Assessing the Evolution of E/E Hardware Modules with Conceptual Function Architectures

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Mercedes-Benz

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- **Introduction: E/E architecture development**
- Use cases E/E module evolution and requirements
- Proposed approach: conceptual function architecture
- Experiences and conclusion

E/E architecture development

E/E architecture

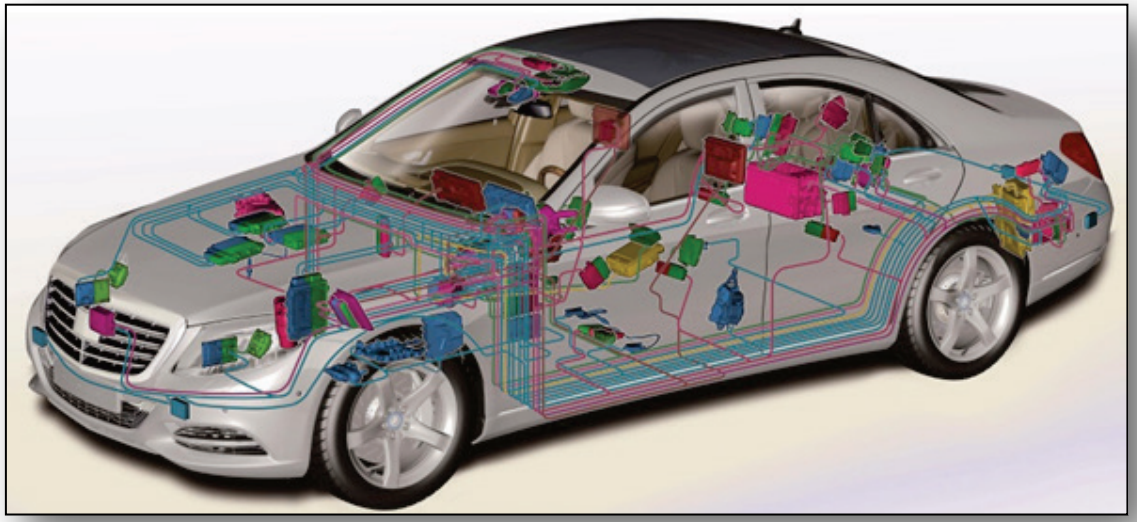
- interfaces, the structure and the interaction of the networked E/E components, the power distribution and the wiring harness

E/E architecture development

- design + assessment + optimisation meeting functional and non-functional requirements

