

# Future Vehicle Evolution and Automotive Functional Safety



## Reliability and Functional Safety

The 6th IEVE 2019

May 9-10, 2019, ICC JEJU Korea

The number '00' is displayed in a white, bold, sans-serif font, enclosed within a white circular border. The background of the slide is a dark, blue-tinted image of a car's interior, overlaid with various circular icons representing automotive technology such as a car, a Wi-Fi signal, a location pin, a smartphone, and a traffic light.

# Opening Remark

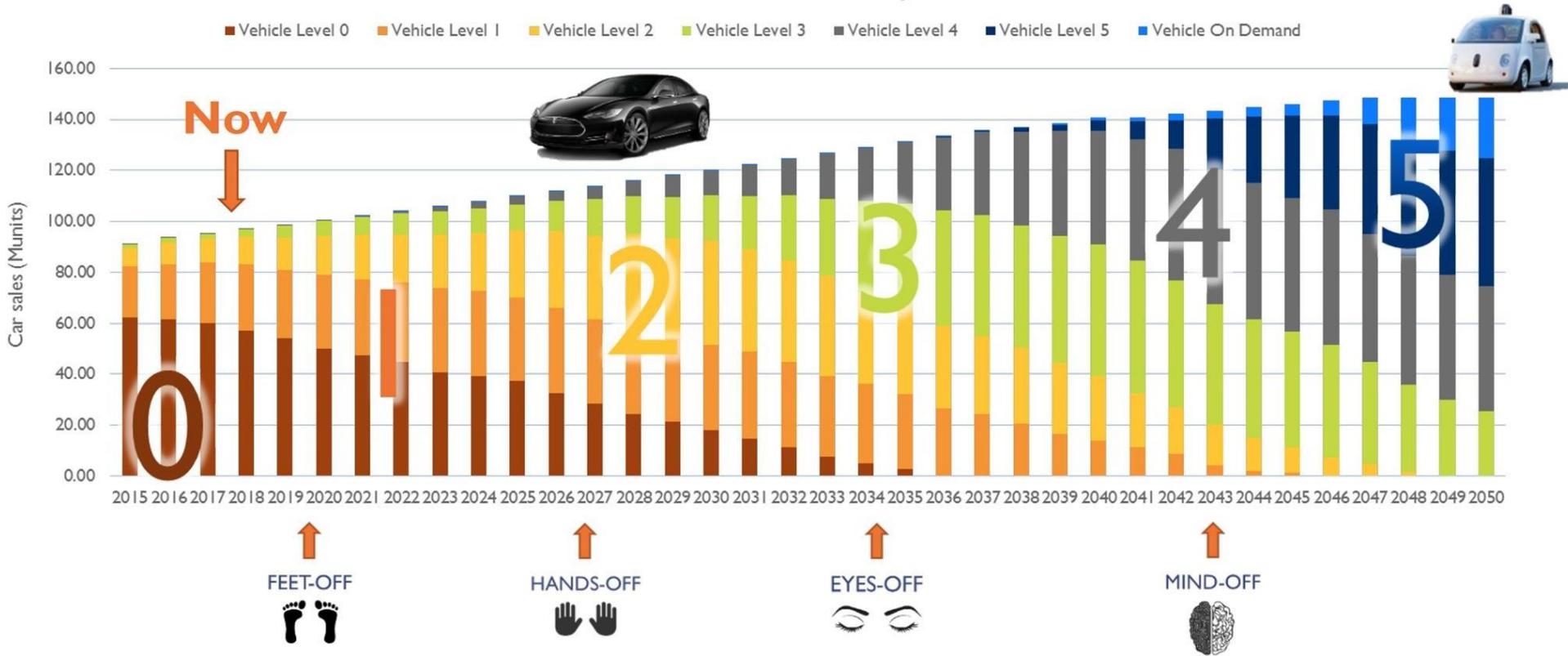


The background of the slide is a dark, blue-tinted image of a car's interior, showing the dashboard and steering wheel. Overlaid on this are several circular icons connected by a network of lines, representing various automotive systems such as navigation, engine performance, and safety. A large, white, circular graphic containing the number '01' is positioned on the left side of the text.

