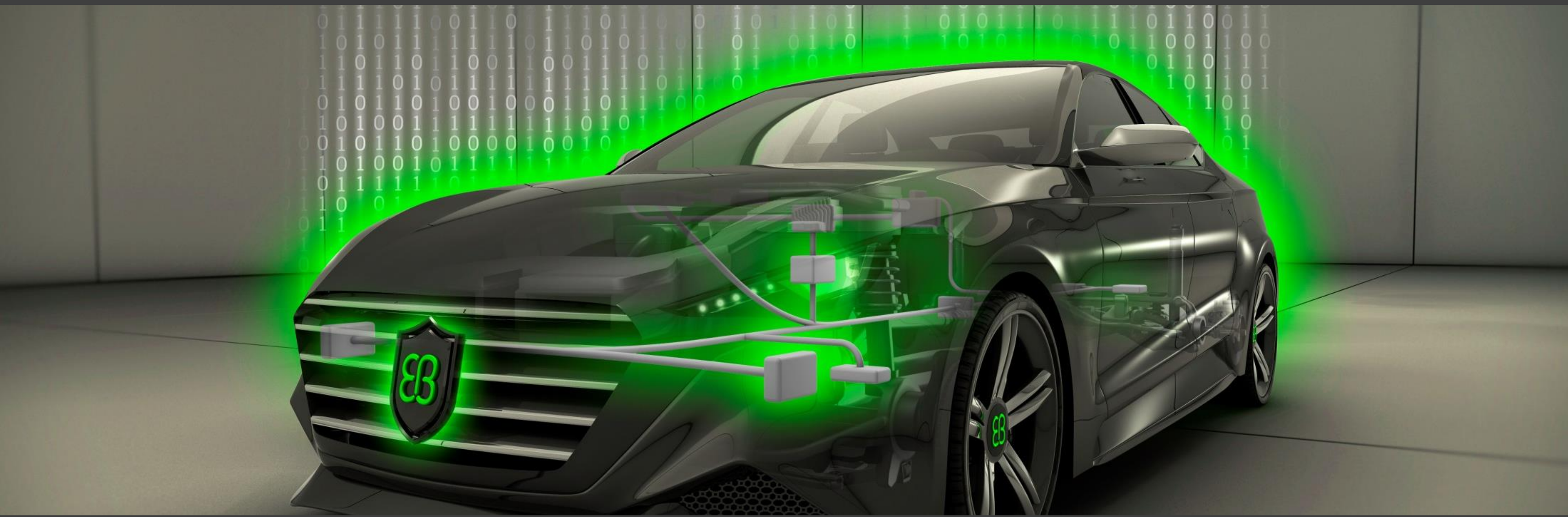
The Safe State: Design Patterns and Degradation Mechanisms for Fail-Operational Systems

Elektrobit

Alexander Much
2015-11-11

safetronic.2015
www.safetronic-congress.com



Agenda

- About EB Automotive
- Motivation
- Comparison of different architectures
- Concept for an 1oo2D software systems
- Summary

EB: Software and Services

Infotainment

Connected navigation software

- HMI tools for in-dash, digital instrument clusters and head-up displays
- Global software integration and engineering services

Connected

- Connected experiences around urbanization and electrification
- Online diagnostics
- Software and content updates

In-Car Infrastructure

- EB tresos – integrated software and tools, based on AUTOSAR standards
- **Solutions for: operating systems, middleware, dependable communication**
- **Solutions for high integrity systems: reliability, functional safety and security**
- Test & simulation

Driver Assistance

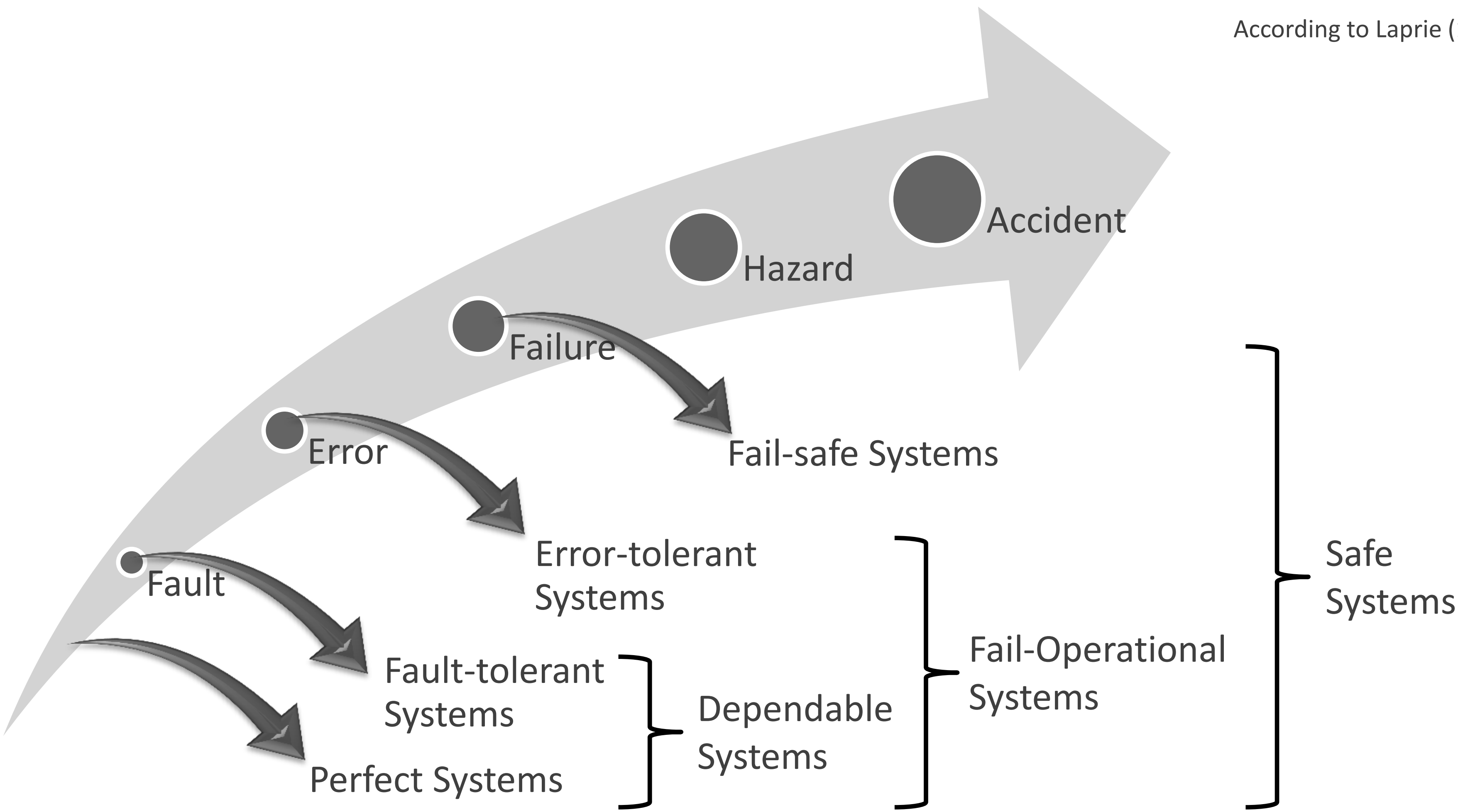
- Software development for driver assistance functions
- Electronic horizon and test drive recording solutions
- Driver assistance algorithms and functions

