Cross-Cutting Approach to Integrate Functional and Material Design in a System Architectural Design – Example of an Electric Powertrain

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Abstract. The automotive industry is currently undergoing tremendous changes. Vehicles get connected and autonomous, the powertrain gets electrified. Intelligent service architectures for future e-mobility services are created. The production is more and more automated, decentralized and controlled by robots. The CO_2 emissions have to be reduced as a contribution to stop the global warming. To meet the requirements of an electric car in the future, it is essential to combine different approaches with each other. In this integrated system the consideration of system, software and material improvements is required. Up to now, there are software functions which are part of system functions which in turn are connected to the vehicle level functions. For the future, the connection of material functions of a vehicle with system and software functions seems to be a promising approach to develop a tailor-made electric car to meet the upcoming requirements. This paper uses the example of a car with an electronic powertrain to explain how material design (tire design, weight of materials, etc.), software, and electronic design need to be combined to come up with optimised functions on vehicle level (e.g. achieving longer distance drive with electric vehicles combined with reduced CO_2 emissions).

Keywords: Cross-cutting approach · Effect chain · Interdisciplinary view on system architectural design · Automotive SPICE · ISO 26262 · CO_2 emissions

1 Introduction

Currently, the design of cars is influenced by recent developments, new norms, and new networked services. These influencing aspects are discussed in Sect. 2 of this paper considering e-mobility, vehicle function and effect chain understanding of cars. Furthermore, the new approach is included that cars are understood as a set functions instead of a set of mechanical components.

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Section 3 of the current paper discusses architectural design issues and different views on the required design of an electric powertrain applying the different state of the art norms. The system architecture explanations consider the aspects already mentioned in Sect. 2.

Section 4 of the paper discusses material aspects with the focus on tire design aspects. The impact of the material and tire design on the system design views and effect chains, discussed in the previous Sect. 3, is presented.

In Sect. 5 the paper provides a conclusion that the aspects outlined in Sect. 4 need to be considered in the architectural designs (which are state of the art in recent car design) described in Sect. 3.

2 Recent Developments Influencing System Design of Vehicles

2.1 E-Mobility

E-mobility becomes more and more important. The driving force for the increase of the E-mobility is the Chinese market. In 2018, 1255000 electric (E-) cars were sold in China, which is an increase of 62% compared to 2017 (Fig. 1). The second strongest market for E-cars is in the US, followed by Norway as the first European country. It is expected, according to a study of the Center of Automotive Management (CAM) in Germany [34], that the sales of E-cars will increase of 40% to a total amount of 2.7 million sold E-cars worldwide in 2019.

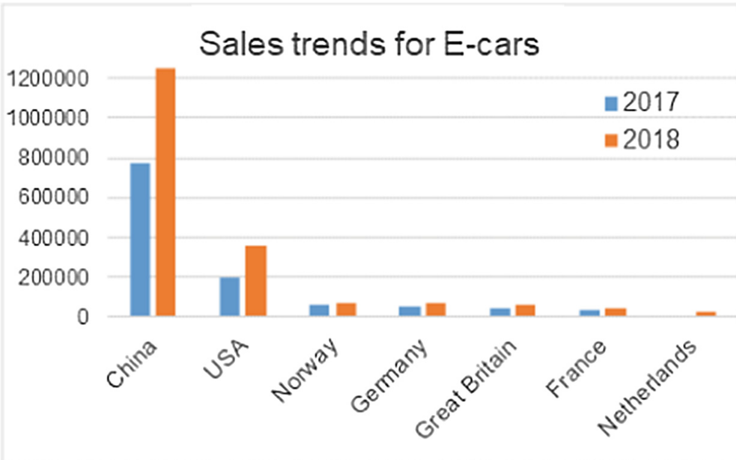

Fig. 1. Sales trends for E-cars [34]

What are the driving forces for this increasing interest in E-mobility? A major impact has the ongoing discussion about the global warming. In 2020, significantly reduced CO2 emissions from vehicles have to be reached to meet the EU-legislation requirements. The increasing use of E-cars can deliver an important factor for the automotive industry to meet these goals.

What are the challenges for the development of E-cars to meet the upcoming requirements? E-cars have for example the disadvantage of an increase in their weight due to the significantly heavier battery. This increases the total weight of the car which lead to a faster consumption of the battery and even lower driving range compared to a passenger car with the traditional combustion engine. Therefore, the rolling resistance of the whole car should be as low as possible. Due to the fact that the rolling resistance of the total car is significantly influenced by the rolling resistance of the tires, the tire design plays an important role as well.