# 01 Advancement of Automotive System

# Toward Fully Autonomous Vehicle

Potential evolution of autonomous car sales by level of automation



Source: Smart Automotive – Latest Trends in LiDAR and Sensors – SEMICON Dec 2017

# From Fail Safe to High Dependability

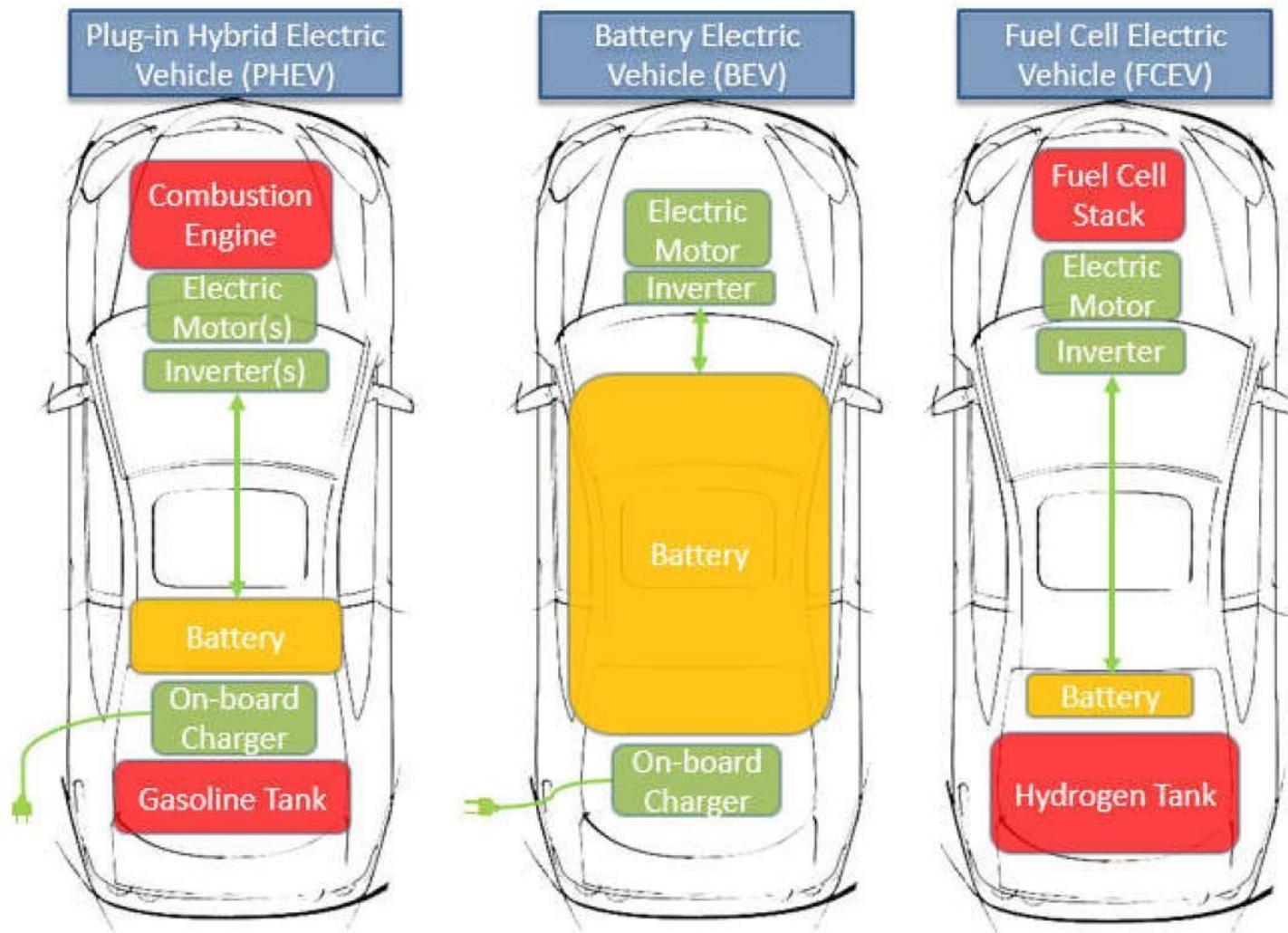


ISO 26262, SOTIF and C-ITS drive highly dependable vehicle

The background of the slide is a dark, blue-tinted image of a car's interior, showing the dashboard and steering wheel. Overlaid on this image are several semi-transparent circular icons representing various automotive technologies: a traffic light, a car, a location pin, a smartphone, a car with a signal wave, and a car with a gear. A large, white-outlined circle on the left side of the text contains the number '02'.

# 02 Full Electric and Connected Vehicle

# Full Electric Drive Vehicle System Layouts



Source: U.S. DRIVE (Driving Research and Innovation for Vehicle efficiency and Energy sustainability), "Electrical and Electronics Tech Team Roadmap"

# Future Vehicle Data Requirement

## Autonomous car data vs. human data

In 2020, the average autonomous car may process 4,000 gigabytes of data per day, while the average internet user will process 1.5 gigabytes.