Agenda

- About EB Automotive
- Motivation
- Comparison of different architectures
- Concept for an 1oo2D software systems
- Summary

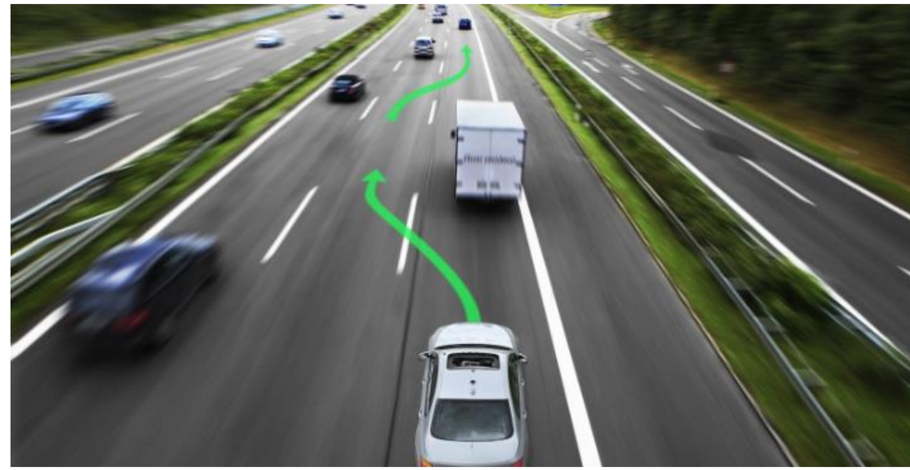
Different Types of Systems

According to Laprie (1992)



Current Automotive Systems are Fail-Safe

Failure Detected?



- Deactivate / degrade function
  → Safe State
- Inform the driver
- Report a diagnostic error

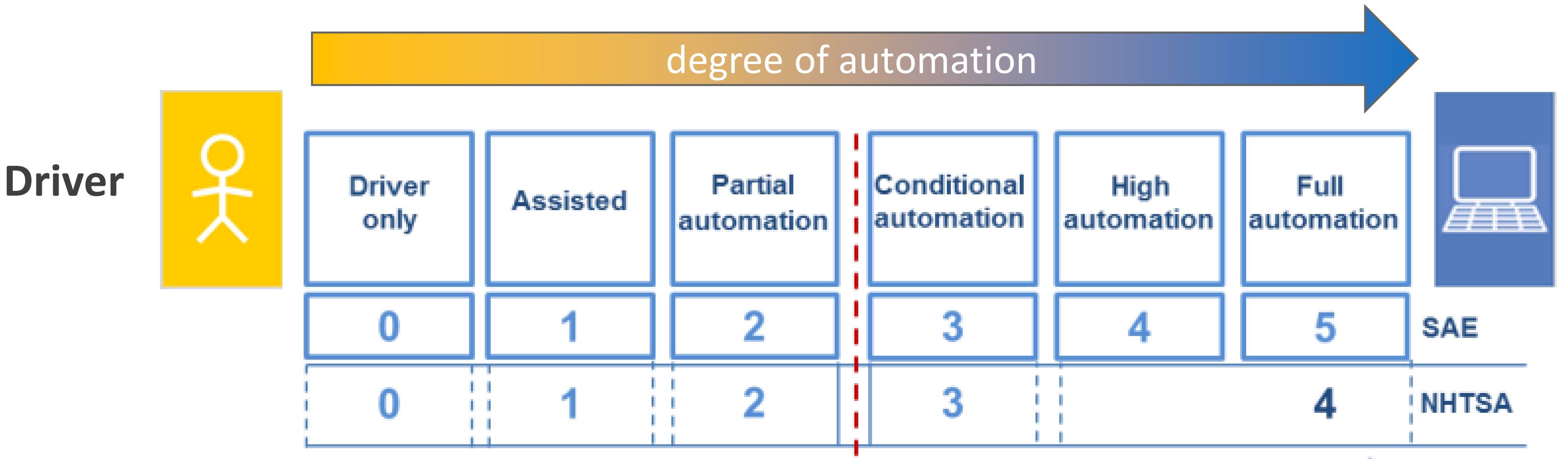
Standard approach in many safety relevant systems:

- Airbag, ESP, air conditioning, battery charging, …
- Driver assistant functions such as adaptive cruise control, lane assist, …

Some functions provide a degraded mode, sometimes limited in time:

- Electronic Power Steering
- Braking

Levels of Autonomous Driving (AD)



