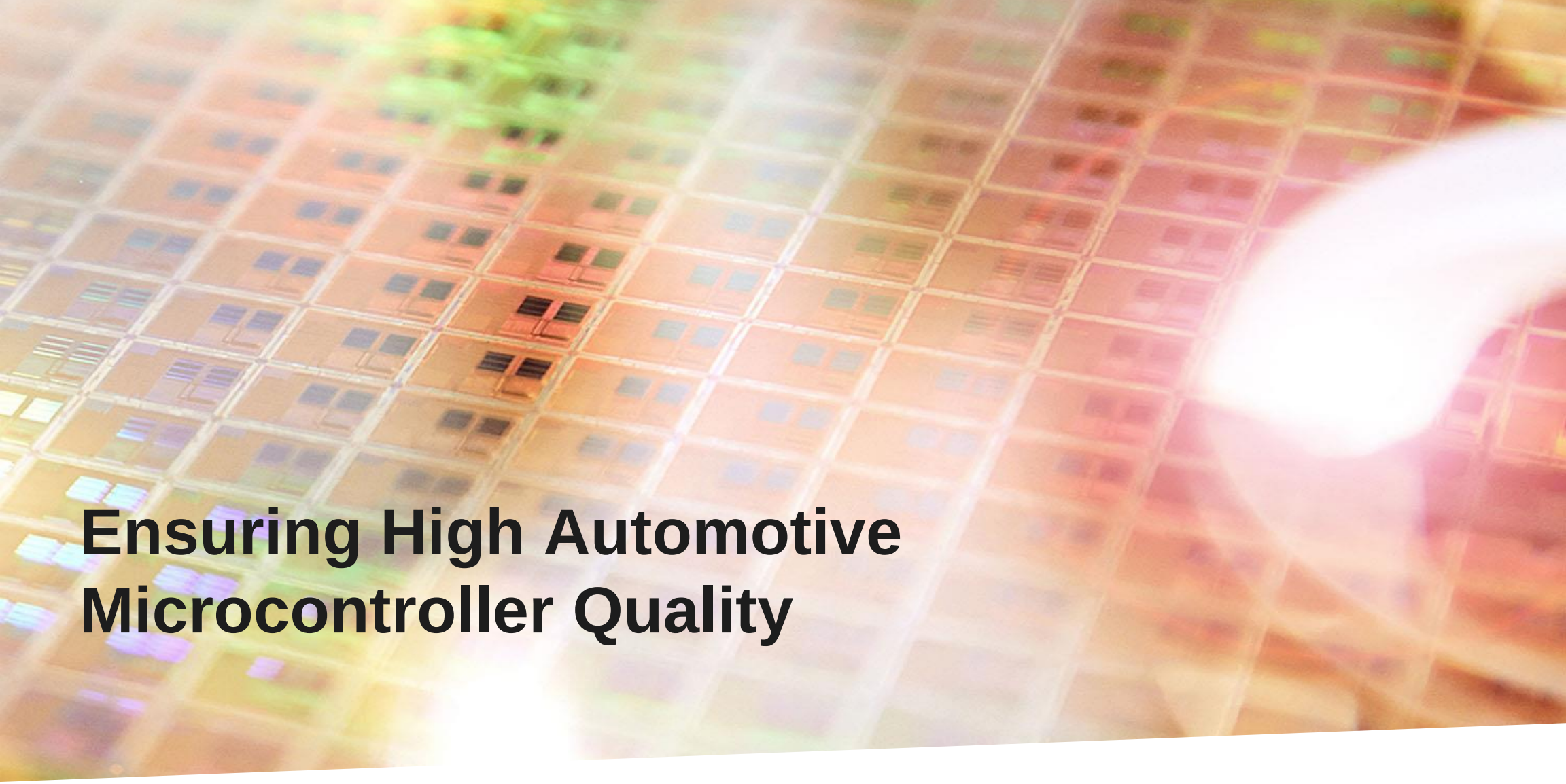

Ensuring High Automotive Microcontroller Quality

Feb 2025

Ralf Arnold

Automotive Microcontroller

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2. Differentiation of Quality Levels / ISO Definitions
3. How to Maintain Automotive Quality
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Motivation for Automotive Quality

WHY?