### THE COMING FLOOD OF DATA IN AUTONOMOUS VEHICLES

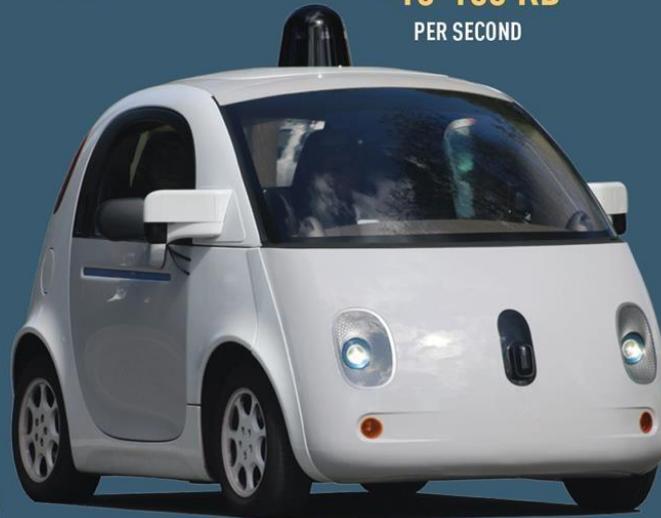
RADAR  
**~10-100 KB**  
PER SECOND

SONAR  
**~10-100 KB**  
PER SECOND

GPS  
**~50 KB**  
PER SECOND

CAMERAS  
**~20-40 KB**  
PER SECOND

LIDAR  
**~10-70 MB**  
PER SECOND



AUTONOMOUS VEHICLES  
**4000 GB**  
PER DAY... EACH DAY

**1 autonomous car = 2,666 internet user**

Source: Intel

# Evolution of Megacities: Key Smart Cities: 2009 -2025



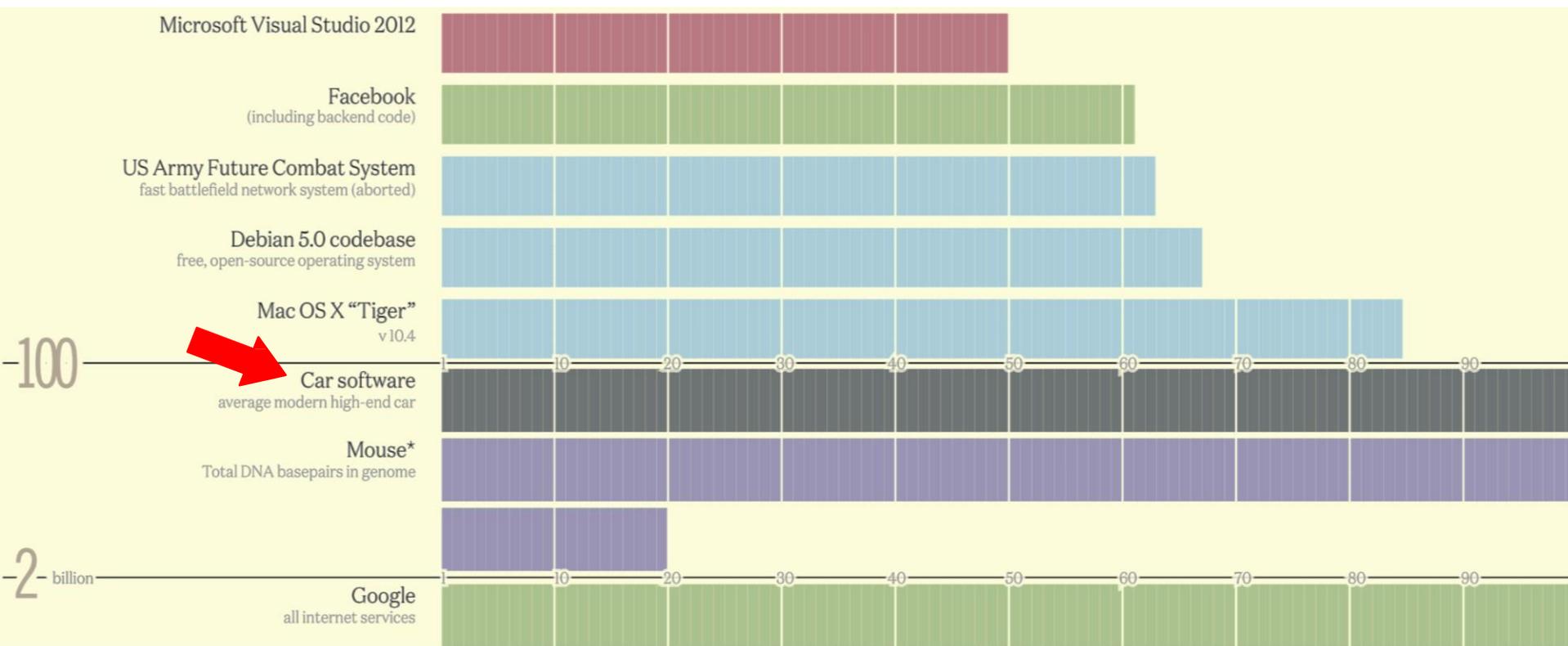
- Legend**
- ★ Cities built from scratch
  - ★ Existing eco cities
  - ★ Existing eco megacities

Source: Sarwant Singh Partner, Frost & Sullivan, "360 Degree Perspective of the Global Electric Vehicle Market Opportunities and New Business Models"

# 152 million connected cars by 2020

Automotive industry needs to be prepared for 4 TB of data being generated by every car every day

Brian Krzanich, CEO of Intel Corporation



Source: <https://informationisbeautiful.net/visualizations/million-lines-of-code/>