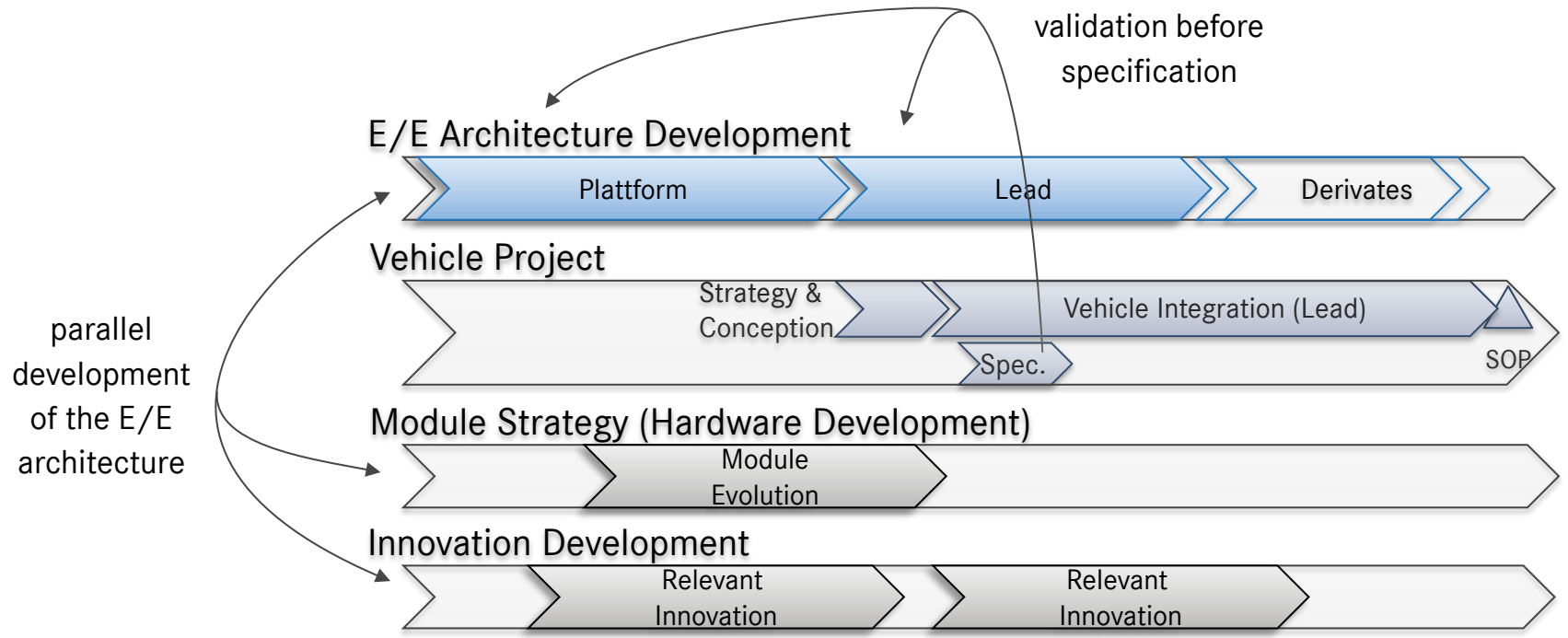
Complexity requires E/E architecture modelling [6]

- different aspects in different layers + connection of the layers (by mapping)
- state-of-the-art and applied by most competitors [7]



E/E architecture development

- concept phase: new product features, like innovative functions, are transferred and integrated into the E/E architecture



Influence on E/E architecture development

Distributed functions

- function contribution (FC): part of function responsible for the realisation on a hardware component
- implemented by AUTOSAR software components (SWCs) [5]

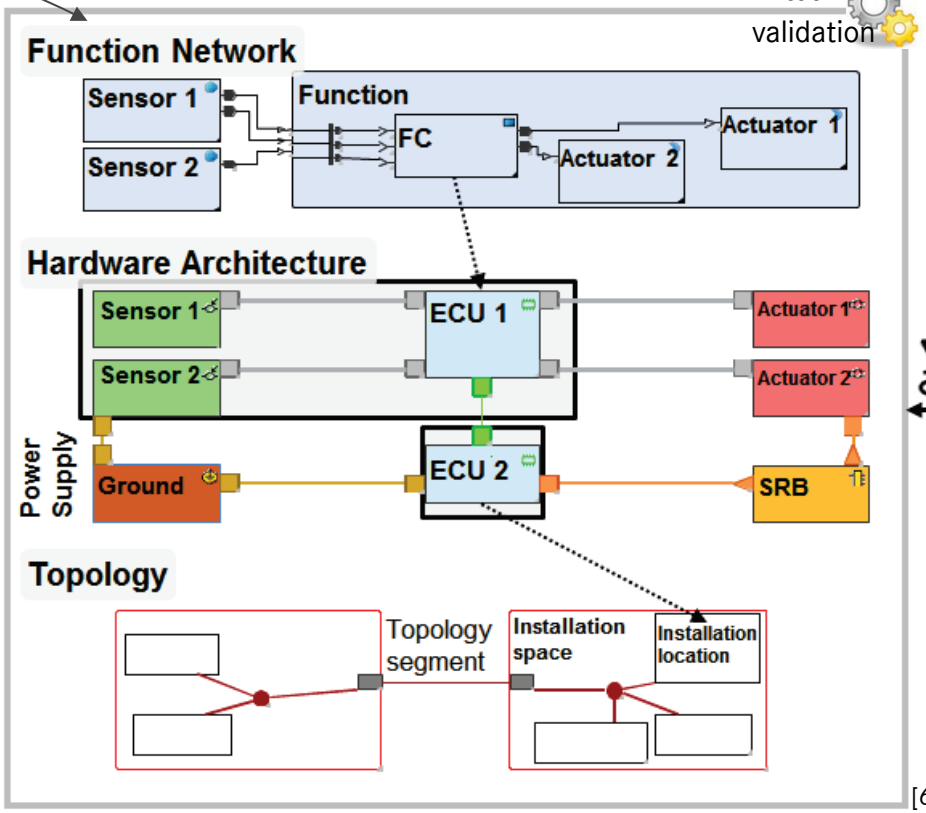
- reuse the once developed hardware components in several vehicle model series
- cost reduction while reducing variants [2]
- performed in industry in different ways [4]: automotive industry - modularisation based on assembly aspects
- E/E module contains sensors, ECUs and actuators associated to an assembly unit

