FUNCTION-ORIENTED DEVELOPMENT OF COMPLEX MECHATRONIC PRODUCTS FROM AN HTO PERSPECTIVE: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

A component-orientated approach is commonplace in the automotive industry where the development focus lies on components. However, current challenges in the industry necessitates a mindset change in the development. Shifting the perspective from the components to functions can help with changing requirements, manage increasing complexity, support cross-disciplinary development, and foster innovation. To successfully implement this approach, it is essential to address not only the technical aspects of the solution, but also the human and organizational aspects affecting the process for its long-term success.

This paper investigates the function-oriented development methods of complex mechatronic products. A systematic literature review is conducted to analyse the current state of research. The existing function-oriented development approaches are summarized, the technological, human, and organizational perspectives are analysed, and the research gaps are highlighted. It is concluded that while function-orientation gains significance in industry and academia, and the importance of human and organizational factors are highlighted in the literature, they are not yet widely considered within the current function-oriented approaches.

Keywords: Function-oriented development, Model-based systems engineering, Design methodology, Multi- / Cross- / Trans-disciplinary processes, User centred design

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Cite this article: Uhri, E., Isenhardt, I. (2023) 'Function-Oriented Development of Complex Mechatronic Products from an HTO Perspective: A Systematic Literature Review', in *Proceedings of the International Conference on Engineering Design (ICED23),* Bordeaux, France, 24-28 July 2023. DOI:10.1017/pds.2023.203

1 INTRODUCTION

Up until the last few decades, automobiles were mainly mechanical products, with additional electronic components and software (Weber, 2009). The product was less complex, and it could be developed with a significant yet reasonable amount of product and disciplinary interfaces to electronics and software. The number of electronics in a vehicle has been exponentially increasing since the 1970s (Weber, 2009; Lindemann *et al.*, 2009). Nowadays, a vehicle is a mechatronic product, where mechanics, electronics, and software disciplines must be handled equally. Since the complexity of the product and process starkly increases and comprehension of the complete product decreases on an individual level, a strong and steady collaboration between disciplines is inevitable. The product development process must be redesigned to address the increasing product complexity and the need for stronger cross-disciplinary collaboration. Function-oriented development can be the successful direction of this redesign (Albers *et al.*, 2019a).

Component-oriented development refers to the focus on technical components within the product. For primarily mechanical products, functions can mostly be contained within the mechanical and/or electronic parts, and a component-oriented approach can be suitable. As the number of electrical and software parts increases, the functions start to distribute over multiple parts or the complete product. The interaction between individual functions should be considered during development. Additionally, the trend towards human-centred design also emphasizes customer functions, i.e., the functions that are needed to fulfil customer expectations. Thus, a shift from components to functions can benefit the involvement of the user in the process considerably (Denger *et al.*, 2012).

For this study, function-orientation is defined as a product development approach with a focus on product functions. Although the starting point of this research is vehicle development, the method is not limited to vehicles, as it can be applied to any complex product. Thus, the scope of this study is limited to complex, mechatronic products where multiple disciplines must collaborate during the development process. This function-oriented approach ensures that customer functions are explicitly defined, allowing the product to address specific user needs. While function-oriented development has been researched in the last couple of decades (mainly in the vehicle development domain), there has not been a standardized definition of the concept (Jacobs *et al.*, 2022; Albers *et al.*, 2018; Gaag *et al.*, 2009). The research thus far has focused mainly on the definition and exploration of function-orientation. Implementation of such a concept in a real-world environment is also an important aspect that should be considered in the design of a new development method.

The success of the implementation does not only depend on the technological concepts, but also on the individuals who interact with the method as well as the established organizational framework (Ernst, 2014; Eklund, 2000). The net benefits of a system can only be extracted by considering the human, technology, and organizational (HTO) aspects (Yusof *et al.*, 2008). Thus, it is important to not only examine the technological concepts of existing function-oriented methods, but also the inclusion of human and organizational factors.

The goal of this study is to systematically analyse the existing function-oriented development concepts for complex mechatronics products to define the research trends and highlight research gaps from the HTO perspective. Thus, this study aims to answer the following research questions (RQs):

RQ1: What are the current function-oriented development methods for complex mechatronic products?
RQ2: How far are the human and organizational aspects are considered within the existing methods?
RQ3: What are the gaps and potentials of function-oriented product development research with regard to human, technological and organizational factors?