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# 03 Advancement of Device Technology

# Moore's Law

*"The number of transistors and resistors  
on a chip doubles every 24 months"*  
-Gordon Moore

TECHNOLOGY AND MANUFACTURING DAY



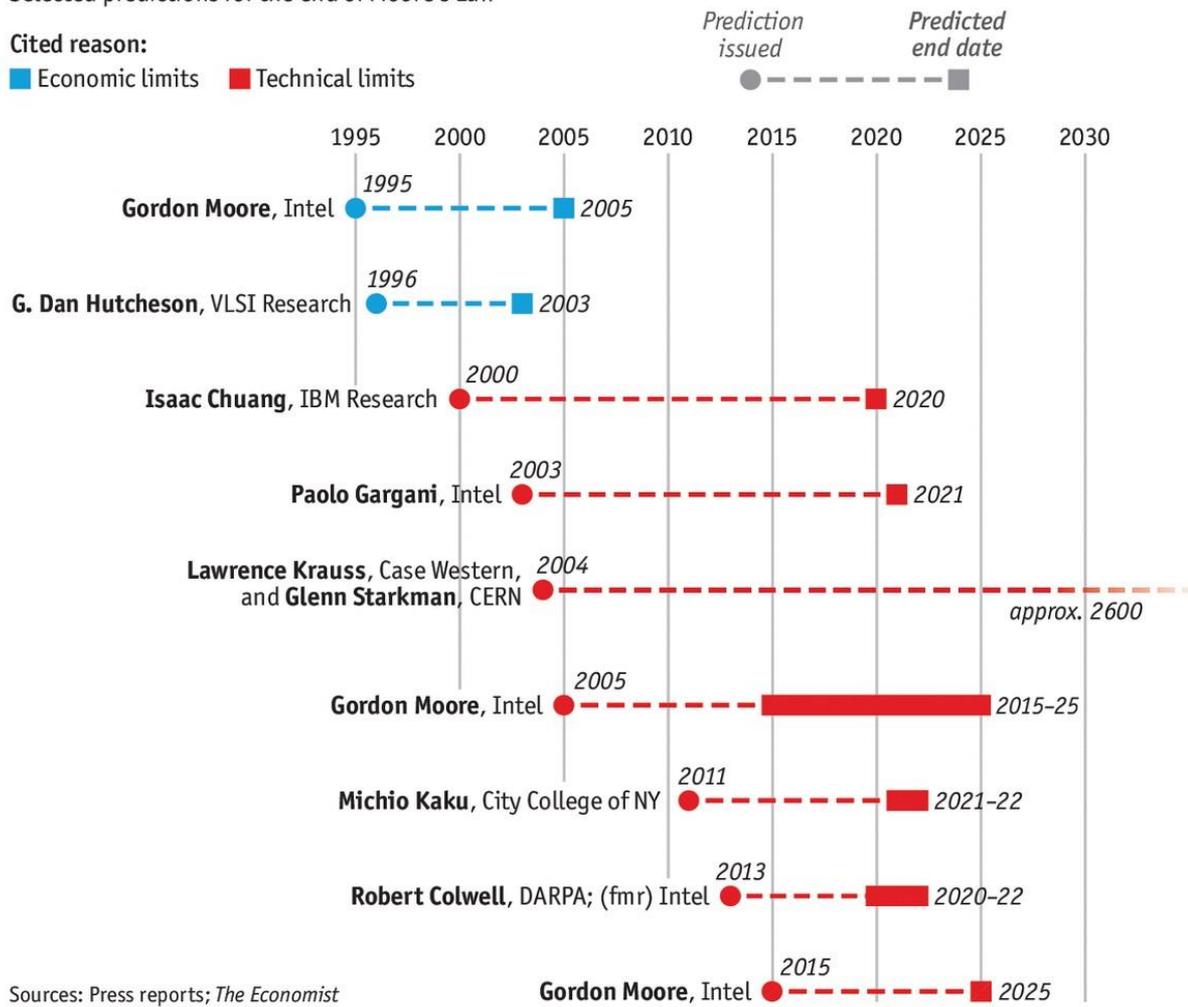
# Faith No Moore

## Faith no Moore

Selected predictions for the end of Moore's Law

Cited reason:

- Economic limits
- Technical limits



Sources: Press reports; *The Economist*

Economist.com

# Intel: EUV-Enabled 7nm Process

EUV estimated demand per fab by market  
Range of layers and corresponding systems per fab<sup>1</sup>

Market	Fab Capacity (kwspm <sup>2</sup> )	EUV layers	EUV systems/fab
Logic (7nm - 5nm)	45	10 - 20	10 - 20
DRAM (16nm - 1Anm)	100	1 - 6	2 - 10

#### Logic EUV capacity:

1 EUV layer requires 1 EUV system for every 45k wafer starts per month

#### DRAM EUV capacity:

1 EUV layer requires 1.5 to 2 EUV systems for every 100k wafer starts per month

<sup>1</sup> "Typical" process and system conditions in the 2018-2022 timeframe, not specific customer condition