Hardware modularisation

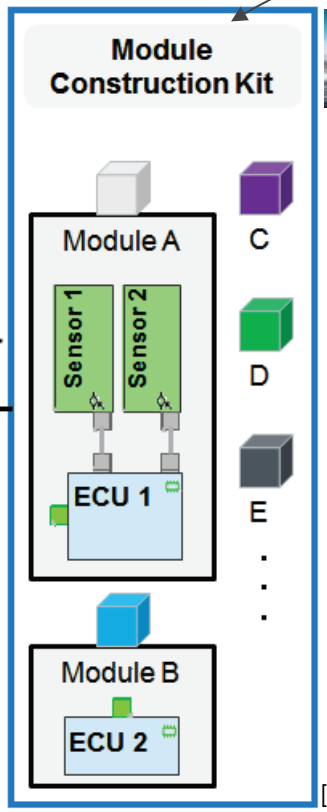
Model-based E/E architecture development

Distributed functions

Vehicle-wide function net = signal flow from signal generation to commands operating an actuator



[6]



[8]

Integration of E/E modules in E/E arch. design [9]: evolve + reuse

Hardware modularisation

- opposing requirements for the E/E architecture development
  - introduction of innovative functions prefers agile methods
  - hardware module strategy prefers stable and cost efficient design concepts
- Challenge: transfer of product features to the design of the E/E architecture

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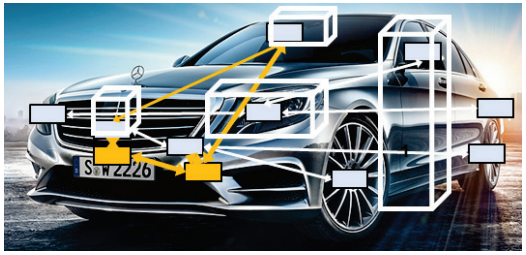
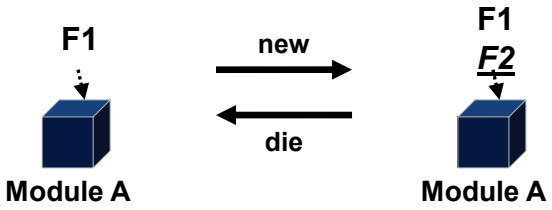
Derived hardware evolution use cases

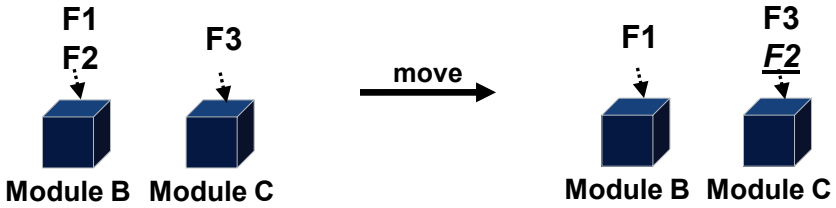
Analysis of past changes:



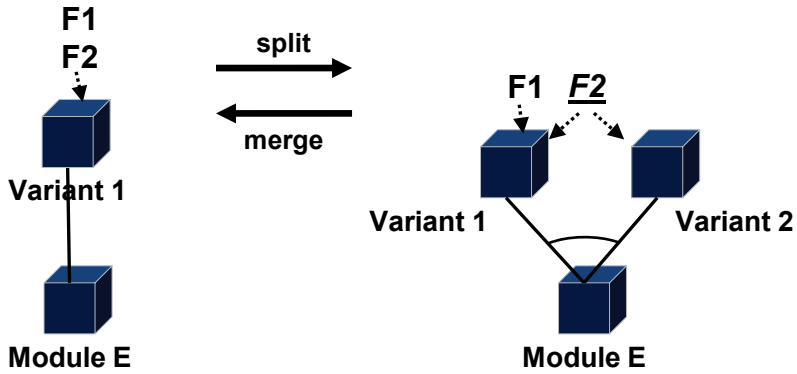
- emergence or disappearance of FCs



- shift of FCs to other E/E modules (e.g. optimisations)



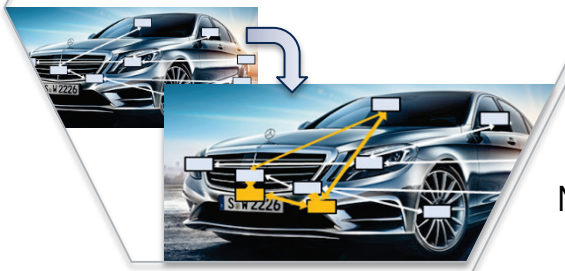
- Creating module variants with part of the functionality (e.g. variant for compact segment)



- reduction of module variants

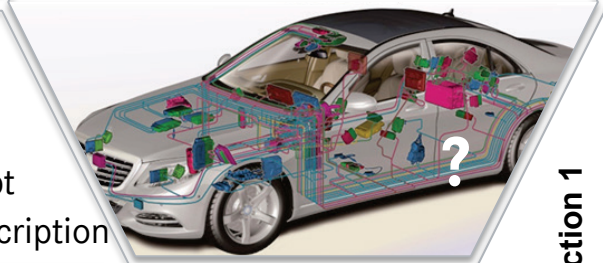
Transfer of product features requires new method

Robust against
flexible changes
of the function net



Determine
affected interfaces
new, change, subset,
ECU-internal interfaces
to ECU-external

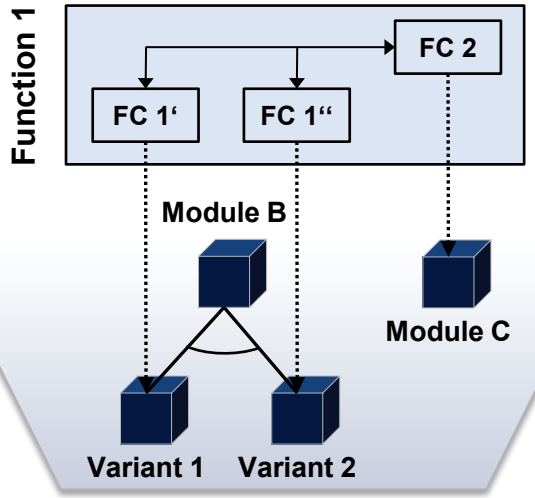
Bus load impact?
sufficient reserves on
bus system?
New or different technology
necessary?