2 RESEARCH METHODOLOGY

Systematic literature review (SLR) methodology was selected to investigate the existing literature on function-oriented complex product development. Using SLR, a research field can be investigated in a transparent and scientific manner where the results can be replicated. The methodology proposed by Xiao and Watson (2019) was adapted for this study, which can be seen in Figure 1.

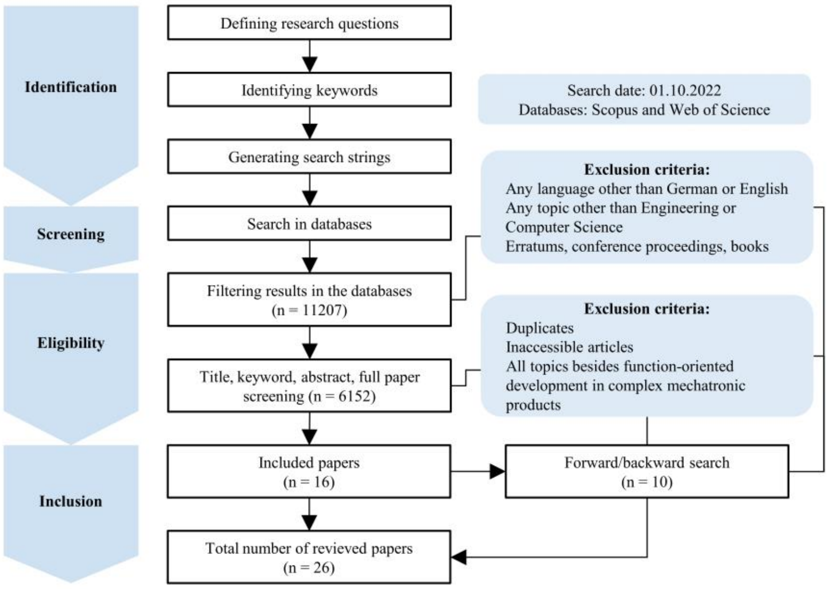

Figure 1: SLR procedure overview used in this study.

The SLR can be divided into four phases: Identification; Screening; Eligibility and Inclusion. In the identification phase, the research questions were defined according to the initial research and problem statement. Based on the research questions, search terms were generated. Two groups of search terms were identified: synonyms or related terms to “function-orientation” and to “product development”. Not every publication mentions the “complexity” of the product, or the “mechatronics” focus explicitly, therefore those terms were used as inclusion criteria. Since the topic is closely related to model-based systems engineering (MBSE), “MBSE” and “RFLP” (Requirements, Functions, Logic, Product) are also search terms included in the first group. Search terms were generated both in English and German languages because the subject field is prevalent in both English and German-speaking communities. Function-oriented development used in this context has originated and has been mainly researched in German communities according to the initial research before the SLR. It should be noted that the German terms are not necessarily the exact translations of the English words but rather approximations. Search strings were formulated from the generated search terms and used to screen the titles, abstracts, and keywords of publications within the databases Scopus and Web of Science. The exact search strings with all the search terms can be found in the Appendix.

A total of 11207 publications were found in the databases. In the screening phase, the search results on databases were filtered using the exclusion criteria. Sources that are neither in English nor in German language were excluded. Keywords and subject fields on the databases were screened and publications that are not in the fields of Engineering or Computer Science were excluded. Errata, books, and conference proceedings were also excluded on the databases. In Scopus, secondary sources (sources that are not indexed yet listed in Scopus) were included for the next steps.

In the eligibility phase, the remaining 6152 sources were screened manually. First, the duplicate titles were removed (n = 1417). Paper titles, abstracts and keywords were screened, and irrelevant sources were removed. Irrelevant in this context refers to all publications that are not focused on function-oriented development of complex mechatronic products. "Function-orientation" as a term exists in other domains, such as biology or software engineering, which made up the majority of the manually screened papers (n = 3639). Papers in engineering design were excluded if the paper did not explicitly examine function-oriented development in complex mechatronics products. Search terms “RFLP” and “MBSE” were also excluded if not explicitly used along with “function-orientation” (n = 945). Afterwards, full texts of the publications were assessed, and irrelevant titles were removed (n = 123). Then, publications that were not accessible to the author were removed (neither open access nor accessible through the institutional library) (n = 12). Lastly, in the inclusion phase, one cycle of forward/backward search was done on the remaining 16 publications, which were subjected to the same exclusion criteria above and resulted in additional 10 publications. The resulting publications were analysed to answer the research questions.