<sup>2</sup> kwspm: x1000 wafer starts per month

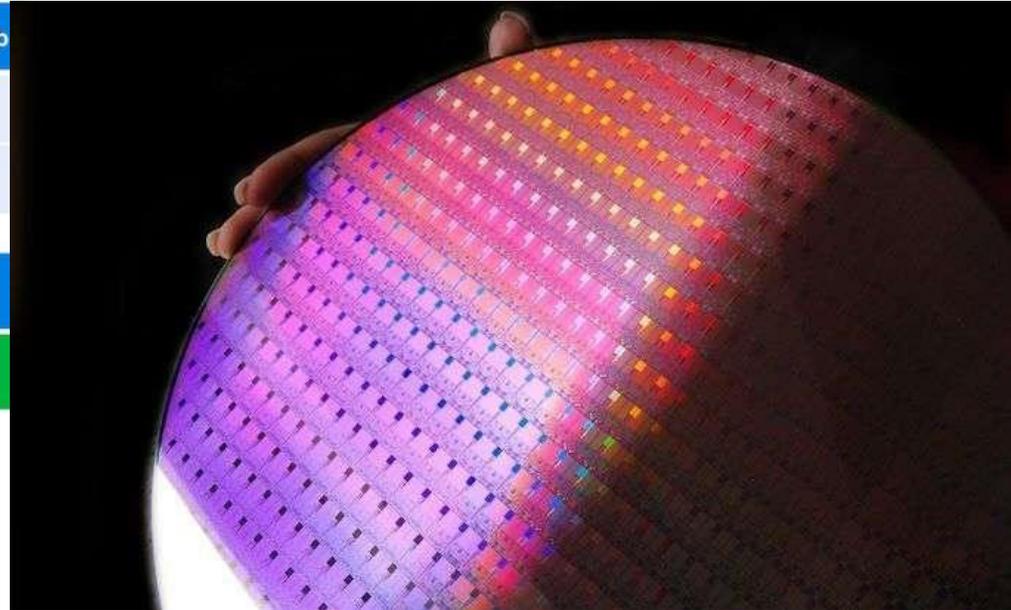
## Extreme Ultraviolet Lithography (EUVL) Demand

We are quite pleased with our progress on 7 nm. In fact, very pleased with our progress on 7 nm.