2.2 Design of Complete Effect Chains for Future Vehicle Design

Automotive SPICE [1, 2, 7] focusses on mechatronic functions which are realised by a combination of software, electronics and mechanics. Functional safety [4, 8, 9] focuses on faults of electronic and software which create hazards (e.g. self-steering failure, missing brake force, etc.). Material research and design focusses on the optimisation of materials, e.g. reducing rolling resistance and noise of tires. This aspect is considered in the VW specific KGAS norm which emphasises functions/features and the grouping of requirements by functions/features [11].

In order to develop the best possible E-car, all different aspects have to be combined [3, 15, 24, 28, 29]. Up to now, the reality is different. Figure 2 shows that mechanic, software, hardware and material design teams work in different departments. To reach the goal, all departments should co-operate and create a functional flow to optimise together the vehicle functionality. The current paper uses the example of an e-mobility design where all four domains are connected to each other to realise a long-distance driving e-car. The arrow in Fig. 2 encloses all four required functions following the above presented idea.

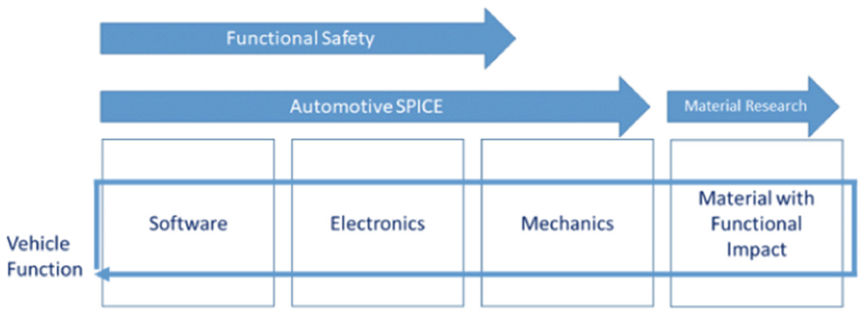

Fig. 2. Effect chains including all domains which have a functional impact

2.3 New Interface Type Material Flow and Design in the VDA Automotive SPICE Guidelines

In Automotive SPICE 3.1 [1, 2, 7] a system architectural design including interfaces and dynamic views is required. The Automotive standard IATF 16949:2016 (updated from TS 16949) includes requirements for the development of products with embedded software. The software development process is included within the scope of the internal audit programme, which can be demonstrated by performing Automotive SPICE® assessments.

In November 2017 (available since Feb. 2018) the VDA published Automotive SPICE Guidelines (blue-gold book [2]) and this contains rules and recommendations to interpret Automotive SPICE® and more specifically System Requirements Analysis and System Architectural Design processes.

For both processes additional requirements regarding energy and material flow have been added in Automotive SPICE rating guidelines [2] indicating that the system design should not limit itself only to mechanical, electronics/hardware and mechanical interfaces:

SYS.3.BP3: Define Interfaces of System Elements [1, 2]

System interfaces represent the interaction between the elements of the system architecture and the interaction between the system and the system environment. The system interfaces are derived by any linkage (intended or not intended) as e.g.

- Mounting
- **Energy Flow** (Mechanic, hydraulic, pneumatic, electric, temperature, etc.)
- **Material flow** (fuel, oil, water, etc.)
- Signals and signal quality
- Noise, vibration, harshness

SYS.2.BP4: Analyse the Impact on the Operating Environment [1, 2]

The analysis of the impact on the operating environment covers the impact on the system itself as well as the impact on other systems and on the entire vehicle considering the following possible aspects:

- Interfaces
  – Mounting
  – **Energy flow** (mechanic, hydraulic, pneumatic, electric, temperature, etc.)
  – **Material flow** (fuel, oil, water, etc.)
  – Signals and signal quality
  – Noise, vibration, harshness
- Environment
  – Temperature
  – Humidity
  – Exhaust
  – EMC
  – Radiation

- Performance
  - Interface response times (mechanic, hydraulic, pneumatic, electric)
  - Subsystem response times (e.g. microcontroller processing time)
- Resources
  - **Energy flow**
  - **Material flow**
  - Memory Usage (RAM, ROM, EEPROM/DataFlash)

By defining more interface types the Automotive SPICE Guidelines effectively defined the scope of requirements for the System Requirement Analysis (SYS.2) and System Architectural Design (SYS.3) processes. While assessments before focussed on the integration of mechanics, electronics/hardware and software, new interfaces were introduced including now material flow and energy flow – to name just a few.