https://doi.org/10.1017/pds.2023.203 Published online by Cambridge University Press

3 RESULTS

In total, 26 publications were reviewed (which are denoted with an asterisk (*) in References). The final article set was examined both quantitatively and qualitatively. The quantitative analysis includes the publication year, university affiliation, article language, authors, type of publication, and the application field. The qualitative analysis includes the technological aspects of the function-oriented methods, the focus on human and organizational aspects (if available), and the future research directions outlined by the authors.

3.1 Quantitative analysis

Figure 2 depicts the analysed number of articles over the publication year. Due to the low number of investigated articles, a clear increase in the number of publications over years cannot be deduced. However, it should be noted that the number of publications in recent years has increased compared to publications prior to 2017.

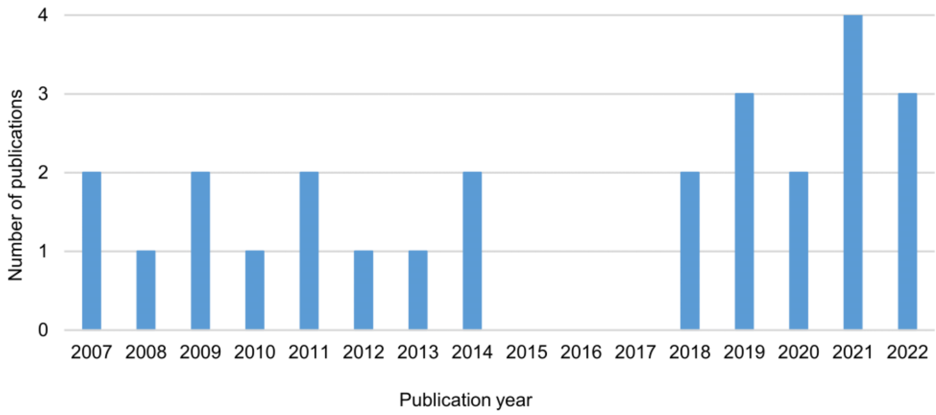

Figure 2: Number of analysed publications in each year

All reviewed publications are either solely (n = 23) or jointly (n = 3 – German/Swiss cooperation) of German origin in terms of university affiliation. Most of the publications are written in English (n = 17), and about one-third are in German (n = 9). While the inclusion of German search terms may have resulted in more German-origin publications, English terms were also used in the search independently and still resulted in mostly German-origin papers. The term “function-oriented development” in this context may be only prevalent in German-speaking communities. A similar development method may exist in other communities under different technical terms (such as "RFLP" without "function-orientation"), though it was not encountered during the search. Nevertheless, the benefits of the method are universal, and it can be implemented for complex mechatronic products regardless of origin.

RWTH Aachen University has published the largest number of articles on the topic (n = 7), followed by Karlsruhe Institute of Technology (n = 6), Technical University of Munich (n = 5), and ETH Zurich (n = 3). The most prominent authors on the topic are Jacobs (2022; 2021; 2021; 2021; 2022), Albers (2018; 2019a; 2020; 2019b), and Politze (2009; 2008; 2009); followed by Gaag (2010; 2009) and Schuh (2018; 2019). All other reviewed articles have unique authors. Most of the reviewed publications are conference papers (n = 15); followed by journal articles (n = 5), book chapters (n = 3) and dissertations (n = 3). Most of the publications apply the method in an automotive context (n = 15). Five of the remaining publications explain the methodology, while the rest of them use a wind turbine (Zhang *et al.*, 2022), a robot (Husung *et al.*, 2022), an automatic can squeezer (Politze and Bathelt, 2009), a windshield wiper (Politze and Dierssen, 2008), a smartphone (Friedrich, 2011), or a conveyor chain (Spütz *et al.*, 2021) as use cases.

https://doi.org/10.1017/pds.2023.203 Published online by Cambridge University Press