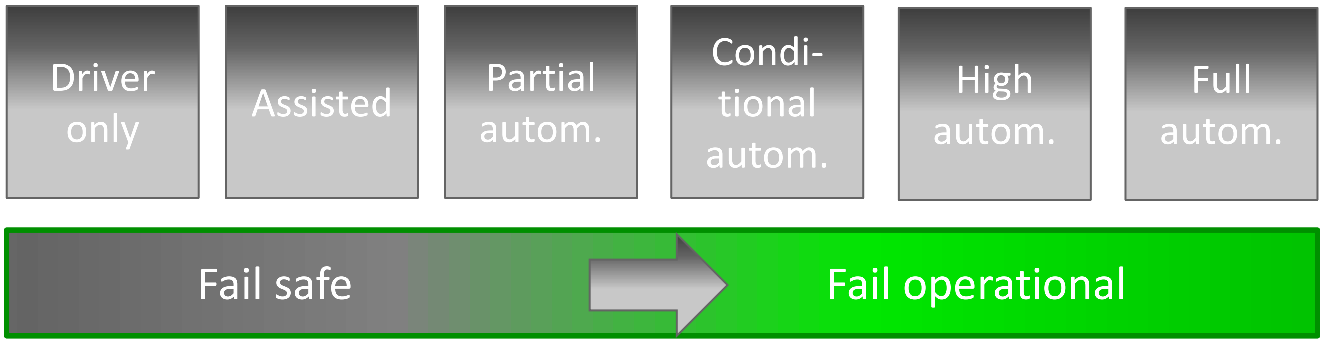
driver in the loop	yes (required)			not required		
time to take control back	-	~ 1s		several seconds	couple of minutes	
other activities while driving	not allowed			specific	all (even sleeping)	
examples	FCW, LDW	ACC, LKA	Traffic Jam Assistant	Highway Chauffeur	Valet Parking	Robot car

FCW … Forward Collosion Warning
LDW … Lane Departure Warning

ACC … Adaptive Cruise Control
LKA … Lane Keeping Assistant

Source: SAE, NHTSA, VDA

Goal: Autonomous driving



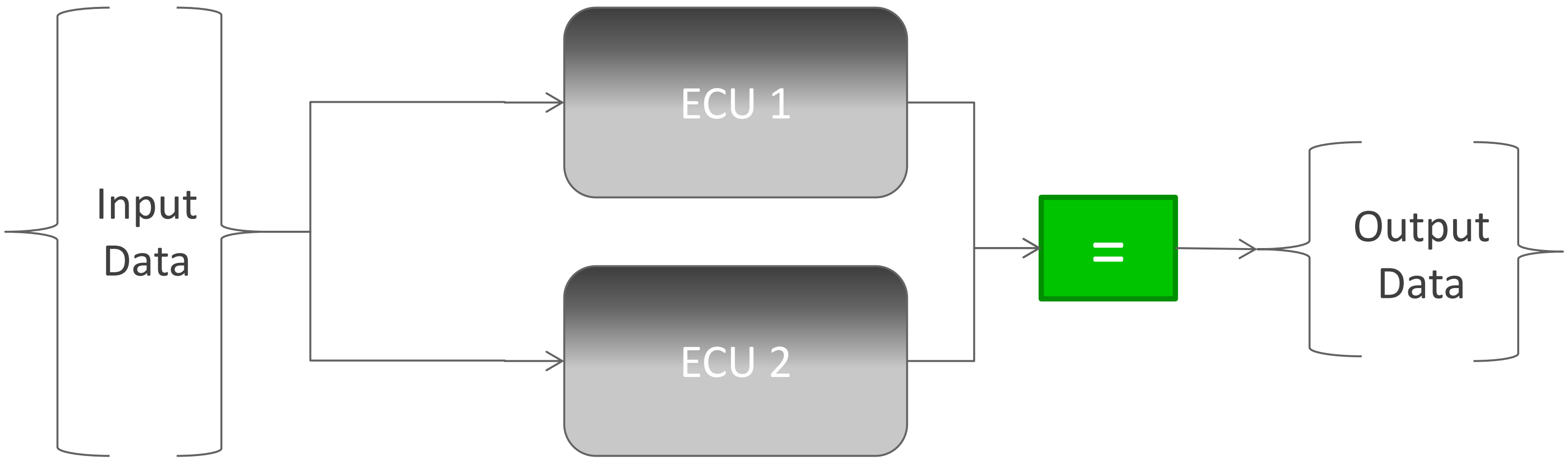
Safe State could mean:

- Continue driving until driver is in the loop
  - approx. 7-15s for conditional autonomous driving
  - Several minutes for high and full autonomous driving
  - **Precondition**: driver monitoring including a black-box
- Perform an autonomous „safe-stop“ (stand-still at a non-hazardous place)
  - Main issue is to get the driver attention focused on the situation
  - Several minutes, depending on the situation
  - **Precondition**: legal acceptance, approved and certified black-box

Agenda

- About EB Automotive
- Motivation
- Comparison of different architectures
- Concept for an 1oo2D software systems
- Summary