If the analysis of the impact on the operating environment does not consider aspects from the lists above or other aspects that are relevant for the project both indicators (SYS.3.BP3 and SYS.2.BP4) should be downgraded respectively.

2.4 The Change of a Car to a Pool of Data and Vehicle Functions

In the past, cars were constructed based on modules and each module was self-consistent. The gear box, for instance, included its own speed sensor. Based on this, the gear was automatically selected. Due to higher safety demands, having still a reliable system even if an electronic part fails, the gear box nowadays uses ESP speed which includes the control of the output shaft rotation, and rpm of the motor to select the correct speed. The cars also get connected to the environment which can provide the recommended speed considering e.g. the weather conditions. This means that all these registered data are connected to each other which implies that the car becomes a data cloud [5, 6, 18, 25, 26].

The vehicle is now understood as a pool of functions [11, 16, 17, 23] and each function is assigned to a set of modules (components) in the car with a real time communication between the components by a bus. Therefore e.g. Volkswagen defined vehicle functions (FUN principle for function based vehicle development) and each supplier maps their own subfunctions/features, and system requirements to these vehicle functions [11, 23]. Automobile manufacturers apply assessments to check the traceability, safety, and security of those functions by assessments [12–14, 17–19]. The fulfilment of the related norms requires the definition of such functional designs, effect chains and dynamic views. ISO 26262 named this signal flow, Automotive SPICE [7–9] refers to it as a dynamic view, and in the cybersecurity norms [10, 16, 27] this is termed as a data and signal flow. But all three are based on the same concept.

The change of a car to a data cloud containing a pool of functions leads to a further new development in the automotive industry: If the car is such a data cloud, cybersecurity attacks become an issue [10, 16–19]. Furthermore, the failure of electronics and software can lead to accidents and hazards, therefore, functional safety norms were published [4, 8, 9, 20–22].

3 Typical System Architectural Design

3.1 Functional Architecture Based on Automotive SPICE

According to Automotive SPICE [1, 2, 6, 35] a system architectural design includes components, interfaces, and a dynamic view (effect chain and timing). In Automotive SPICE three domains are usually integrated, such as mechanics, electronic/hardware and software. Figure 3 below shows an example for a functional architecture of an electric powertrain. It contains the following abbreviations and numbers:

ECU: Electronic Control Unit which contains electronics, software and is connected to a vehicle bus
FOC: Field Oriented Controller which is a special module that cascades power through the T1, T2, T3 transistors in the inverter in a 3 phases sinus cycle;
Vehicle bus: A message based protocol where a message contains a number of signals e.g. demanded torque;
T1, T2, T3: insulated-gate bipolar transistor (IGBT) switches, to switch the electric power; I1, I2, I3: three phase currents

(1) The vehicle controller converts the accelerator pedal inputs, speed, etc. into a demanded torque and sends the demanded torque to the electronic control unit (ECU) of the E-motor.
(2) The ECU of the E-motor measures the current rotor speed, calculates the current torque and controls the T1, T2, T3 insulated-gate bipolar transistor (IGBT) switches and power of the motor to achieve the target/demanded torque.
(3) The inverter uses semiconductor elements that can switch the three phase currents I1, I2, I3. This is done in a 120° phase shift by a sinusoidal function because the coils are placed in a 120° angle position in a circle around the rotor.
(4) The 400 V Lithium Ion battery provides the electric power for the inverter and motor and has its own battery management system.
(5) With the electric power the coils (in a 120° shift) create the magnetic fields to turn the rotor.
(6) The rotor is in most cases a permanent magnet rotor.