Murthy Renduchintala, chief engineering officer & president of technology



Dec. 6, 2018

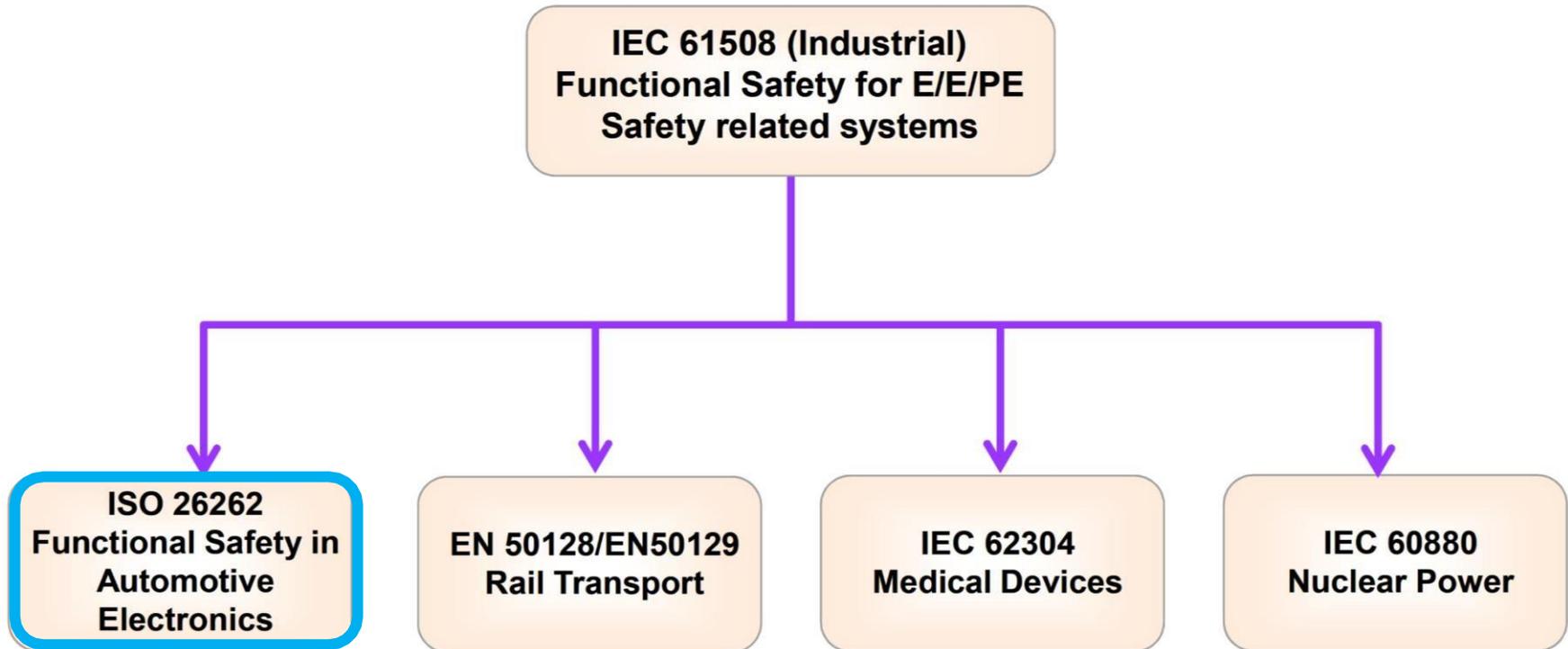


The background of the slide is a dark, blue-tinted image of a car's interior, showing the dashboard and steering wheel. Overlaid on this are several semi-transparent circular icons representing various automotive technologies: a traffic light, a car, a Wi-Fi signal, a location pin, a smartphone, and a car's front view. A large white circle on the left contains the number '04'.

# 04 ISO 26262 Overview

# ISO 26262 Genealogy

**ISO 26262 is an adaptation of IEC 61508 for the automotive industry**



# IEC 61508, ISO/PAS 19451 and ISO 26262

IEC 61508	ISO 26262
<b>Part 1:</b> General requirements	Part 1: Vocabulary
<b>Part 2:</b> Requirements for electrical/electronic/ programmable electronic safety-related systems	Part 2: Management of functional safety Part
<b>Part 3:</b> Software requirements	Part 3: Concept phase
<b>Part 4:</b> Definitions and abbreviations	Part 4: Product Development: System Level
<b>Part 5:</b> Examples of methods for the determination of safety integrity levels	Part 5: Product Development: Hardware Level
<b>Part 6:</b> Guidelines on the application of parts 2 and 3	Part 6: Product Development: Software Level
<b>Part 7:</b> Overview of techniques and measures	Part 7: Production and Operation
	Part 8: Supporting Processes
	Part 9: ASIL-orientated & safety-oriented analysis
	Part 10: Guideline
<b>ISO/PAS 19451</b>	Part 11: Guideline for semiconductors

# Comparison of each revision

Chapter	Revision 1	Revision 2	FDIS 02-26-2018	Final Version Dec 2018
Ch 1	23	46	47	33
Ch 2	26	55	51	45
Ch 3	25	34	36	28
Ch 4	36	43	42	34
Ch 5	76	92	93	90
Ch 6	40	68	71	57
Ch 7	11	18	20	14
Ch 8	48	66	66	60
Ch 9	16	37	38	29
Ch 10	89	80	85	79
Ch 11		182	179	179
Ch 12				42
<b>Total Pages</b>	<b>390</b>	<b>769</b>	<b>728</b>	<b>690 pages</b>