Automotive applications:

MUST be safe and

MUST protect human life

➔ **Products are developed, produced and managed according to the ISO26262 Safety Standard**

› **Automotive Quality**

› **Is a Philosophy,**
a Mind Set,
a Passion

› Others might say: paranoid, picky

Automotive Quality – Why?

„Customers“ expect from our semiconductor devices:

- Fault free functionality of Automotive Products
  - Must operate robust in a noisy environment (car)
  - Covering full specification
    e.g. Temp, frequency and VDD range
  - Long lifetime 10+ years

=> Achieving highest possible Quality = High Automotive Quality

$$\text{Quality (Failure Rate)} = \frac{\text{Customer Rejects}}{\text{All delivered Devices}}$$ [PPM] Parts per Million

Automotive Quality does not come for free

- Mind Set „Quality first!“. E.g. throw away maverick parts / lots!
- Much time, effort and investment is needed to improve quality to a **„High Automotive Quality“** level
- Many years of exerience / competency within the company is needed
- Analysis of Customer Rejects over many years - to improve quality
  - Each single defect counts (negatively)
  - Learning from failures and improving methods
  - Methods for defect detection are key
  - Clearly defined production procedures are to be strictly followed

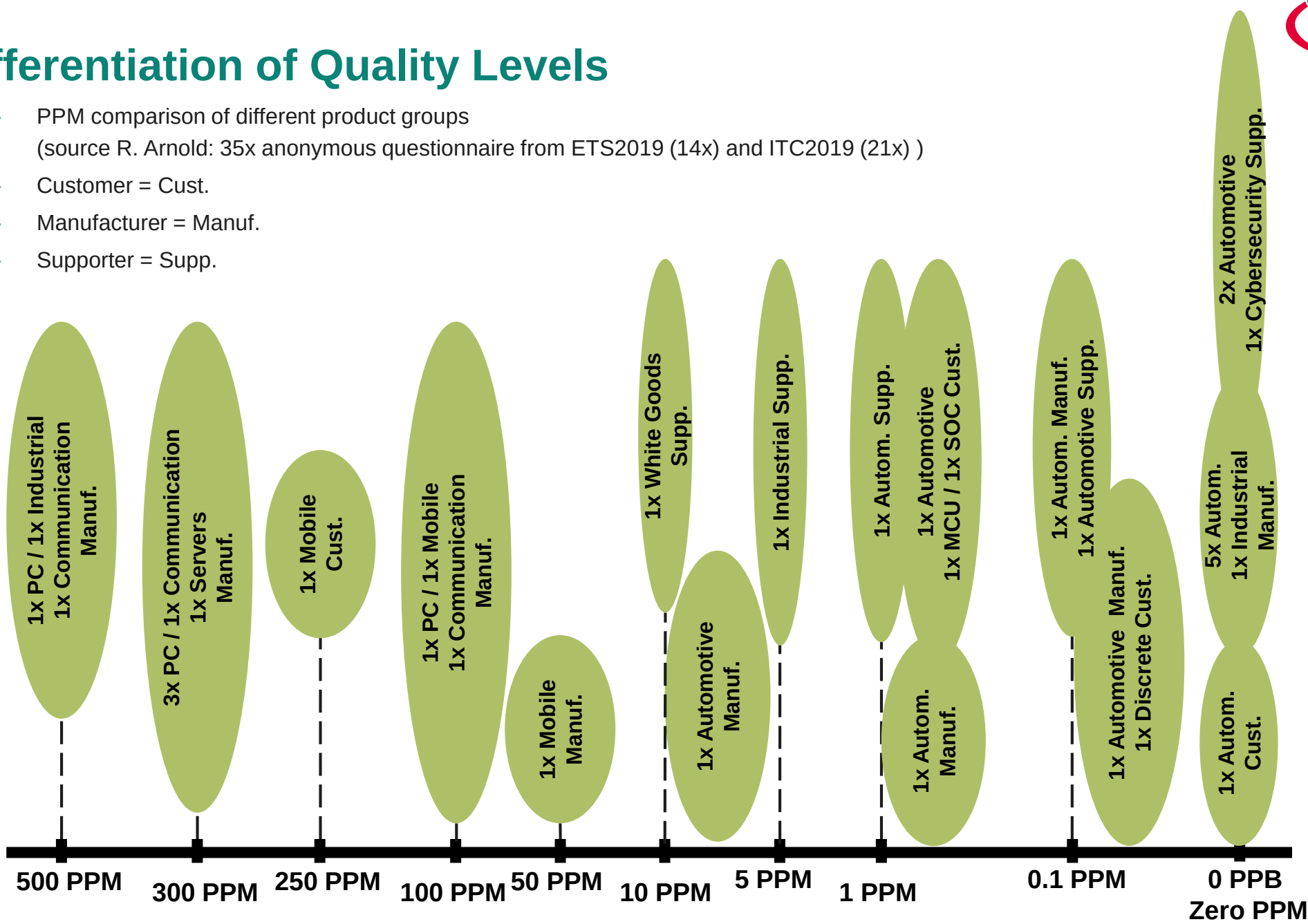
Quality vs. Safety

- ISO26262:
  - Ensures Car operation is safe in case of a fault
  - Independent of quality

- Quality takes care on Car application availability (Fit: Failure in time)
  - High Automotive Quality => high Car application availability
  - Low Quality => Car is often in the garage = high Fit - rate

Differentiation of Quality Levels

- PPM comparison of different product groups
  (source R. Arnold: 35x anonymous questionnaire from ETS2019 (14x) and ITC2019 (21x))