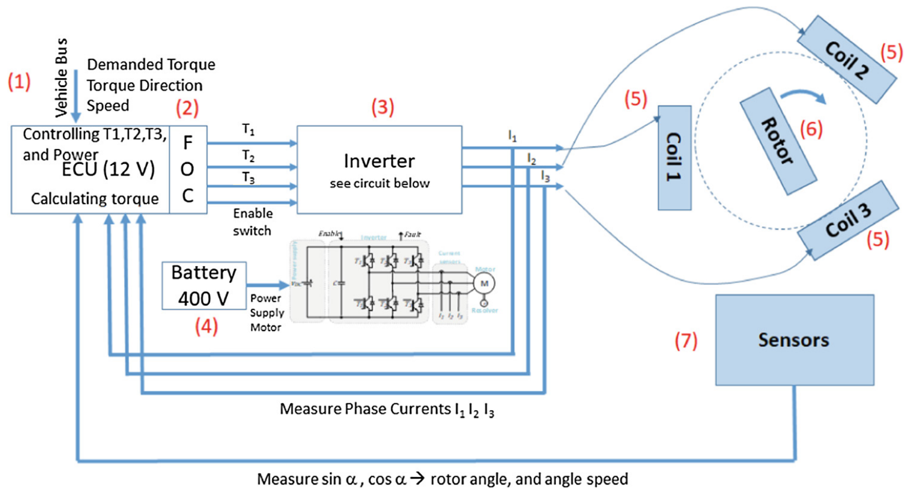

Fig. 3. Example for a system architectural design view on an electric powertrain

The above example demonstrates the effective combination of different domains: mechanics, electronic/hardware and software and represents a static view of the interfaces between the components. In addition, a dynamic view is prepared describing the designated behavior of the system and the components between them (Fig. 4).

This system architectural design shows how a successful combination of the above mentioned domains was already established but does not consider some of the requirements listed in Sect. 2.3 regarding the impact of the materials on the design

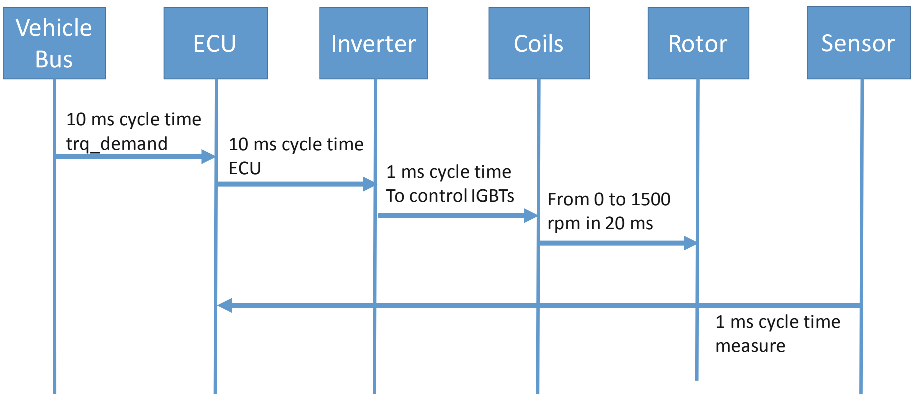

Fig. 4. Example for a dynamic view based on Automotive SPICE

3.2 Functional Architecture Based on ISO 26262 (Functional Safety)

In the case that the project is safety relevant, the system architecture design has to be extended to support the requirements from the ISO 26262 [8, 9]. Functional safety [4, 7–9] analyses the potential risks in a H&R (Hazard and Risk) Analysis and assigns an ASIL A to D to a potential malfunction. To avoid risks, safety functions and monitoring functions are created and added to the system design. A single point fault (one fault appears and leads to a hazard) is avoided by creating (especially in ASIL D case) two redundant and diverse systems, both rated as ASIL B(D). For an ASIL B(D) component still a qualified hardware with a software diagnostic coverage of 90% (90% of all faults will be detected) is needed.

Note: The ISO 26262 norm allows other decomposition options as well, here only one of the options is explained.

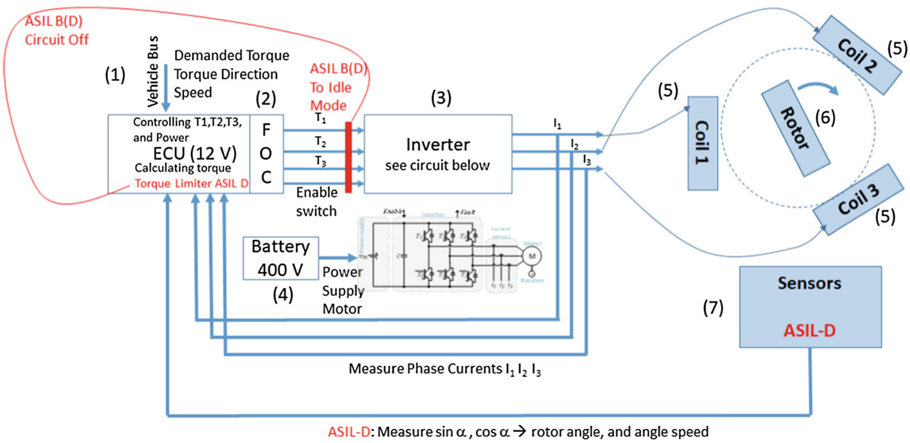

Fig. 5. Example of a functional safety view of an electric powertrain

One of the safety goals is that the electric motor shall not produce more torque than demanded by the vehicle control unit. Figure 5 shows an example decomposition, where a torque limiter function monitors the torque. In the case the demanded torque is exceeded, the motor can be switched off by two independent ASIL B paths. Figure 5 shows also the example of a sine and cosine function (diverse mathematical functions) to determine the rotor angle and angle speed.