3.2 Qualitative analysis

3.2.1 Overview of the existing function-oriented development methods

There are various approaches to function-oriented development of complex mechatronics products. Methods such as Product Generation Engineering (PGE) (Aksoy *et al.*, 2021; Albers *et al.*, 2018; Albers *et al.*, 2019a; Albers *et al.*, 2020; Albers *et al.*, 2019b), MBSE and RFLP model (Denger *et al.*, 2012; Husung *et al.*, 2022; Renner, 2007; Stark *et al.*, 2010; Jacobs *et al.*, 2022; Wyrwich *et al.*, 2021; Zerwas *et al.*, 2021; Spütz *et al.*, 2021; Zhang *et al.*, 2022), function-oriented product descriptions (Politze and Bathelt, 2009; Politze and Dierssen, 2008; Politze *et al.*, 2009) or function-oriented solution search (Gaag, 2010; Gaag *et al.*, 2009) are function-orientation based or aim to integrate it as a main part of the proposed method. Modular product architecture (Schuh *et al.*, 2018; Schuh *et al.*, 2019), requirements engineering (Allmann, 2017; Ehring *et al.*, 2020), integration of geometrical and functional data (Cohrs *et al.*, 2014), functional safety (Kaiser *et al.*, 2013; Ehring *et al.*, 2020), and information management (Friedrich, 2011) employ a function-oriented look at the system.

Most of the publications include a data structure for the development artefacts (such as requirements, functions, solutions, and relations) (Aksoy *et al.*, 2021; Allmann, 2017; Denger *et al.*, 2012; Ehring *et al.*, 2020; Friedrich, 2011; Husung *et al.*, 2022; Jacobs *et al.*, 2022; Wyrwich *et al.*, 2021; Zerwas *et al.*, 2021; Spütz *et al.*, 2021; Zhang *et al.*, 2022; Politze and Bathelt, 2009; Politze and Dierssen, 2008; Politze *et al.*, 2009; Renner, 2007; Stark *et al.*, 2010). Multiple publications base function-oriented product development on an MBSE approach using the RFLP model (Denger *et al.*, 2012; Ehring *et al.*, 2020; Jacobs *et al.*, 2022; Wyrwich *et al.*, 2021; Zerwas *et al.*, 2021; Spütz *et al.*, 2021; Zhang *et al.*, 2022; Renner, 2007). In the proposed models, based on the RFLP model, solution-neutral product functions (F-layer) are derived from product requirements (R-layer), which mainly stem from customers. The solution alternatives for each function are derived on the L-layer. The modelling of the selected solutions onto the system builds the P-layer.

The emphasis on model-based development allows a structured and well-documented practice. (Jacobs *et al.*, 2022; Zerwas *et al.*, 2021). The proposed model is additionally used successfully in cost models (Spütz *et al.*, 2021), product portfolios (Wyrwich *et al.*, 2021), virtual testing workflows (Zhang *et al.*, 2022), modular product architectures (Renner, 2007), and integration of product portfolios with complexity management methods and semantic technologies (Denger *et al.*, 2012). A similar method to the RFLP model can be used for function-oriented design (FOD), where the system is described in requirements, functions, components, and relations (Stark *et al.*, 2010). Function-oriented MBSE can also be used based on Design Theory and Methodology (DTM) employing Systems Modelling Language (SysML) (Husung *et al.*, 2022).

Table 1 lists the three significant requirements given by multiple authors for function-oriented product development. A tick mark indicates that the requirement is listed in the publication. If none of the factors is included in any publications, the author is not listed. Main authors who have worked on the topic in multiple publications are condensed into one row.

Table 1: List of the three most significant technological requirements for function-oriented development per each author

Author	Solution-neutrality	Model-based approach	Functions as a communication basis
Aksoy *et al.* (2021)	✓	✓	
Albers *et al.* (2018; 2019a; 2020; 2019b)	✓	✓	✓
Allmann (2017)	✓		✓
Cohrs *et al.* (2014)			✓
Denger *et al.* (2012)	✓	✓	✓
Ehring *et al.* (2020)		✓	
Husung *et al.* (2022)		✓	
Jacobs *et al.* (2022)	✓	✓	✓
Politze *et al.* (2009; 2008)	✓		
Renner (2007)	✓	✓	✓
Stark *et al.* (2010)		✓	