- Customer = Cust.
- Manufacturer = Manuf.
- Supporter = Supp.



Measures in Production

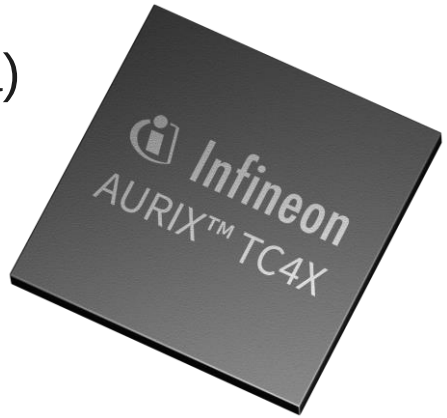
➔ Lead to Better Quality

- Production Measures to Ensure Quality
  - Defect Density Check
  - Outgoing Optical Inspection (OOI)
  - PCM Technology Parameters
  - Production Test incl. statistical safe guarding (e.g. Lot release criteria)
  - Incl. quality measures (e.g. statistical yield analysis)
  - Robust test methods (repeatability and reliability checking)

- Statistics statistics statistics

  => Big Data analysis to identify the enemies
  - Find maverick behavior
  - Root cause analysis of systematic yield loss

AURIX™ 1G



AURIX™ 3G

AURIX™ 2G

A Stringent Predefined Work Flow is a MUST

➔ Lead to Better Quality

- Products are developed, produced and managed according to ISO26262 Safety Standard
- Requirements Driven Development Flow (RDDF) is needed
- Change and Control Management prevents unstructured working style
- Release documents in revision controlled database
- Ask the specialist – required!
  - Specialist represents best state-of-the-art techniques
  - Specialist GO required

Measures in Development – for Tolerant Products

➔ Lead to Better Quality

- Technology: characterised and qualified for Automotive
- Layout: design rules for DfY, DfM, DfR
- Library: reliable library + memories => qualified Automotive Library
  ⇔ contradicting with area and speed optimized libraries that are used for „HIGH PPM“ e.g. Communication applications
- Design: verification, design, according to DfM, DfY, DfR rules
- Product:
  - Characterization + validation + qualification for High Automotive Quality
  - Characterization using silicon splits
  - Robustness check to detect weaknesses