2 channels with comparison

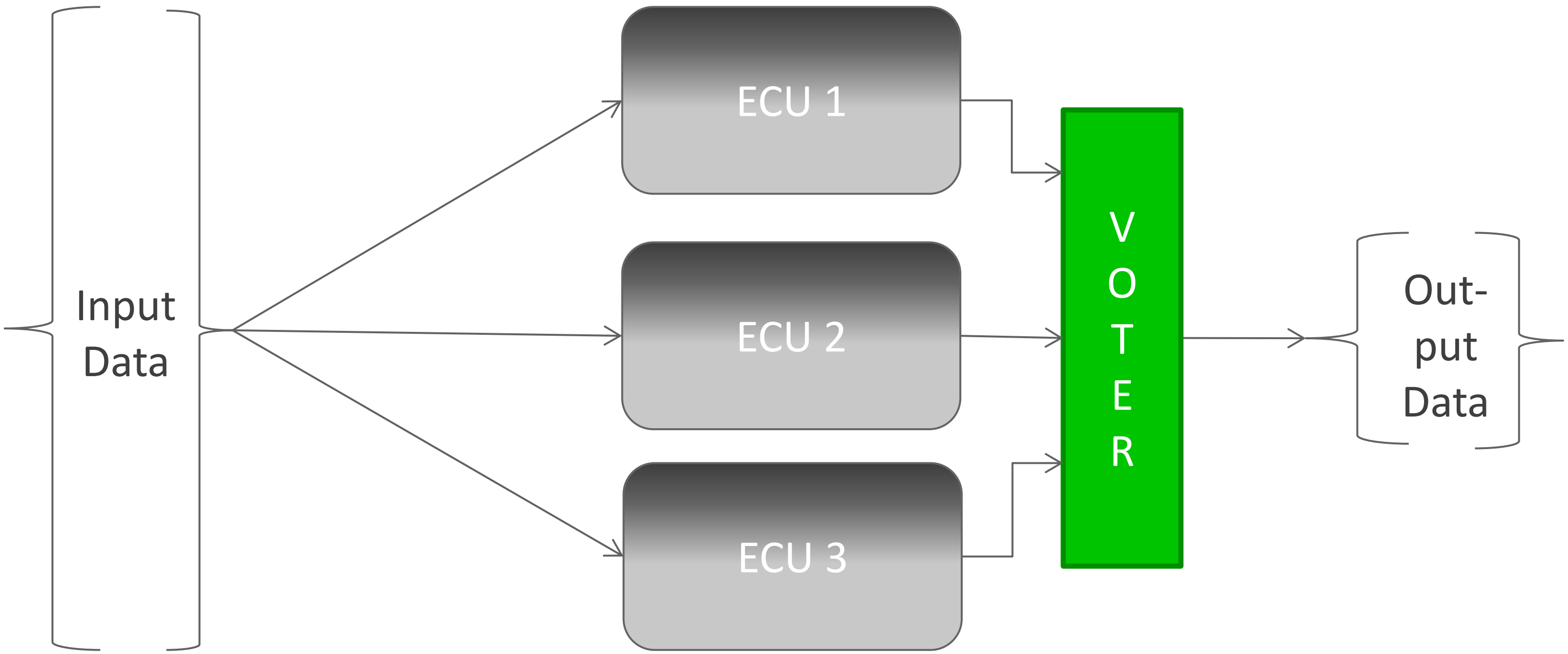


Redundant ECUs calculate using redundant data, output is compared.

A 2 channels with comparison system is fail-safe since you cannot distinguish between "ECU1 not ok" and "ECU2 not ok".

The safe state is a complete system shutdown.

2oo3 Systems



Three redundant ECUs calculate on redundant data, output data is voted upon

If one of the ECUs fails the system can continue with the remaining two ECUs.

Failures in the input data can be detected by an “Input-Voter”.

2oo3 Systems and the Automotive Domain

Applicable for automotive?

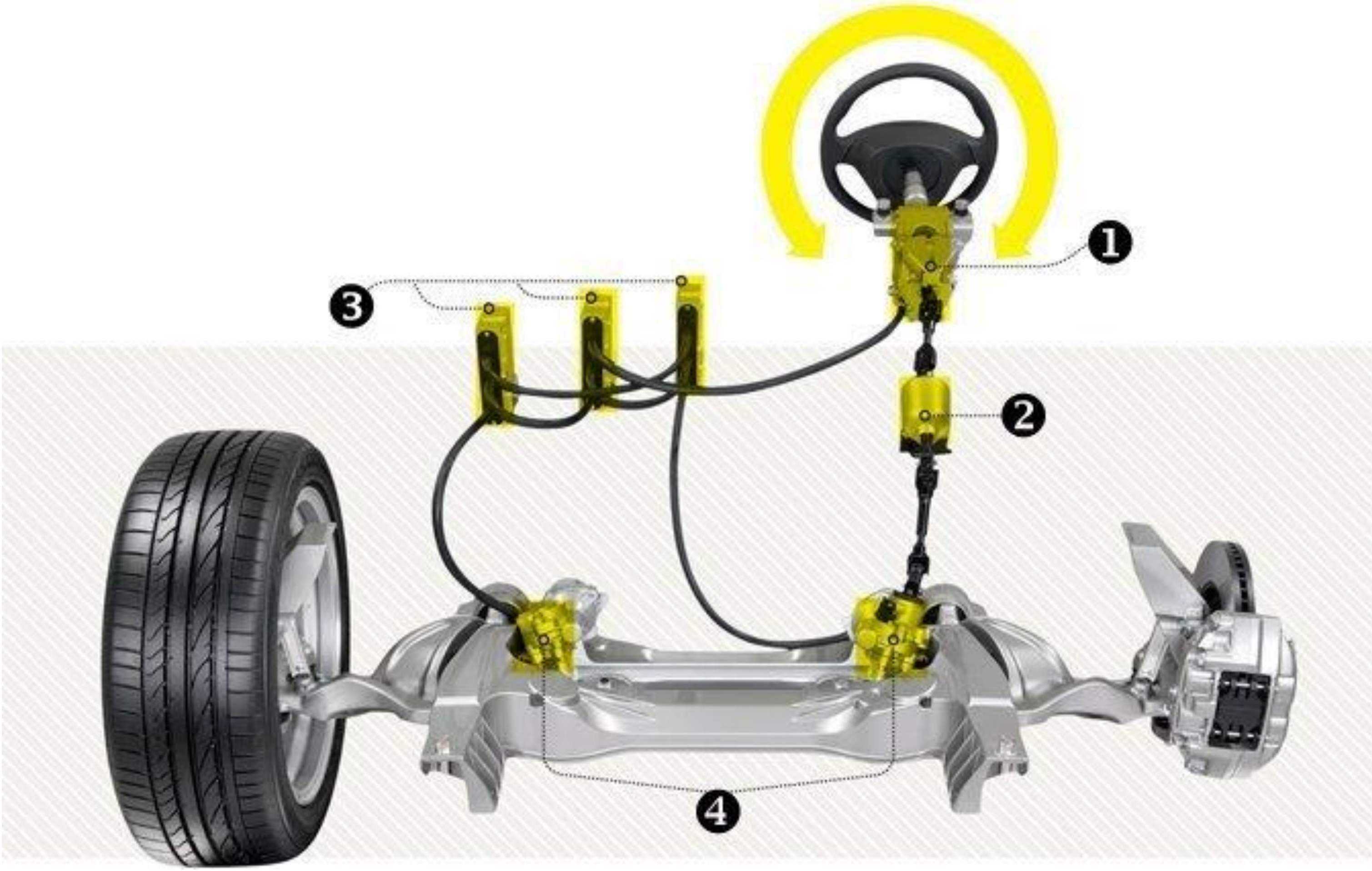
- More ECUs
- More wiring
- More weight
- More power consumption
- Higher complexity to manage

Will we as a customer accept that?

- Different opinions and market studies
- Referring to several studies, customer will pay 1500 - 3000€ more for autonomous driving car (mid-size car).