The existing dynamic view needs to be extended if safety relevant projects are in focus. The following attributes are added (Fig. 6):

- Fault tolerant time: Minimum time –span from the occurrence of the fault in an item to a possible occurrence of the hazardous event, if the safety mechanisms are not activated. This time is provided by vehicle testing and the manufacturer.
- Fault detection time: Time-span from the occurrence of the fault to its detection.

- Reaction time: time-span from the detection of a fault to reach a safe state or to reach an emergency operation.

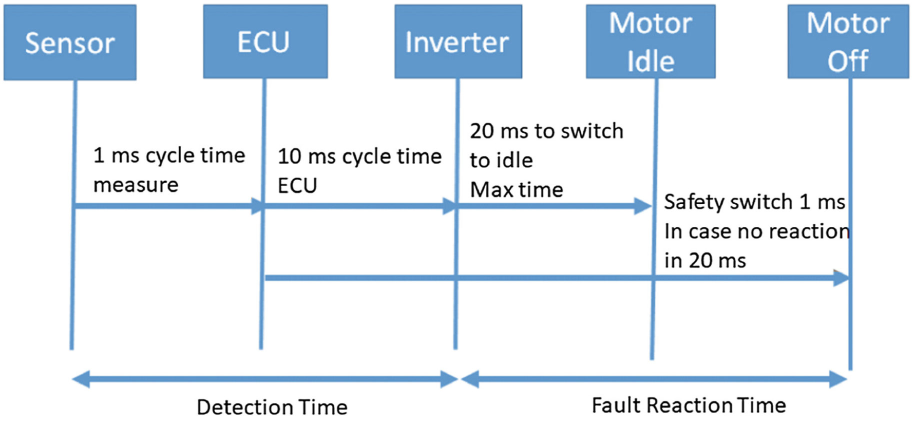

Fig. 6. Example of a dynamic view on a switch to a safe state

The examples of typical system architecture designs from automotive projects (safety and non-safety) show in detail the interaction between mechanics, electronics/ hardware and software, however, the interfaces to material flows and the impact of materials as required by the Automotive SPICE Guidelines are still missing.

4 Impact of Material Design on System Architectural Design

Vehicle functions [11, 21–23, 25, 26] are implemented by mechatronic functions (mechanics, hardware, software) but are largely dependent on material design (material flows). These interfaces (see Fig. 1) are now included in the Automotive SPICE guidelines as well [1, 2].

In this chapter a material design example is described which illustrates that the functions offered by an electric powertrain depend to a large extent on such material interfaces.

The material aspect needs to be considered in future system architectural design. That this is an important issue is shown in the following example: A battery for an electric car lasts for 150 km. Due to the addition of several new components into the car, the weight increases which results in a higher rolling resistance of the car. This leads to a faster consumption of the battery. If new materials can be found which can be used in the car which reduces the rolling resistance, this problem can be solved. This shows that the combination of mechatronic functions and material functions can be a powerful tool to fulfil the requirements of the future electric car.

4.1 Background on Material Design – Car Tires

The reduction of the rolling resistance of a car is an important overall goal for the whole car. By reducing the rolling resistance of a car, less fuel consumption is required which leads to a reduction in the CO_2 emission. This means as well, that the range of a typical passenger car can be extended taking the same amount of fuel into account. Which means for an electric car, that a reduction of the rolling resistance leads to an increase in the driving range as well due to a slower consumption of a battery.

An important contribution to the rolling resistance of a car delivers the tires, the only contact between the road and the car. The first important example for a significant extension of the driving range of a car was the change of diagonal tires to radial tires. Here the construction of the whole tire was changed in such a way that the rolling resistance was significantly reduced.

4.1.1 Green Tire Technology

Another important development for the reduction of the rolling resistance of the whole car was the introduction of the "Green Tire Technology" by Michelin in 1992 [37]. This was a real material related approach. Modern tires have to fulfill very high demands concerning their contribution to a higher safety, longer service life and lower fuel consumption which leads to a reduced CO_2 emission. These three main performance criteria of tires are correlated to:

- the wet grip behavior, which indicates the grip to the road and braking distance on wet surfaces (safety aspect)
- the abrasion resistance, which indicates the distance a tire can be used safely until it has to be replaced (service life)
- the rolling resistance, which indicates the fuel consumption and therefore the distance to drive with the same amount of fuel.