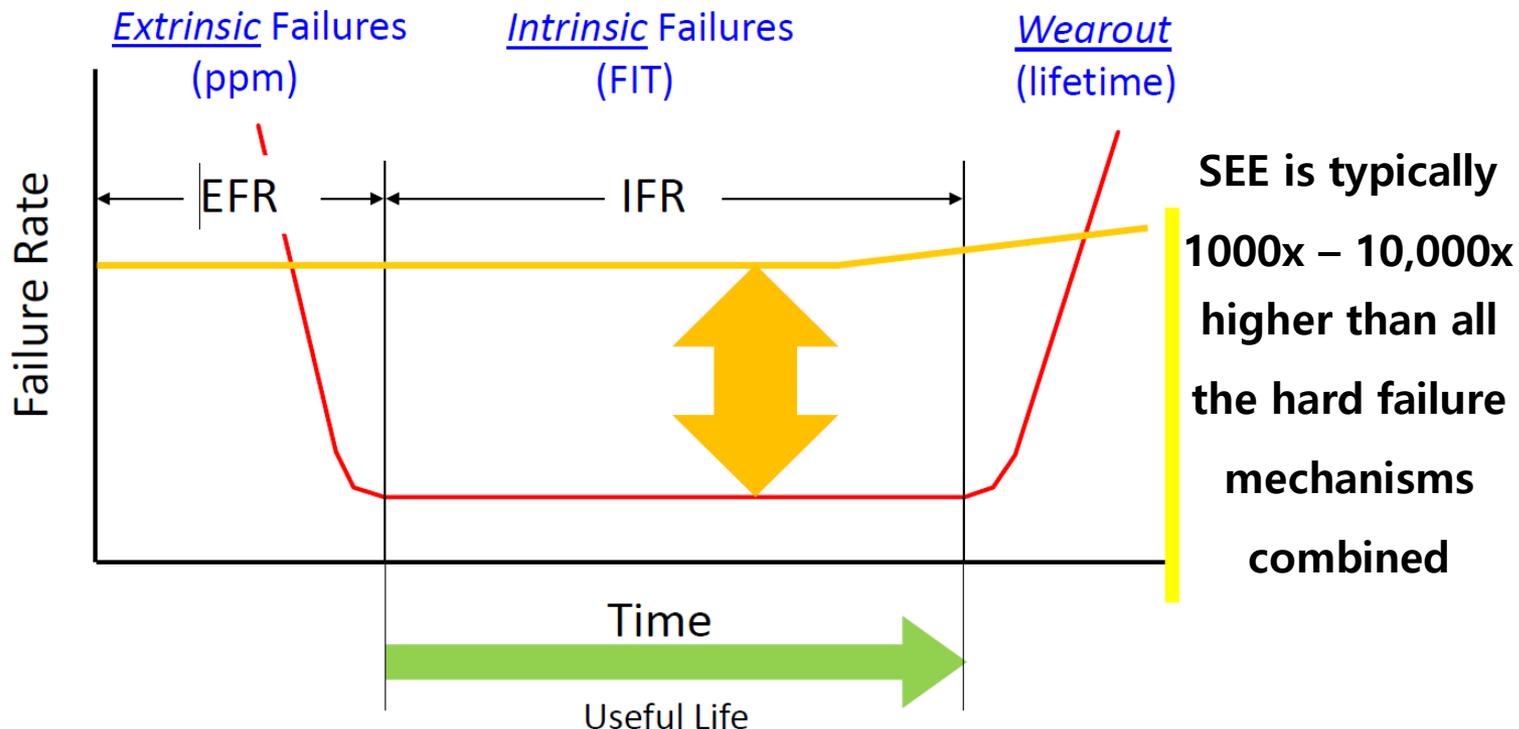
The background of the slide is a dark, semi-transparent image of a car's interior, showing the dashboard and steering wheel. Overlaid on this are several circular icons representing various automotive systems: a traffic light, a car, a location pin, a car with a checkmark, and a car with a warning light. A large, white-outlined circle on the left contains the number '05'.

# 05 Impact of Soft Error (Transient Fault)

# Soft error rate in modern devices

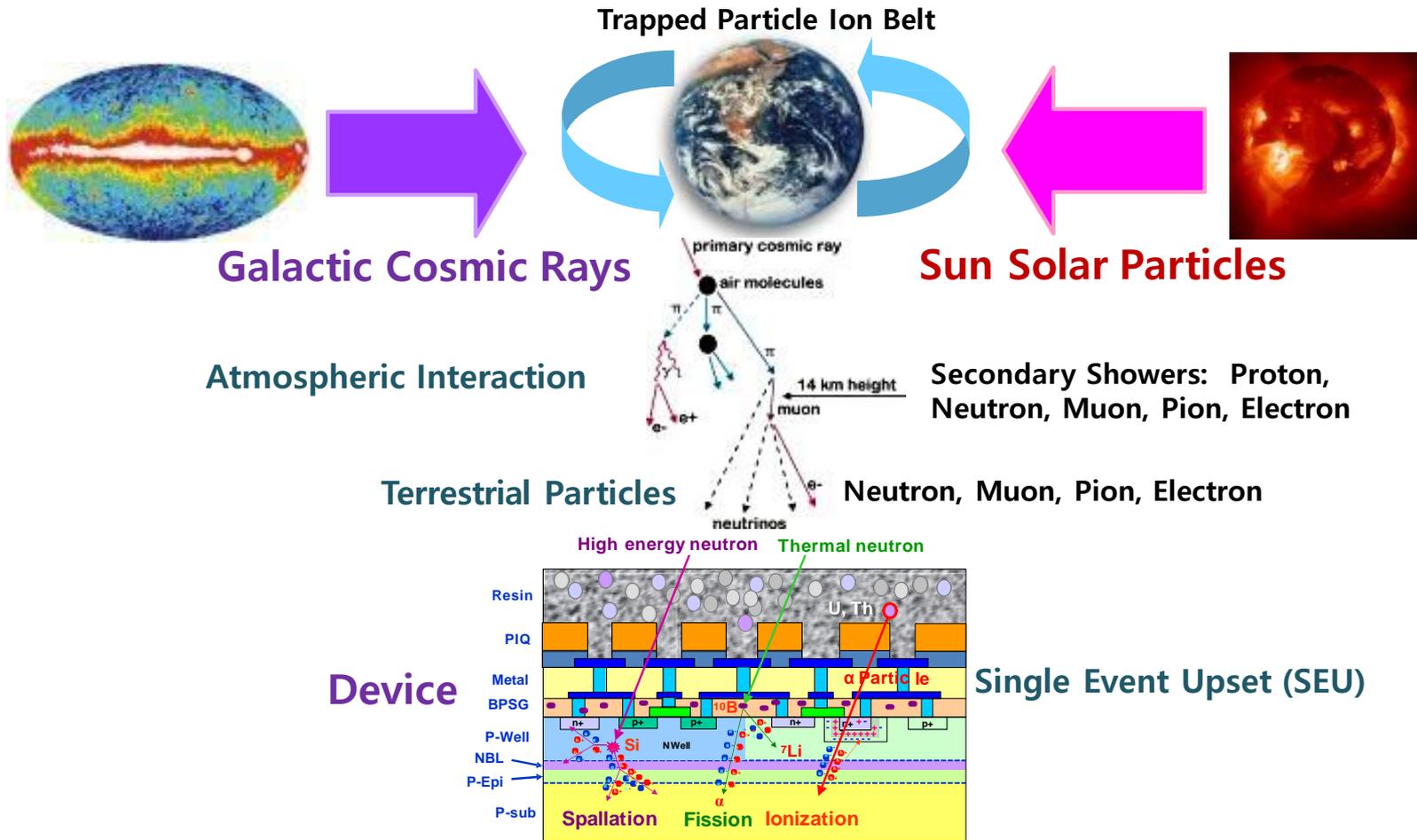
“Soft errors induce the **highest failure rate of all other** reliability mechanisms combined.” Baumann, Robert.