Source: KPMG(2013), autelligence (2015)

2oo3: An Example (Nissan Steer-by-Wire)

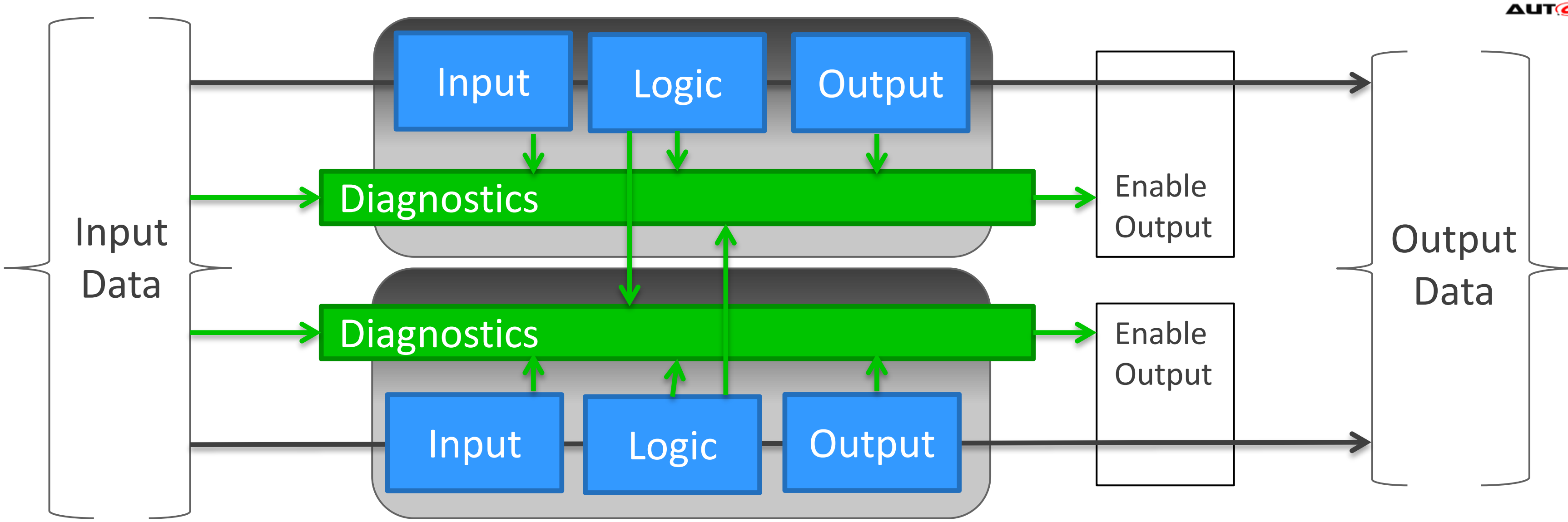


Source: http://www.caranddriver.com/features/electric-feel-nissan-digitizes-steering-but-the-wheel-remains-feature

Agenda

- About EB Automotive
- Motivation
- Comparison of different architectures
- Concept for an 1oo2D software systems
- Summary

1oo2D Systems



If an ECU fails in one of the two channels, the system does not shut down but continues to operate with only one channel
The best policy is not to operate on a single channel for a "long" period of time.

Controlling this time and matching it with complete system behavior is the key.

Precondition: very high diagnostic coverage needed for each ECU to detect failures.

From Detection to Prevention

Integrity mechanisms:

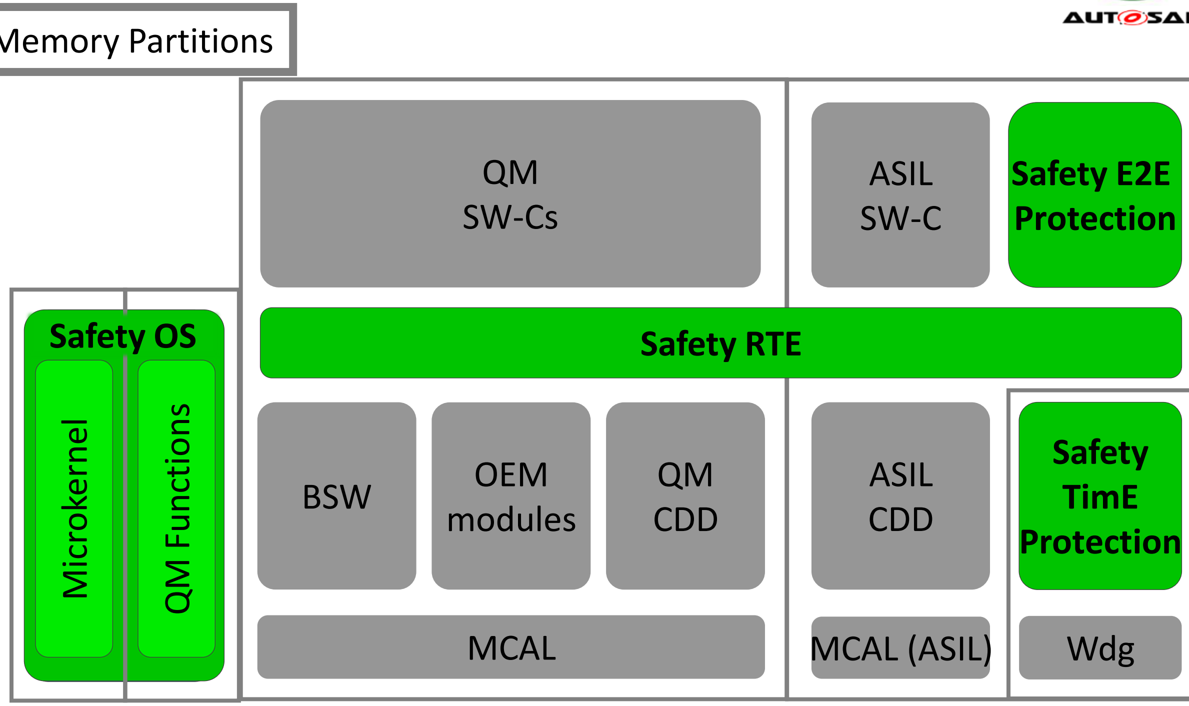
- Memory partitioning
- Data protection
- Temporal protection

Software Engineering:

- Plausibility checks
- Functional monitoring
- Defensive programming
- Semantic analysis
- Robustness

Car Infrastructure:

- Fault tolerant Ethernet
- Service orientated communication



Safety OS

- Data Protection
- Stack Protection
- Context Protection
- OS Protection
- Hardware Error management