3rd Party IP Module Integration - Our Expectation to IP Vendors

- Electrical Concept required for:
  - High Automotive Quality DFT / Production Test Concept
  - Verification (design), Characterization, Qualification (e.g. aging behavior), Validation and Customer Reject analysis

- IP module Pattern Interface required
  - Easy pattern generation / reuse

- Quality Requirement to the IP Module
  - Each module contributes to Failure Rate / Quality
  - E.g. @0.1 PPM and usage of 50 IP modules – does not support High Automotive Quality
  - Each module shall have max Failure Rate of 0.002 PPM
  - Bad testable IP Module can add up to 20 Parts Per Million

Q100 (AEC - Q100-007 Rev-B) September 18, 2007

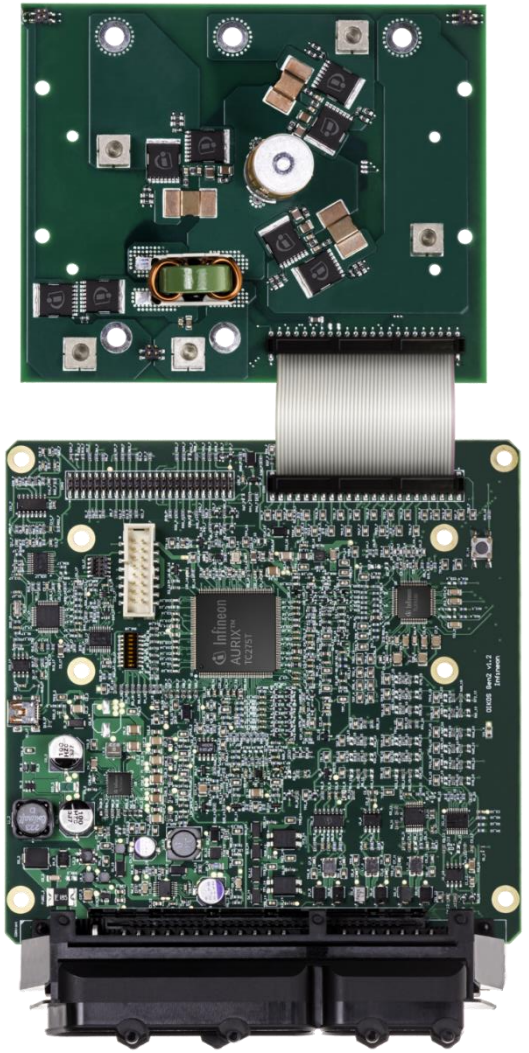
Section 6 “ACCEPTANCE CRITERIA”

- 100% of the devices are tested
- Analog circuits or analog circuit blocks of mixed mode circuits

  => 100% specification coverage
- Digital circuits of digital circuit blocks of mixed mode circuits

  >= 98% stuck-at test coverage

- Digital circuits of digital circuit blocks
  - >= 97% stuck-at test coverage
  - Acceptable IDDQ: reasonable target 70% TC
  - Transition Delay: reasonable target 80% TC



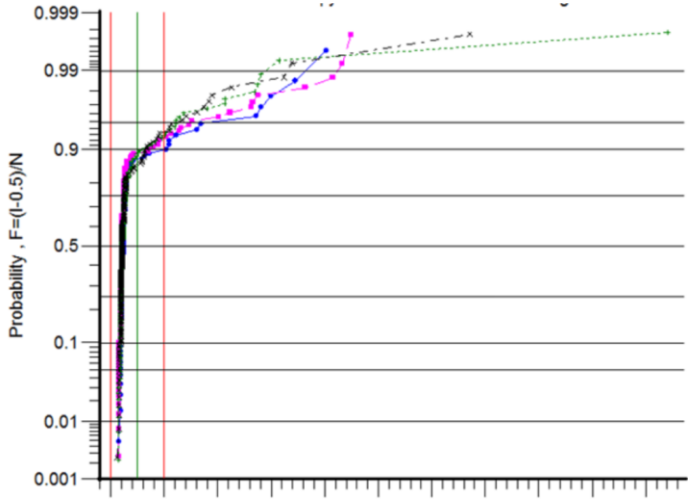
IEC61508-2 (2nd Ed.), Incl. ANNEX F (Table F.1) is used because ISO26262 has no dedicated test coverage targets***

