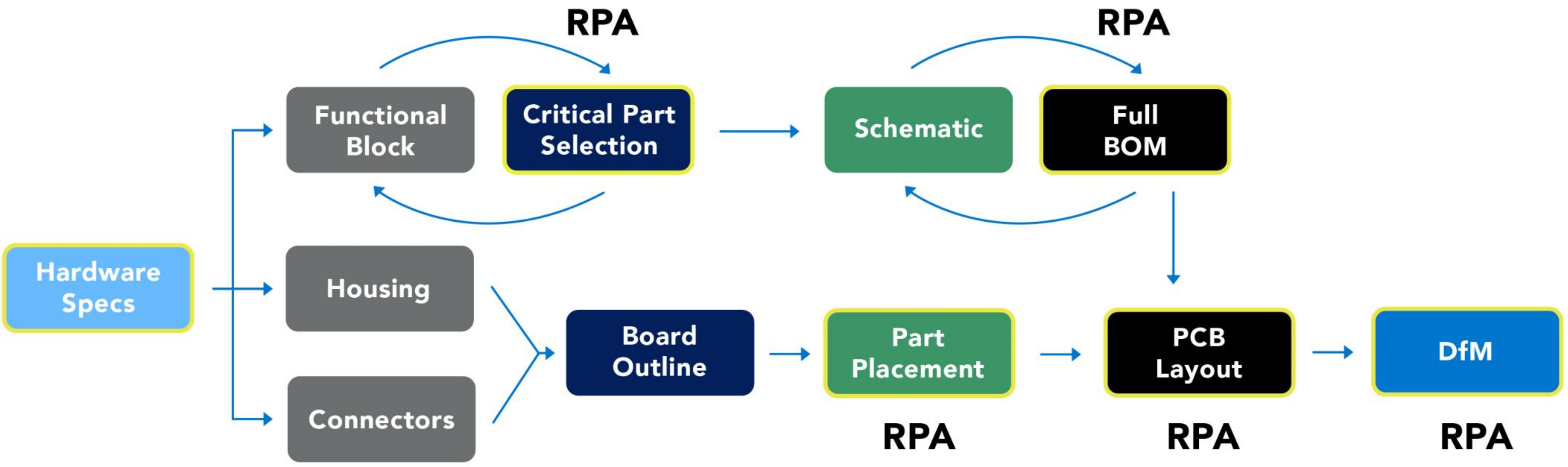
- **Today, This Is Not Enough!**

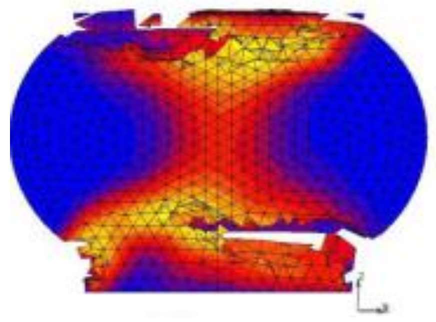


DESIGN – BUILD – TEST – FIX (D-B-T-F)

  - All design issues often not well defined
  - Early Builds do not match Final Processes
  - Test Environment ≠ Field Environment
  - Problems found Too Late for effective Corrective Action
  - Project Schedules no longer include allowance for D-B-T-F
  - AEC-Qxxx not always enough; needs early engagement to establish board level performance
  - Environmental testing costs Time and Money
  - The Cost and Delays of qualification contributes to Obsolescence and Counterfeiting!
  - Requires too much engineering resource
  - Delays time to market

Simulation (FE) has an Important Role!





- Simulation is a very effective tool for securing the quality of design
- Its performance is dependant on the capability of the user
- Don't believe results without question!
- But it's a good opportunity to enable efficiency and effectiveness