“Thus, one could postulate that there will be a cross-over point where **SET induced error rates will exceed the traditional SEU error-rates**” Kenneth La Bel



After Robert C. Baumann, “LANDMARKS IN TERRESTRIAL SINGLE-EVENT EFFECTS” IEEE 50<sup>th</sup> 2013 NSREC Short-Course

# How Does Soft Error Happen



The background of the slide is a dark, semi-transparent image of a car's interior, showing the steering wheel, dashboard, and center console. Overlaid on this image are several circular icons in a light blue color, representing various automotive systems and components such as a traffic light, a car, a location pin, a gear, and a person's head. The text '06 ISO26262 Language and Transient Fault' is prominently displayed in the center in a large, white, sans-serif font. The number '06' is enclosed within a white circular border.

# Definition: Error

- 3.46 **Error**: discrepancy between a computed observed or measured value or condition, and the true, specified or theoretically correct value or condition
  - Note An error can arise as a result of a fault (3.54) within the system (3.163) or component (3,21) being considered
- 3.50 **Failure**: termination of an intended behavior of an element (3.41) or an item (3.84) due to a fault (3.54) activation
- 3.109 **Permanent Fault**: fault (3,54) that occurs and stays until removed or repaired
- 3.173 **Transient Fault**: fault (3.54) that occurs once and subsequently disappears
  - Note: Transient fault can appear due to electromagnetic interference, which can lead to bit-flips. Soft errors such as Single Event Upset (SEU) or Single Event Transient (SET) are Transient faults.

# Transient Fault Types

- **Single Event Transient (SET):** A momentary voltage excursion (e.g. a voltage spike) at a node in an integrated circuit caused by the passage of a single energetic particle
- **Single Event Upset (SEU):** A soft error caused by the signal induced by the passage of a single energetic particle
- **Single Bit Upset (SBU):** A single storage location upset from a single event
- **Multiple Cell Upset (MCU):** A single event that induces several bits in an IC to fail at the same time. The error bits are usually, but not always, physically adjacent
- **Multiple Bit Upset (MBU):** Two or more single-event-induced bit errors occurring in the same nibble, byte, or word. An MBU could be not corrected by a simple ECC (e.g. a single-bit error correction)
  1. **SET, SEU, SBU, MCU** and **MBU** are typically indicated as "soft errors".
  2. **Transition faults** and similar timing related phenomena are considered when relevant for the specific.
  3. **Some fault models** can have the same effect as other fault models and therefore can be detected by the same safety mechanism. (**masking, derating**) An appropriate justification is provided to show that correspondence.

The text '07 Summary' is displayed in a large, white, sans-serif font. The number '07' is enclosed within a white circular outline. The background of the slide is a dark, blue-tinted image of a car's interior, overlaid with a network of white lines and various circular icons representing automotive technology such as a car, a Wi-Fi signal, a location pin, a smartphone, and a traffic light.

# ISO26262 is here for functionally safe vehicle design

## ISO 26262



**Soft Error Rate Evaluation becomes a  
Normative Requirement of ISO26262**

# So What's the problem for Future Safer Cars

- All current & future components must be **tested for SER**
  - Test facilities & services will be **over loaded** as the industry start to implement ISO 26262 compliance for E/E parts
- Auto industry will face very steep **SEE Learning Curve**
  - The standard defines SEU induced soft error as the **Transient Fault**
  - Many believes **Intrinsic Error Rate >> Extrinsic Error Rate**
  - Majority of automotive component suppliers don't believe that the neutron can impact automotive safety
  - Alpha impacts shall be quantified and minimized for future nodes
- Following terms need more clarification in the Standard
  - **SER Derating & Masking Method**
  - **Architectural Vulnerability Factor** analysis & respective derating
- We all wants **Safer Car** but the workers are few
  - We need more talent pool
  - We need more focus group to work on reliability and functional safety

# Q & A