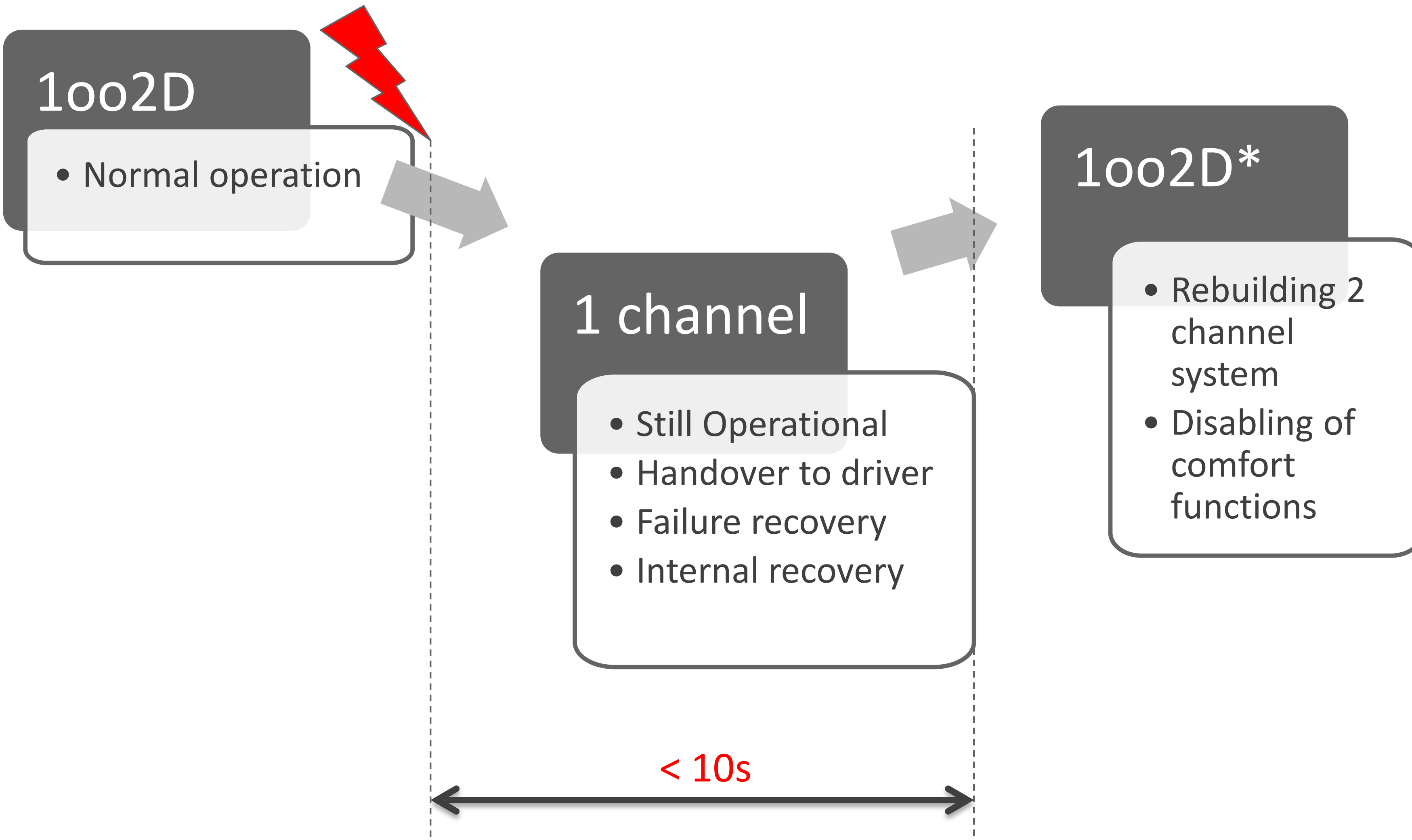
Safety E2E Protection

- Safe communication

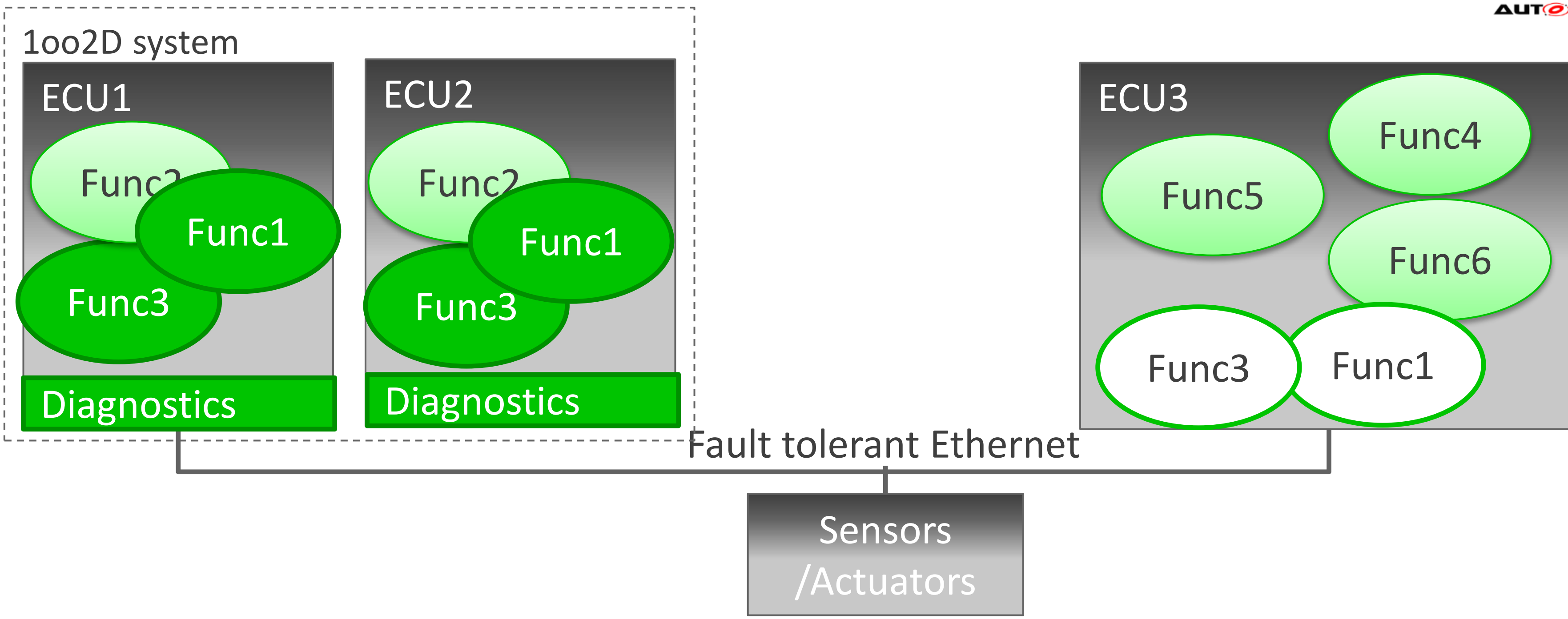
Safety TimE Protection

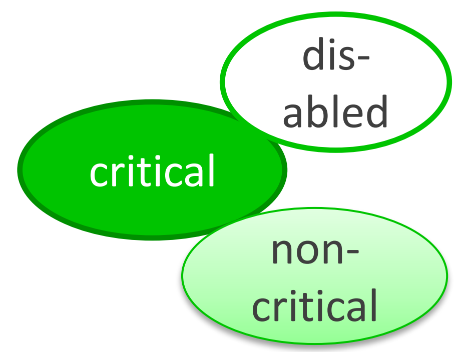
- Alive supervision
- Deadline Monitoring
- Control flow monitoring