Basis for
design decisions

based on rough concept
without a formalised E/E description

E/E module can
contain variants
support 150% representation

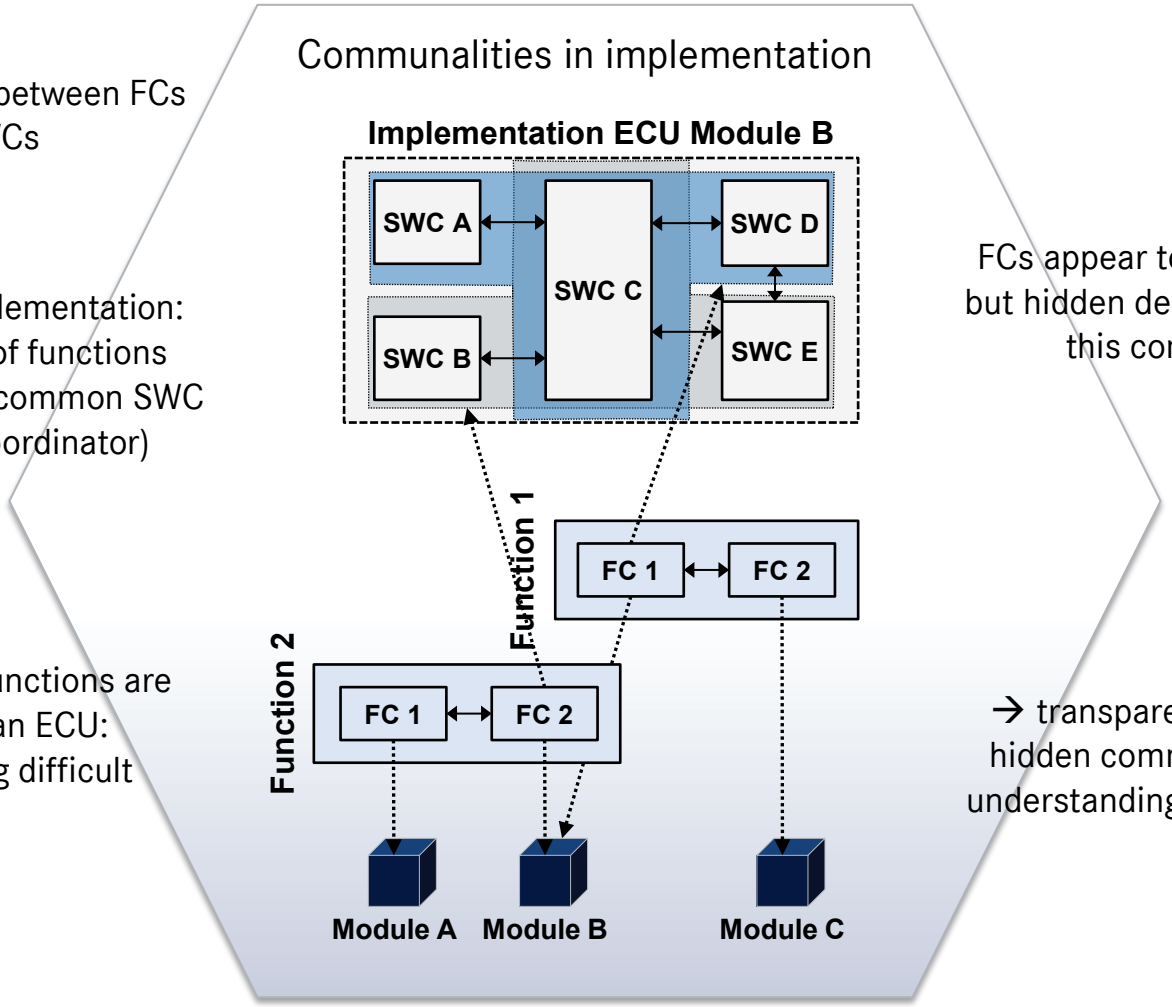


Transfer of product features requires new method

m:n relationship between FCs and SWCs

optimise the implementation: communalities of functions implemented in a common SWC (e.g. central coordinator)

FCs of several functions are present on an ECU: understanding difficult



FCs appear to be independent but hidden dependency through this common SWC

→ transparent description of hidden communalities + easy understanding of the complexity