These three aspects are known as the "magic triangle" of tire performance. The biggest challenge is to improve one of these criteria without worsen one of the other two.

The introduction of the Green Tire Technology is the latest big breakthrough in tire tread development but already more than 25 years old. In this case, highly dispersible precipitated silica together with bi-functional silanes are used as a reinforcing filler system in a passenger car tire tread. In combination with a special polymer blend system, S-SBR/BR (high Tg solution-styrene-butadiene copolymer and a low Tg 1, 4-polybutadiene), it was possible to improve the rolling resistance and also the wet grip of passenger tire tread compounds while keeping the abrasion resistance on an comparable level as with previous technologies (E-SBR with carbon black).

Recently, Prof. Ulrich Giese commented on the challenges for tire performances by using electric cars [38]. Especially the direct torque of electric powertrains and the additional weight of a car due to relatively heavy rechargeable batteries can increase the tire wear up to 30%. In addition, the rolling resistance and as a result the fuel consumption and CO_2 reduction gets more and more into focus. Therefore, it is necessary to develop new material compositions and also to take the construction of the tire into consideration.

4.1.2 Weight Reduction of Cars

A further approach to reduce the fuel consumption and CO_2 emission of electric cars is the reduction of weight of a car in general. However, recent trends in the automotive industry next to the heavy rechargeable batteries lead to an average increase in total weight. These are for example the increase of customer demands e.g. for ADAS - Advanced driver-assistance systems, such as Adaptive cruise control, Collision avoidance system, Lane departure warning system. Parking and Rain sensors, Surround View system etc. where cameras, sensors, control units etc. are adding the weight, etc. as well as the increase in safety demands like airbags and stiffer construction. Therefore, new materials have to be developed which can replace e.g. metal parts inside the car with lighter materials. The biggest challenge for these materials is to obtain the same performance, lifetime and safety criteria as with conventional parts.

Following study in Fig. 7 depicts the overall changes of material composition inside a car from 1970 until 2020.

It can be seen that the total amount of metal has been strongly decreased over the last 40 years inside the car and was replaced by lightweight materials like plastics and rubber. Nowadays, these materials are not only be used for the interior of the car but also e.g. in the body and inside the engine bay.

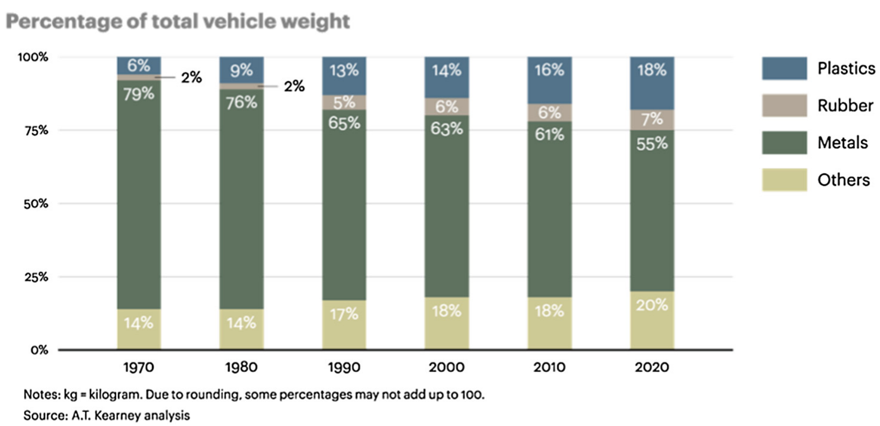

Fig. 7. Change in material composition of a car over 50 years

One example for the replacement of steal is the use of mineral reinforced polyamide PA 66 and acrylonitrile/polybutadiene/styrene for the front side wall of the BMW 3 series coupe/cabriolet in 2009. In this way it was possible to reduce the weight of 3 kg [36]. Another example is the replacement of the oil pan, previously made out of aluminum/steel, by plastic e.g. PA (Ultramid). By doing this, it is possible to reduce its weight by 60%. An estimations showed that in 2009 approximately 65000 t CO_2 could be saved by only using plastic oil pans inside of all German passenger cars [39].

Expected future trends are e.g. front spoilers, B-pillars and room frame structures made out of plastics and rubber instead of metal. In addition, it is expected that the use of endless fibers and carbon fibers will increase in the near future being used as strongly reinforcing materials in plastics and rubber. The main drawback for these high performance materials in general are the relatively high (production) costs.