Dynamic 1oo2D

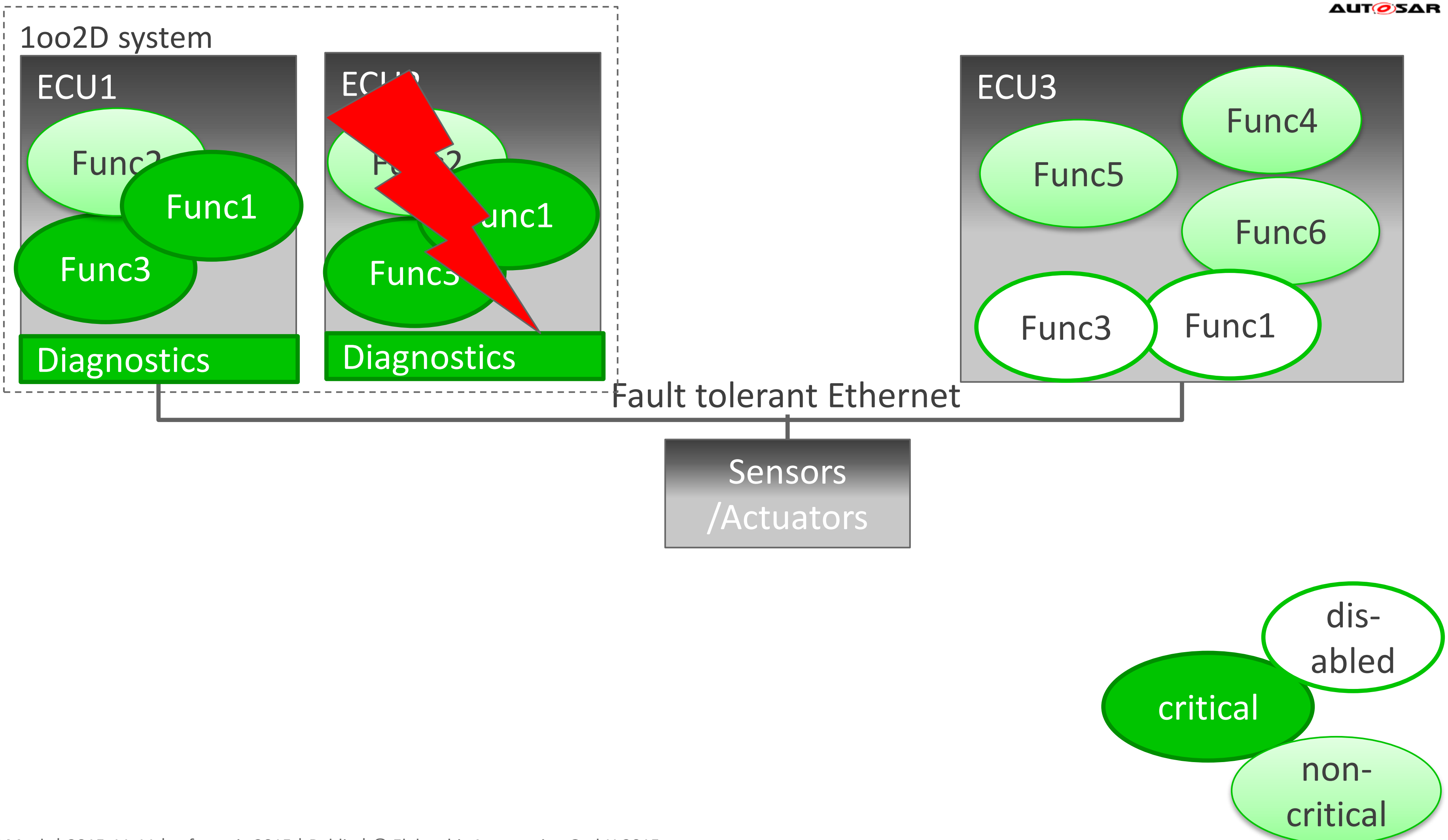


1oo2D - Normal operation



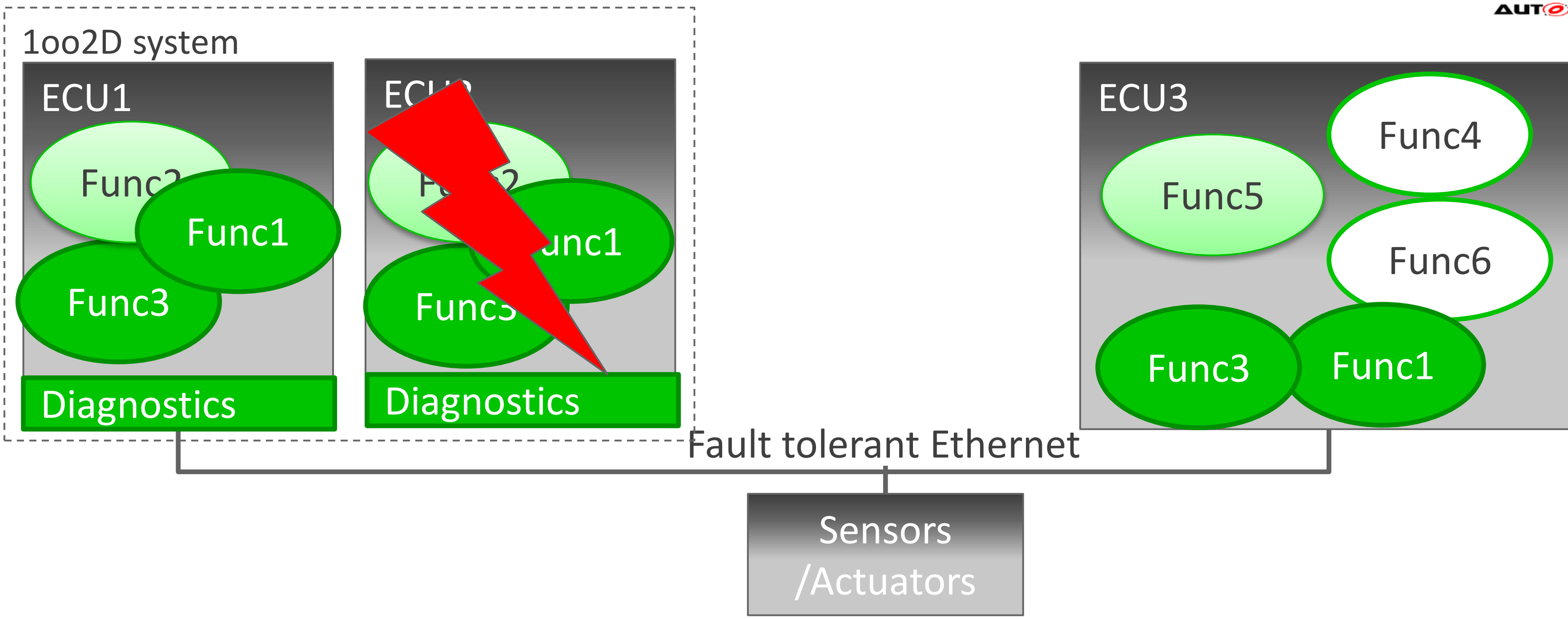


1002D – 1 channel



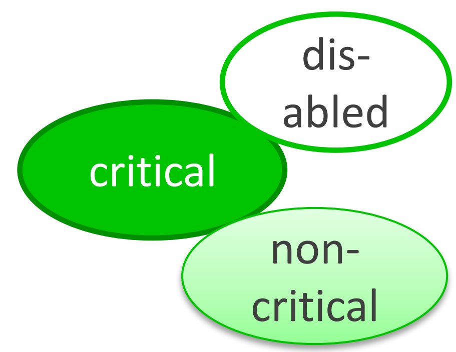
Elektrobit

1002D*

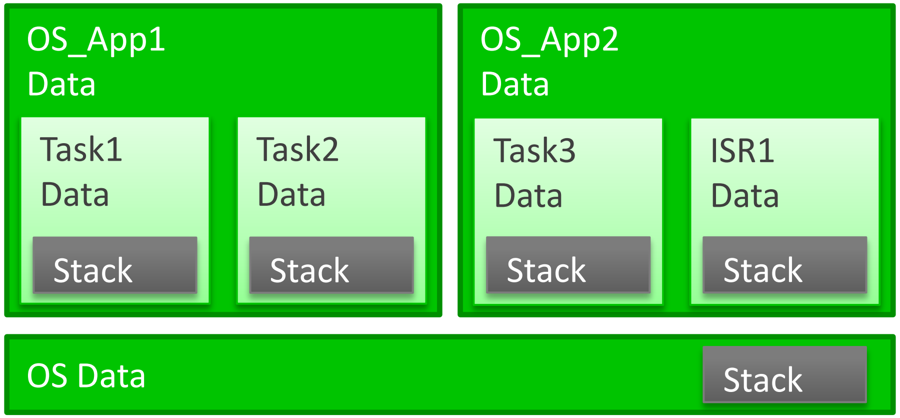


Requirements for Reconfiguration

- Req. 1: Functions can be dynamically relocated
- Req. 2: Sensor/Actuators are redundant or accessible via network



Dynamic Re-Configuration



Req. 1: Functions can be dynamically relocated

- Application information based on AUTOSAR xml description available
- Runtime environment (RTE) supporting reconfigurable software components
- Threads can restarted with e.g. Safety OS

Req. 2: Sensor/Actuators are redundant or accessible via network

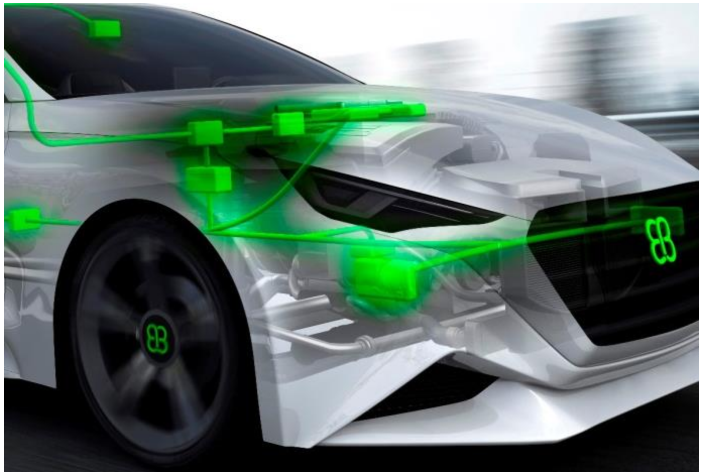
- Service orientated communication
- Multi-cast fault-tolerant Ethernet

Agenda

- About EB Automotive
- Motivation
- Comparison of different architectures
- Concept for an 1oo2D software systems
- Summary

Summary

- Re-use of available integrity mechanisms from fail-safe systems is the basis for building fail-operational systems.
- Software systems that are designed to achieve a high diagnostic coverage are available today and can be extended to fail-operational.
- Fault tolerant Automotive Ethernet is available today.
- Established concepts for fail-operational system are available and can be reused in automotive systems with budget constraints.



Let‘s build the next generation software systems for autonomous driving!

Contact us!

http://automotive.elektrobit.com
alexander.much@elektrobit.com
rudolf.grave@elektrobit.com