A shift from components to functions allows for a more customer-oriented product, because the customer expectations of the product behaviour can be explicitly fulfilled by the product functions and the risk of overlooking customer functions is decreased (Albers *et al.*, 2018; Albers *et al.*, 2019a; Allmann, 2017; Politze and Dierssen, 2008). Solution neutrality describes the independence of the function from the solution principle. Solution-neutral description of the product functions is a significant requirement of the method, as it allows a clear separation between functions and solution alternatives (Albers *et al.*, 2018; Jacobs *et al.*, 2022; Denger *et al.*, 2012; Renner, 2007). This allows functions to be used as a cross-disciplinary communication platform, where functions are explicitly defined and described in a way that is comprehensible for all disciplines (Albers *et al.*, 2018; Albers *et al.*, 2019a; Cohrs *et al.*, 2014; Jacobs *et al.*, 2022; Ehring *et al.*, 2020). Thus, interactions between subsystems and disciplines are defined and potential conflicts between disciplines can be eliminated (Albers *et al.*, 2019a).

Additionally, explicit modelling of the functions can foster creativity and innovation through a possibly larger solution space. Experience in the field often plays a large role and designers use solution-specific functions and realizations of a system, which may deviate from customer requirements in the long term (Albers *et al.*, 2018). Existing solutions can be scrutinised in light of new requirements. Previously not considered solution ideas can be generated from explicitly written functions (Albers *et al.*, 2018). Function-oriented development also helps companies meet future trends in the industry (Aksoy *et al.*, 2021), helps to speed up the development process (Stark *et al.*, 2010), ensures data consistency through a traceable process (Ehring *et al.*, 2020), and allows managing the prevalent complexity (Kaiser *et al.*, 2013).

3.2.2 Focus on the human perspective within the existing methods

For a development process, the user is the designer employing the development process or method. Multiple articles consider the user as the end customer of the product and emphasize the importance of customer-oriented development (Aksoy *et al.*, 2021; Albers *et al.*, 2018; Albers *et al.*, 2019a; Albers *et al.*, 2020; Albers *et al.*, 2019b; Allmann, 2017; Politze and Dierssen, 2008; Renner, 2007). However, the user as the designer is not completely regarded in the analysed publications. The importance of including the designers' perspective is also emphasized (Albers *et al.*, 2020; Gaag, 2010; Renner, 2007), though not all illustrated problems are addressed within the respective proposed methods.

Different perspectives on product functions from customer and designer points of view are investigated in the PGE framework. Designers are encouraged to include the customer perspective on the product functions along with the technological perspective to deliver customer-oriented product functionalities (Albers et al., 2020). Individual designers and their adaptability to a new concept and the fundamental understanding of the system play an integral role in the success (Renner, 2007). Semantic barriers during solution search can be overcome by abstracting the problem statement, finding a solution at the abstract level, and concretizing the found solution (Gaag *et al.*, 2009). Functions can be used as a communication basis between humans or computer systems refer to the same concept. Additionally, a function concept ontology can be used to model functionalities from a human perspective (Politze and Dierssen, 2008).

3.2.3 Focus on the organisational perspective within the existing methods

Another non-technological aspect to consider is the organizational structure of an institution that is needed for function-orientation. Multiple publications emphasize the effect of organizational structure on the success of the implementation, though they do not necessarily provide a solution for all the issues presented (Albers *et al.*, 2018; Albers *et al.*, 2019a; Gaag, 2010; Renner, 2007).

In the PGE framework, the cooperation between departments and disciplines can be increased efficiently with function-orientation (Albers *et al.*, 2018). An organization structure can be introduced where the traditional component-oriented departments are supplemented with interfaces according to product functions and properties. This aims to overcome cross-departmental barriers and ensure efficient cooperation between disciplines (Albers *et al.*, 2019a). Organizational barriers between departments, heterogeneous usage of terminologies, lack of abstract function definitions, different structures and data protection are some of the significant issues of function-oriented solution search. Using company- and domain-specific terminology, adapting the ontology to the specific company, and the approval of the ontology usage by the company can help eliminate some of these issues (Gaag, 2010). Function-oriented modular product architecture can only be implemented by having a

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corresponding company strategy that will support modularity. A top-down approach should be taken, and management support is essential. Considerations about change management should also be part of the strategy. The establishment of the modular product architecture as a long-term successful project can only happen by considering the organizational framework the company is in (Renner, 2007).