Ref	Technique/Measure IEC61508-2 (ISO26262)	SIL 1 (ASIL A)	SIL 2 (ASIL B)	SIL 3 (ASIL C/D)	SIL4 (non automotive)
11	Design for testability (depending on the Stuck-At test coverage in percent)	>95%	>98%	>99%	>99%
27	Implementation of test structures	>95%	>98%	>99%	>99%
28a	Estimation of the test coverage by simulation (based on achieved test coverage in percent) **	>95%	>98%	>99%	>99%
28b	Estimation of the test coverage by application of ATPG tool (based on achieved test coverage in percent)*	>95%	>98%	>99%	>99%
44	Test coverage of the manufacturing test (see above)	>95%	>98%	>99%	>99%

* It is important to notice that the test coverage is limited to the circuit logic, which is covered by the scan-path. The modules such as memory, BIST or part of circuits that are not integrated in the scan-paths are not considered in the test coverage estimation
** E.g. using fault simulation (stuck-at fault model)
*** ISO26262-1 page V: “ISO 26262 is the adaptation of IEC 61508 to comply with needs specific to the application sector of electrical and/or electronic (E/E) systems within road vehicles. This adaptation applies to all activities during the safety lifecycle of safety-related systems comprised of electrical, electronic and software components.”

High Automotive Quality Testing – State of the Art Methods

- Quality tests (e.g. Burn-In, IDDQ) ➔ **Lead to Better Quality**
- Guardbanding (e.g. freq, voltages) ➔ **Lead to Better Quality**
- IDDQ Diagnosis to improve yield and finally quality

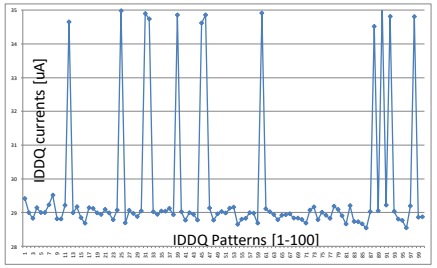


Physical analysis showed poly structuring fault

⇒ Lead to technology improvement

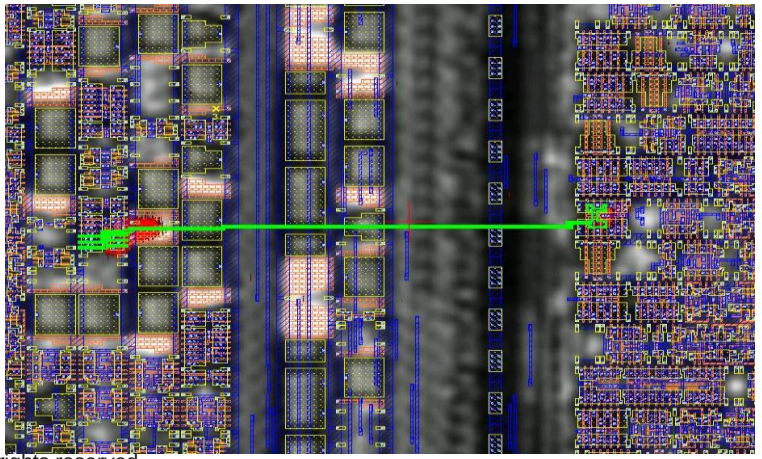
⇒ **Lead to better yield and therefore Better Quality**

- See also publication on IDDQ Diagnosis: „Deterministic IDDQ Diagnosis Using a Net Activation Based Model";
  A. Kun, R. Arnold; Paper 15.3.; ITC2011