Another factor when replacing metal with light weight high performance materials is the human sense and trust which is not often taken into consideration. An example for this is the replacement of the brake pedal (metal) with carbon fiber reinforced plastics. It was shown that the acceptance by the costumer regarding the trust into "weak" plastics instead of "strong" metal for an important safety relevant function is very low, even with proven and guaranteed function and safety. Therefore, building awareness in society for these issues are important driving factors as well.

4.2 Extending System Architectural Design by Material Design

The functions of an electric powertrain need to be extended by functional/mathematical models of the weight and tire resistance impact for long distance drive simulations.

Tire construction and weight of the car influence the rolling resistance. The higher the rolling resistance the more battery power is consumed and this has an influence on the km distance the electric car is able to drive.

In case of a Continental tire 185/60 R14, for instance, the rolling resistance has been reduced to 7,6 due to recent research [46].

Formula (i) [43]: CR = Rolling Resistance/max. load capacity of tire

The rolling resistance coefficient C_R is determined by dividing the rolling resistance by the max. Load of the tire. The maximum load capacity index of the tire is 82, which represents a max. weight of 475 kg.

C_R = 7,6/475 = 0,016 (rolling resistance coefficient, application of Formula (i))

Formula (ii) [43]: The typical estimation formula for a given car is $F_R = C_R * F_N$ with

F_R - rolling resistance force for a specific vehicle, with a specific weight, in kWh
C_R - rolling resistance coefficient
F_N - Newton power on the wheel depending on the weight of the car.

Example calculation of impact on battery:

Formula (iii): Conversion used 1 kg = 9,81 N, and 1 kWh = 3,6 MJ (Mega Joule)

Application of Formula (ii) for a specific example, e.g. based on Volkswagen E-Golf data [45]:

Vehicle with 2020 kg, with a Continental 185/60 R14 tire the C_R = 0.016, the resistance force will be approx. 2020 * 9,81 * 0.016 = 317 N. This produces per 100 km 317 N · 100 000 m = 31,7 MJ = 8,80 kWh power consumption just caused by tires resistance and weight of the car.

Also the correct pressure of the tire has an influence on the consumption. Only with a correct pressure the above approximation is correct: the lower the pressure the higher is the fuel consumption of the car.

Additionally, the air/wind resistance due to the aerodynamic design of the car consumes power from the battery.

These data then lead to a re-design of the system concept and the functional effect chain.

4.2.1 Influence of This Calculation on the Electric Powertrain Capability

Currently a battery (example VW E-Golf [45]) has approx.. a capacity of 35,8 kWh and consumes ca. 20 KWh per 100 km. The car drives ca. 179 km.

How much of that consumption is due to tire resistance and vehicle weight?

E-Golf
Weight with no load: 1.615 kg
Max. weight with load: 2.020 kg

The resistance per 100 km is (formula (ii) above)
Resistance Force: 2020 * 9,81 * 0.016 = 317 N.
Consumption in kWh: 317 N · 100 000 m = 31,7 MJ = 8,80 kWh per 100 km.

This leads for a 179 km drive to a contribution (by weight and tire resistance) of 179/100 * 8,8 kWh with a weight of 2020 kg, which is 15,75 kWh of the battery power (ca. 15,75/35,8 = 43% due to rolling resistance and weight and not counting other factors).

This means that by reducing weight of the car and reducing the tire coefficient the driving range of the electric powertrain increases.

Very often this material impact is not considered in a system architectural design (see Sect. 3).

4.2.2 Extending the System Architectural Designs

Figure 8 shows an example where mechatronic functions interface material functions and the system architectural design considers the above discussed material flows.

In such a system the material flow and composition can be used in estimation models to provide driver assistance functions or e.g. calculation of the distance which can be driven based on the vehicle loading situation and tires used.

This leads to the following requirements:

1. Tire pressure should be measured and driver should get warned.
2. Due to incorrect pressure the software should calculate the reduced distance and display that to the driver.
3. Optimum tire design and C_R coefficient is part of that calculation and becomes critical in the design of electrified cars.