3.2.4 Future research directions with regard to HTO aspects

The outlook sections of each publication give valuable insight into possible research directions and gaps in the literature. Though there are many different research areas mentioned by the authors, there are some overlapping, specific directions that can be deduced. Table 2 lists the human and organizational aspects listed in the outlook sections in at least two publications (in a similar fashion to Table 1). Technological aspects are not included in the table due to legibility (as they predominantly mention either the validation or the transferability of the methods, or the requirements from Table 1).

Table 2: List of human and organizational aspects mentioned in the outlook sections of the reviewed publications

Author	Human aspects		Organisational aspects		
	Mindset change	*User-friendly interfaces*	*Step-by-step transformation*	*Aligning to the existing structures*	*Management support*
Allmann (2017)			✓	✓	
Cohrs *et al.* (2014)	✓				
Denger *et al.* (2012)					✓
Ehring *et al.* (2020)	✓		✓		
Friedrich (2011)		✓		✓	
Jacobs *et al.* (2022)		✓			
Politze *et al.* (2009; 2009; 2008)				✓	
Renner (2007)				✓	✓
Schuh *et al.* (2018; 2019)		✓			

The majority of the publications point out the importance of validation of the presented methods (Albers *et al.*, 2019a; Cohrs *et al.*, 2014; Gaag *et al.*, 2009; Stark *et al.*, 2010; Politze and Bathelt, 2009; Politze *et al.*, 2009; Schuh *et al.*, 2019; Wyrwich *et al.*, 2021), transferability to other domains (Albers *et al.*, 2020; Albers *et al.*, 2019b; Aksoy *et al.*, 2021; Kaiser *et al.*, 2013; Zhang *et al.*, 2022) or expanding/refining the method (Albers *et al.*, 2018; Allmann, 2017; Denger *et al.*, 2012; Friedrich, 2011; Gaag *et al.*, 2009; Jacobs *et al.*, 2022; Zerwas *et al.*, 2021; Spütz *et al.*, 2021; Politze and Dierssen, 2008; Husung *et al.*, 2022). Though human and organizational factors are not exhaustively investigated, multiple authors indicate the importance of these factors for the successful implementation of the proposed methods.

There is an emphasis on the model-based aspect of the method, where the focus is shifted from a document-based to a model-based approach (Aksoy *et al.*, 2021; Albers *et al.*, 2020; Denger *et al.*, 2012; Ehring *et al.*, 2020; Husung *et al.*, 2022; Jacobs *et al.*, 2022; Stark *et al.*, 2010). Models are advantageous because they can serve as a communication tool, can remove ambiguities between designers and can provide a consistent and universal database for development. Model-based specifications of the information flow modelling of the customer-product interaction should be investigated further and made accessible to designers (Albers *et al.*, 2020). The functions can and should be used as a communication platform between designers and stakeholders (Allmann, 2017). A holistic and interdisciplinary development approach should be taken to maximize the benefits of function-orientation (Cohrs *et al.*, 2014).

The importance of the human perspective is emphasized in multiple publications (Albers *et al.*, 2018; Albers *et al.*, 2019a; Cohrs *et al.*, 2014; Denger *et al.*, 2012; Ehring *et al.*, 2020; Friedrich, 2011; Husung *et al.*, 2022; Zhang *et al.*, 2022; Schuh *et al.*, 2018; Schuh *et al.*, 2019). Customer, user, and provider benefits should be concretized (Albers *et al.*, 2018; Albers *et al.*, 2019a). A change of mindset is required from the designers and the company to be able to implement a function-oriented process (Cohrs *et al.*, 2014; Ehring *et al.*, 2020). User-friendly interfaces and standards for data

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exchange between designers and domains can increase the acceptance level of the proposed project (Friedrich, 2011; Zhang *et al.*, 2022; Schuh *et al.*, 2019). User-friendly interfaces and the reliability of the methods play into the usability and the applicability of function-orientation (Friedrich, 2011). The efficiency of the proposed methodologies should also be investigated from the designers' perspective (Husung *et al.*, 2022).