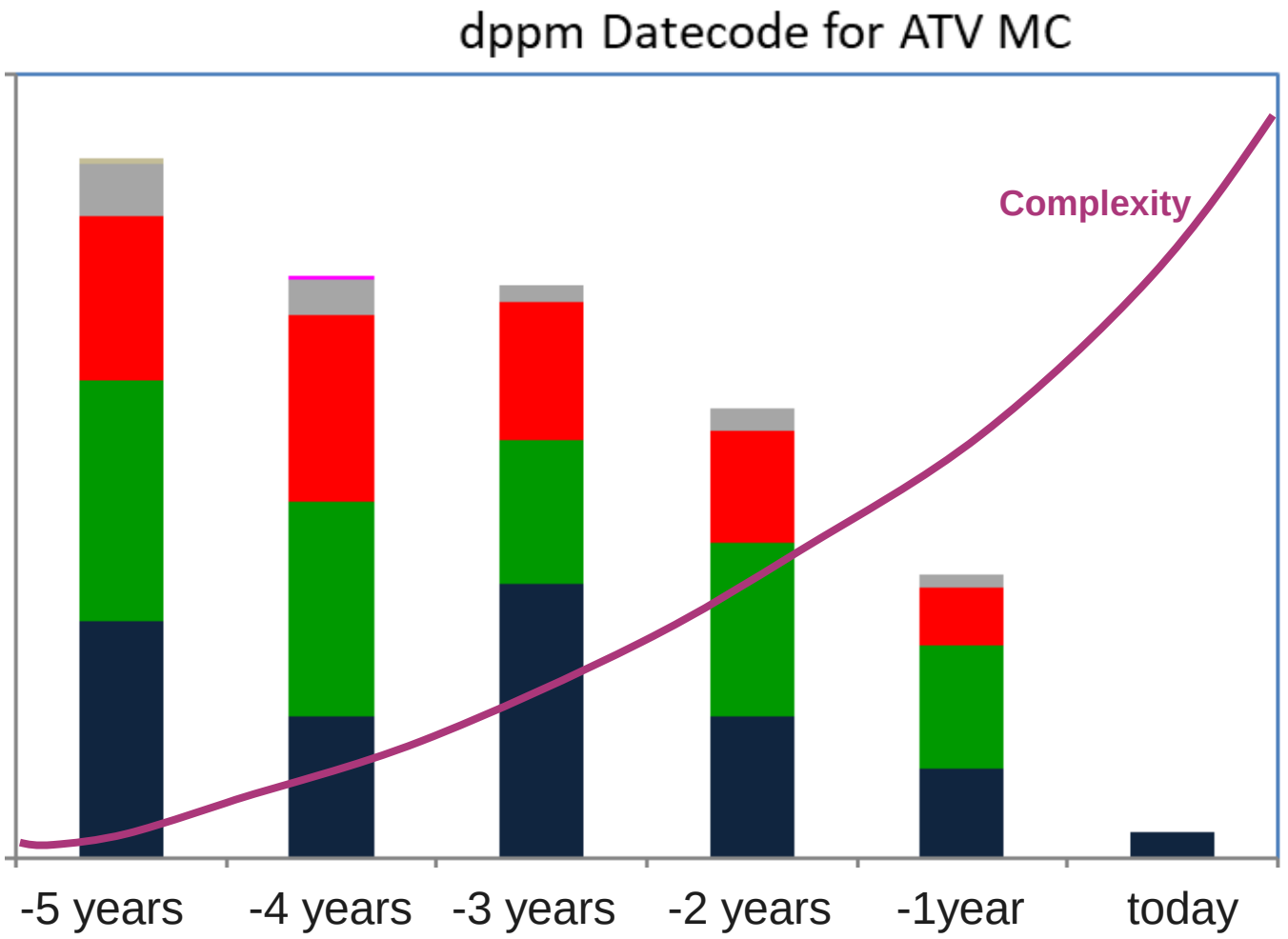


IDDQ Diagnosis

Lead to Better Quality



DPPM Development over Time shows
THE „High Automotive Quality Trend“



- Zero PPM Mind Set
- Learning from Failures Philiosophy
- Lot of effort and experience needed to deliver real **„High Automotive Quality Level“**
- Mature Library, Technology, DFT and Test Concept mandatory
- MUST follow stringent predefined Work Flow – Development and Production

Thanks for your attention!

Questions?


infineon