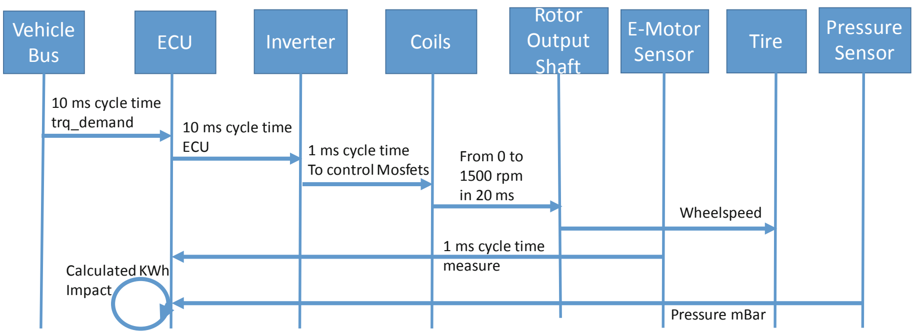

Fig. 8. System architectural view including material flow impact

5 Conclusion About Integrating System Architectural Design with Material Design - Cross-Cutting Approach

Automotive SPICE 3.1 and the newly published Automotive SPICE guidelines list the material and energy flow as mandatory interfaces [2]. This paper has illustrated the impact of such a material and energy flow on the mechatronic and vehicle functions.

The examples described in the current paper illustrate that by combining material and system and/or software functions [5, 6], the development of tailor-made electric cars seems to be possible in a most effective way. Up to now, there are some first examples for such combinations: The tire pressure has an important impact on the vehicles' safety and efficiency. Therefore, already in the 1980s, a tire-pressure monitoring system (TPMS) was integrated in the tire. This is an electronic system designed to monitor the air pressure inside the pneumatic tires on various types of vehicles [40]. The target of a TPMS is to avoid traffic accidents, poor fuel economy, and increased tire wear due to under-inflated tires through early recognition of a hazardous state of the tires.

The combination of this system function approach – the integration of a sensor – with a material development – introduction of a new type of tire - becomes visible in the following example: To reduce the risk of car accidents due to flat tires, run-flat tires were developed.

A run-flat tire is a pneumatic vehicle tire that is designed to resist the effects of deflation when punctured, and to enable the vehicle to continue to be driven at reduced speeds - under 90 km/h - and for limited distances - generally between 16 and 80 km depending on the type of tire [41]. But with run-flat tires, the driver does most likely not notice that a tire is running flat, hence a "run-flat warning system" were introduced based on the TPMS technology. The calculations in Sect. 4.2.1 of the paper outlined that optimum e-car design depends on understanding the functional dependencies between all domains, including material functions (Fig. 9).

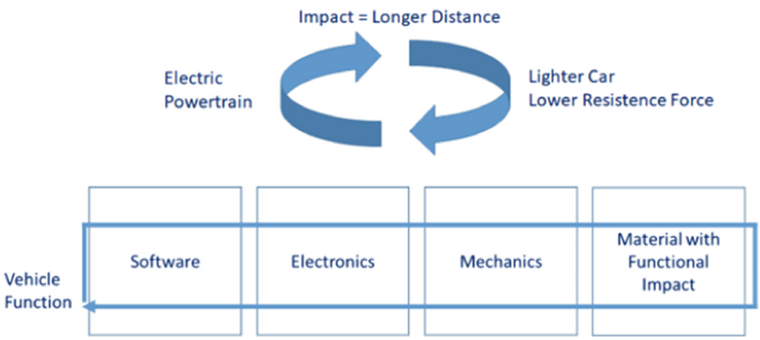

Fig. 9. Understanding vehicle functions and material functions I an integrated cycle

6 Relationship with the SPI Manifesto

A platform were such new cross-cutting approaches can be discussed is EuroAsiaSPI[2]. Its mission is to develop an experience and knowledge exchange platform for Europe where Software Process Improvement (SPI) practices can be discussed and exchanged and knowledge can be gathered and shared [30–32, 42]. The connected SPI manifesto defines the required values and principles for a most efficient SPI work. One main goal is to support changes by innovation and include all affected stakeholders. There are two main principles which supports this whole development process:

The principle "**SPI is inherently linked with change**" means that change is part of the normal development process which lead to new business opportunities. A current major change in the automotive industry affects the mobility. The mobility behavior of the people nowadays have changed again, the tremendous increase in the mobility in the last decade has decreased due to the increasing availability of online-connecting possibilities.

The principle "**Create a learning organisation**" means that best practices and knowledge need to be shared.

A further principle "**Support the organisation's vision and business objectives**" is proposed and should enhance the effectivity of the above described development process [6].

Another important platform for such new cross-cutting approaches is the European DRIVES project. DRIVES is a BLUEPRINT [33, 44] project for the automotive industry and creates a strategy that support the development of new business visions for 2030. It make also use of the above mentioned principle "Create a learning organisation" by combined the knowledge of different automotive associations, educational institutes and automotive related companies.

Using both platforms can be a starting point to develop real cross-cutting approaches to realize in the end the development of the electric car of the future which meets the new upcoming requirements.

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