The transformation from component- to function-oriented development should be gradual since there can be resistance from the company (Allmann, 2017; Ehring *et al.*, 2020). Nevertheless, change towards function-orientation is necessary to remain competitive in the market and adapt to digitalization in product development. The effort for change is likely worthwhile to implement the function-oriented approach (Ehring *et al.*, 2020). An analogous product or data structure to the existing ones (Allmann, 2017), integrating function-orientation into established development processes and milestones (Renner, 2007), or using prevalent functional vocabularies (Politze and Dierssen, 2008) can aid the transformation process via a smoother learning curve for designers. Personnel training concepts, the adaptation of the workplaces and IT structures as well as the management commitment are necessary for the success of the implementation (Denger *et al.*, 2012). Specific roles, such as systems or lead engineers, can be the stakeholders during the implementation of the method (Schuh *et al.*, 2018). The proposed methods can support agile work and changing requirements (Jacobs *et al.*, 2022). A combination of agile and sequential work can be used for FO, though the benefits are not yet validated (Albers *et al.*, 2019a).

4 CONCLUSION & OUTLOOK

Function-orientation gains more and more significance within product (specifically vehicle) development as focusing on functions can help companies create more customer-oriented products, allows for more innovative solutions, and enables a communication base between different disciplines. This study gives an overview of the existing function-oriented development methods for complex mechatronic products. An SLR was conducted to analyse the existing methods. Current function-oriented development methods are summarized, the focus on human and organizational factors within the models are listed, and the research gaps are determined to answer the three research questions. This paper aims to support the researchers in the field of function-oriented and/or complex product development by identifying the research gaps and providing possible research directions.

MBSE – RFLP approach and the PGE framework are the most prominent function-oriented methods. Model-based development and solution-neutral, explicit descriptions of the functions are necessary. Functions also serve as a basis for communication between disciplines and functional modelling allows the simulation of system behaviour in early development phases. The benefits of a function-oriented process include customer-oriented product development, shorter development times, stronger cross-disciplinary development, innovative solution generation, complexity management, data consistency within the process, and following industry trends.

While there is some focus on the implementation of the methods from a human and/or organizational perspective, the qualitative analysis shows that the emphasis is more on the end customers rather than on the designers. Multiple publications highlight the inclusion of the designer and organizational perspectives, yet they are considered in a very limited fashion in literature. Future research should focus on the user-centred design of the function-oriented development process including the organizational framework of the company. Change management methodologies can also be adapted for the implementation and long-term success of the method. Future research should also address extracting all the HTO requirements for function-oriented development. Another future research direction is the application field. While the methods are applicable to all complex mechatronics products, the main research domain has been the automotive industry. The advantages of function-orientation can be utilized in other domains such as aircraft, spacecraft, or healthcare technology development. Future research directions of this study include the broader research of literature including other domains (such as only electronics or software development), providing a consistent definition of the term "function-oriented development", defining requirements for function-orientation, and the application of relevant methods in a case study for a qualitative evaluation of the methods.

ACKNOWLEDGEMENTS

This research was funded by BMW Group.

https://doi.org/10.1017/pds.2023.203 Published online by Cambridge University Press

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APPENDIX

The following search strings are given to the databases Scopus and Web of Science, where the titles, abstracts and keywords of publications are screened:

English: *(((product AND development) OR (product AND design) OR (product AND engineering) OR (product AND creation) OR (product AND implementation) OR (npd) OR (design AND metodolog*) OR (engineering AND design) OR (pdp)) AND (("model-based systems engineering") OR (mbse) OR (rflp) OR ("function oriented") OR ("function driven") OR ("function centered") OR ("function orientation") OR ("function based") OR (rfla) OR ("function centric")))*

German: *(((funktionsorientiert*) OR (Funktionsorientierung) OR ("model-based systems engineering") OR (mbse) OR (rflp) OR (rfla) OR (funktionszentriert*) OR (funktional*) OR (funktionsbasiert*) OR (funktions*)) AND ((Produktentwicklung) OR (Produktentstehung) OR (Produktgestaltung) OR (Produktentwicklungsprozess) OR (Produktentstehungsprozess) OR (Produktgestaltungsprozess) OR (pep) OR (Entwicklung) OR (Gestaltung) OR (Modellierung) OR (Konzept) OR (Lenkung) OR (Entwicklungsprozess) OR (Entstehungsprozess) OR (Gestaltungsprozess)))*