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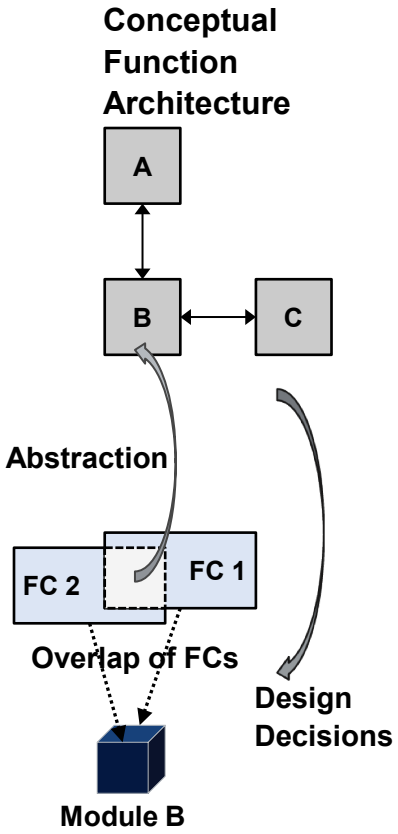
Idea: Conceptual Function Architecture

New modelling layer for abstraction describing:

- the distributed functions implemented by E/E modules
- their complex relationships
- their hidden dependencies
- in a 150% representation covering a whole E/E module with all its variants

How? Reengineering.

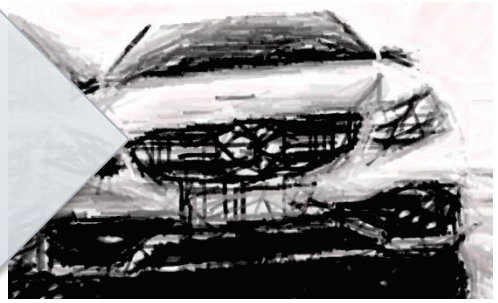
- abstraction of the implementation of the function net
- abstraction creating an intuitive and clear understanding of the functionality
- implementation relevant information is ignored unless E/E architecture relevant (central coordinator)
- interfaces of the function net considered as coupled are summarised as one abstract interface



Integrating novel functionalities with Conceptual Function Architecture

First E/E architecture assessment

- for elements of the function, an abstract element is created
- abstract interfaces describing the information flow
- size for each abstract interface is assigned (new: approximated, existing: received)
- stepwise optimisation in dialogue with the function and E/E component experts