Innovative Approach…

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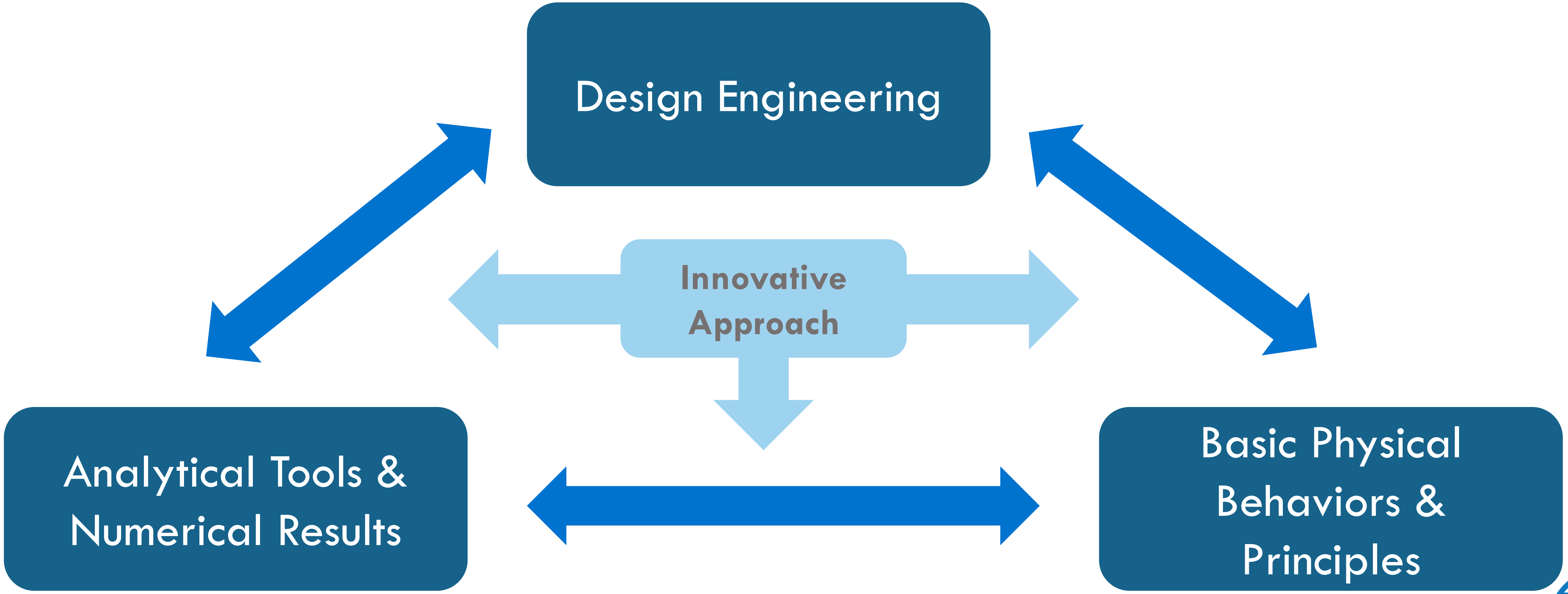
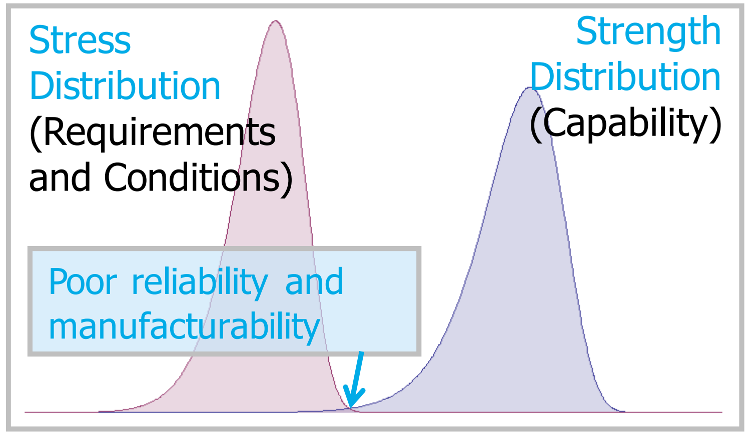
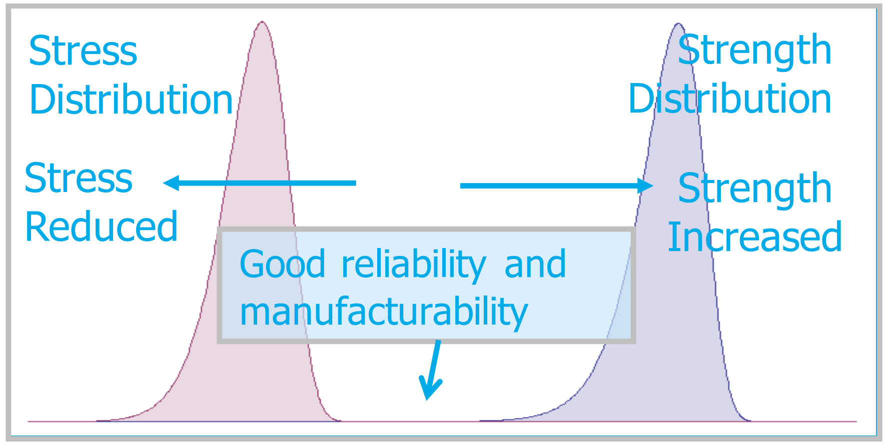
- Combines the understanding of physical behavior's with the power of analytical tools…



Consistency in Manufacturing

- Trend of increasing performance expectation
- Relationship to process variation - Stress-Strength Interference





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Design Margin

- The Design Margin can be preserved either by:-
  - Reducing the variability in the manufacturing process to produce a narrower distribution with no overlap

And/or

  - Moving the 'stress distribution' by using different materials e.g. PCB, solder, component package…
- Reducing process variability for improved consistency will play an increasingly important role in maintaining the Design Margin

In Summary

- The changing landscape in Automotive Electronics is challenging us to find innovative solutions to deliver reliability performance improvements
- Interconnections are vital and continue to increase in number, complexity and safety criticality
- Understanding the phenomena is key and applying a Reliability Physics based approach can deliver optimized solutions
- Don't forget other important factors such as the contribution from manufacturing and the supply base!

Speaker Bio

John Coates, Chief Engineer, Core Technology Engineering, Electronics & ADAS at ZF Group

John started with Cummins Engine Company in Darlington, UK in 1983 as an Apprentice Technologist progressing to Manufacturing Engineering Project Lead. In 1996, he moved to Lucas Wiring as Advanced Manufacturing Engineer (AME) Manager, and then as Overseas Development Manager.

In 2000, John moved to TRW Automotive as AME Manager, establishing the Manufacturing Technology group in 2007. In 2012, John became a Chief Engineer responsible for Core Technology which includes Manufacturing Technology, Component Engineering, PCB (Substrate) Technology and Product Stewardship.

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Thank You!

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