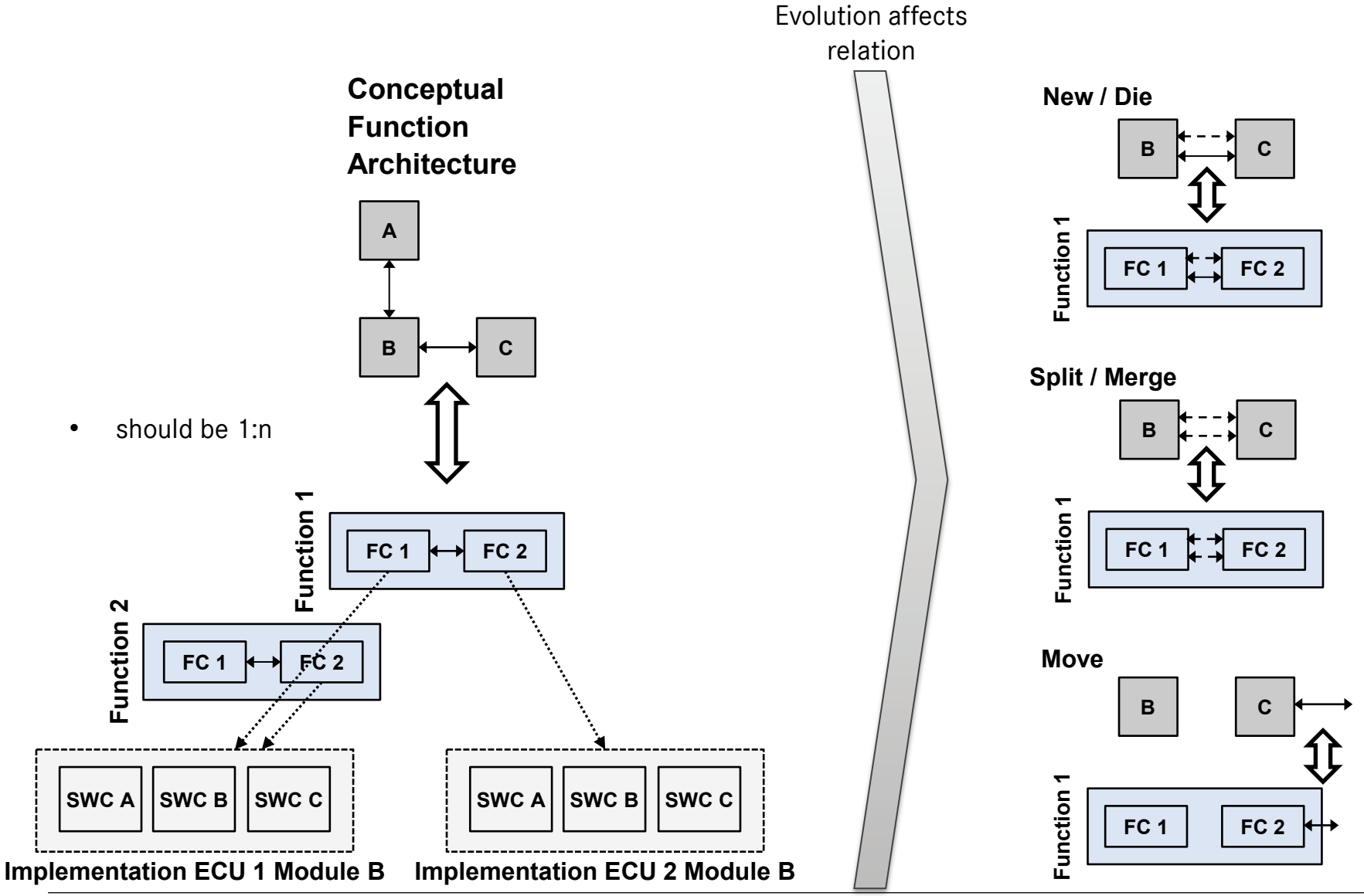


Concretisation

- Change/elaboration of interfaces and functionality
- These detailed information are modelled in the function net
- findings might require adapting the abstraction

Relation between abstract & detailed interfaces

- should be 1:n



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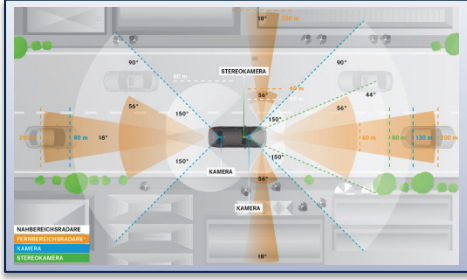
Experiences



- ADAS module of the current Mercedes-Benz S-class used for reengineering and the abstraction of the function net
- support the evolution towards the next generation Mercedes-Benz S-class

Overlap of function net

- Successfully resolved

Robustness

- Generation spanning description of functionality
- function net layer update without impact on the abstract layer

Relation

- new or changed detailed interfaces needed assignment to corresponding abstract interfaces
- Modelling-tool extension to automate establishment + evolution of relationship specified + currently in implementation

Conceptual Function Architecture as basis for the first discussion with function experts

Experiences

Conceptual Function Architecture as basis for the first discussion with function experts

Easy entry to discuss

- complex functionalities
- changes resulting from new features

Abstraction

- small number of interfaces left detailed
- disturbed reading and comprehension

Information flow

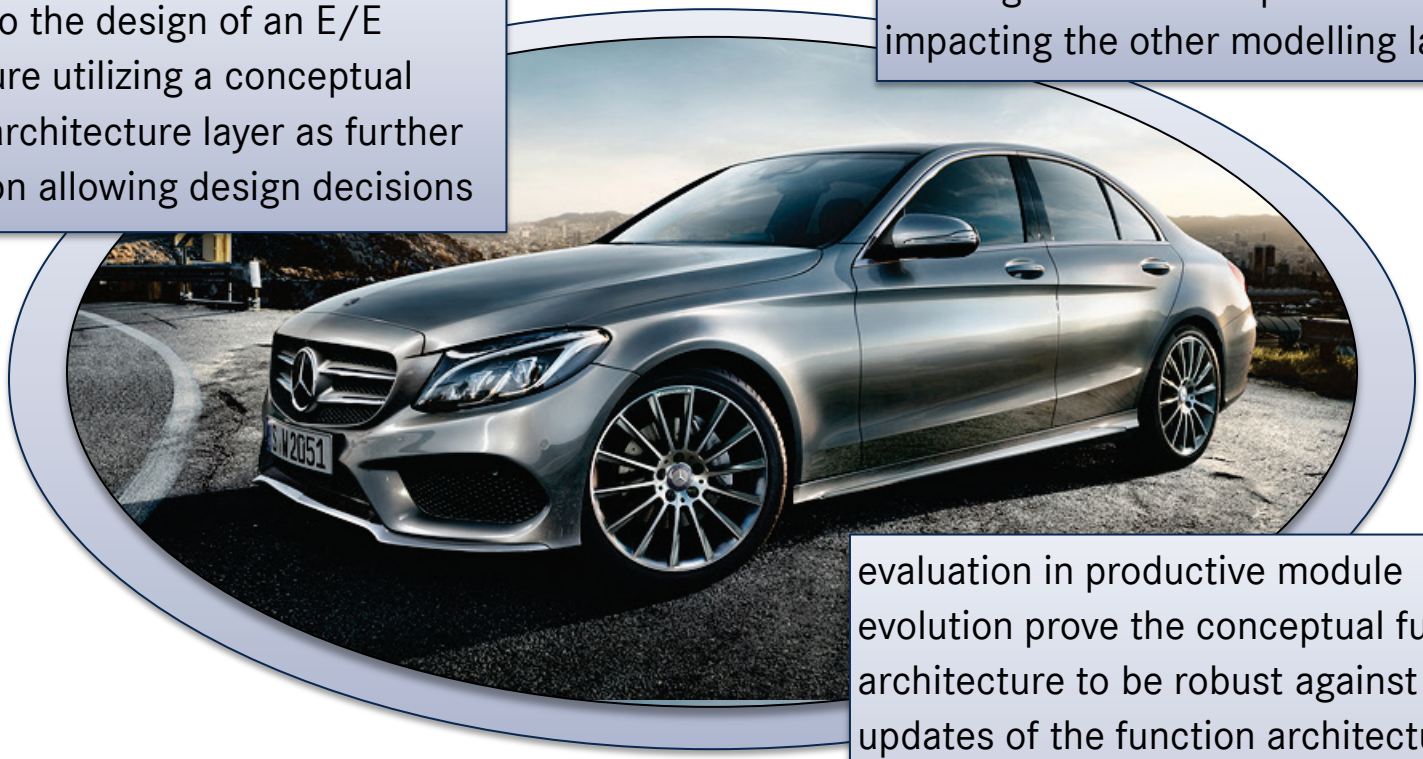
- order of the abstract function elements influenced the comprehension
- from sensor elements to actuator elements was crucial for understanding of complex functions
- parts inconsistent in this sense hindered comprehension or were missed by the experts

- used as basis for making design decisions while integrating new features
- other modelling layers were affected and had to be adapted accordingly to create a consistent model

Conclusion

novel approach to transfer new features to the design of an E/E architecture utilizing a conceptual function architecture layer as further abstraction allowing design decisions

most abstract view on a hardware module and allows a first assessment defining functional requirements and impacting the other modelling layers



evaluation in productive module evolution prove the conceptual function architecture to be robust against updates of the function architecture, supportive in understanding the complexity of a large number of functions, and utilisable for product management decisions


thank you.

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