Book of Abstracts

27. – 28.09.2021

SYMPOSIUM
Design
for **X** 2021

Book of Abstracts
Symposium Design for X

27. and 28. September 2021

virtual conference

Prof. Dr.-Ing.
Kristin Paetzold

Seit März stellt uns das neuartige Coronavirus immer wieder vor neue Herausforderungen. Auch das DfX-Symposium bleibt nicht unverschont. Um die Sicherheit der Teilnehmer sowie eine seriöse Planung der Veranstaltung gewährleisten zu können, haben wir uns letztlich dazu entschlossen, das Symposium einmalig als Webkonferenz durchzuführen. Dabei liegt es mir besonders am Herzen, den einzigartigen Charakter des DfX-Symposiums zu erhalten, nämlich den intensiven wissenschaftlichen Diskurs zwischen Jungwissenschaftlern und Professorinnen und Professoren. In diesem Zusammenhang freue ich mich, dass einige meiner Kolleginnen und Kollegen den Weg nach Erlangen antreten werden, um in reduzierter „Professorenrunde" die virtuellen Beiträge live zu diskutieren.

In dieser schnelllebigen Zeit geht mein Dank insbesondere an meine beiden Mitveranstalter und Kollegen Sandro Wartzack und Dieter Krause für das eingebrachte Engagement und die Flexibilität, das Symposium dieses Jahr neu zu erfinden. Darüber hinaus möchte ich meinen Mitarbeitern Herrn Denk Martin sowie Emir Gadzo für die Organisation und das Einbringen neuer Ideen und deren kompetente Umsetzung danken. Zuletzt möchte ich natürlich auch allen Teilnehmerinnen und Teilnehmern für ihre Beiträge danken.

In diesem Sinne freue ich mich auf viele interessante Vorträge und eine sicher spannende und lebhafte Diskussion.

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Ab München Hbf: S-Bahn S6 (Tiefgeschoss) bis Endstation Tutzing oder Regionalbahn in Richtung Garmisch bzw. Kochel.

Fußweg vom Bahnhof zur Akademie: ca. 10 Minuten – Bahnhofstraße, Hallberger Allee, Hauptstraße, Schlossstraße.

Digital Engineering

Produktentwicklung für die additive Fertigung

MBSE/Systems Engineering

Menschzentrierte Produktentwicklung

Design for X

Program: Montag 27. September

09:00 - 09:10 Uhr	▌Technisches Setup (Keynote: nach der Mittagspause)
09:10 - 10:25 Uhr	**Begrüßung & Session 1 „Digital Engineering"**

- A data model for linking testbed and field test data
  (Christopher *Sauer, Friedrich-Alexander-Universität Erlangen- Nürnberg*)
- Methodik zur frühzeitigen Integration prozessspezifischer Einflussfaktoren aus der automatisierten Montage in die Auslegung funktionskritischer Komponenten
  (Eva *Russwurm, Friedrich-Alexander-Universität Erlangen- Nürnberg*)
- Erweiterung des Nutzens von Sensordaten durch Verwendung in simulationsgestützten virtuellen Sensoren auf Basis der Finite-Elemente-Analyse
  (*Andreas Kormann, Universität Bayreuth*)

10:25 - 11:40 Uhr	Kaffeepause
11:40 - 11:45 Uhr	▌Technisches Setup
11:45 – 12:00 Uhr	**Session 2 „Nutzerzentrierung"**

- Procedure for the transferability of application-specific boundary conditions for the testing of components and products
  (*Lukas Schwan, Technische Universität Hamburg*)
- Herausforderung Methodeneinsatz – Erklärungsansätze aus der Akzeptanzforschung
  (*Simon* J. *Nicklas, Universität der Bundeswehr München*)
- Objective evaluation of vibration comfort through the design of a vibration filter - Implementation of a study design for vibration comfort evaluation
  (*Diana Fotler, Karlsruher Institut für Technologie*)

12:00 - 13:00 Uhr	Mittagspause
13:00 - 13:05 Uhr	▌Technisches Setup
13:05 - 13:25 Uhr	Keynote
13:25 – 14:40 Uhr	**Session 3 „Additive Fertigung"**

- Potentiale additiv gefertigter Gitterstrukturen – ein Review
  (*Fiona Schulte, Technische Universität Darmstadt*)
- Konstruktive Potentiale einer Mikrostrukturgradierung von topologieoptimierten L-PBF-Bauteilen
  (*Johannes Geis, Technische Universität Darmstadt*)
- Systematische Erfassung von Einflussfaktoren für das Additive Tooling von Spritzgusswerkzeugen
  (*Steffen Schrock, Hochschule Offenburg*)

14:40 – 14:55 Uhr	Kaffeepause
14:55 - 15:00 Uhr	▌Technisches Setup
15:00 – 16:15 Uhr	**Session 4 „MBSE"**

- Architecture of the Digital Twin in Product Validation for the Application in Virtual-Physical Testing to Investigate System Reliability
  (*Felix Leitenberger, Karlsruher Institut für Technologie*)
- Synthetic Data Generation for Deep Learning Models
  (*Christoph Petroll, Wehrwissenschaftliches Institut für Werk- und Betriebsstoffe*)
- Systematische Bewertung von Auswirkungsanalysen des Engineering Change Managements
  (*Iris Gräßler, Universität Paderborn*)

16:15 - 16:30 Uhr	Kaffeepause
16:30 – 16:35 Uhr	▌Technisches Setup
16:35 – 17:50 Uhr	**Session 5 „Digital Engineering"**

- Voraussetzungen für den Einsatz datengetriebener Methoden in der Produktentwicklung
  (*Jan Mehlstäubl, Universität der Bundeswehr München*)
- Methodischer Aufbau von Entwicklungsumgebungen nach dem Generative Parametric Design Approach
  (*Kevin Herrmann, Leibniz Universität Hannover*)
- A semantic web approach for structuring data-driven methods in the product development process
  (*Benjamin Gerschütz, Friedrich-Alexander-Universität Erlangen- Nürnberg*)

09:00 - 09:10 Uhr	Technisches Setup

09:10 - 10:25 Uhr — **Session 6 „Additive Fertigung"**

- Ansatz zur belastungsgerechten Auslegung additiv gefertigter Meso-Strukturen in Bauteilen
(*Fiona Schulte, Technische Universität Darmstadt*)
- Evaluation of design support tools for additive manufacturing and conceptualisation of an integrated knowledge management framework
(*Claudius Ellsel, Technische Universität Berlin*)
- Entwicklung eines Prozesses zur Konstruktion von Hybrid-Implantaten für die Herstellung mittels additiver Fertigung
(*Martin Pendzik, Technische Universität Dresden*)

10:25 - 10:40 Uhr — Kaffeepause

10:40 - 10:45 Uhr — Technisches Setup

10:45 - 12:00 Uhr — **Session 7 „MBSE"**

- Ansatz eines holistischen Datenstamms zur modellbasierten, domänenübergreifenden Nutzung in der Produktentstehung
(*Markus* C. *Berschik, Technische Universität Hamburg*)
- Heterogene Modellierung - Verknüpfung und Integration von Systemmodellen der SysML mit CAD-Modellen
(*Thomas Schumacher, Technische Universität Clausthal*)
- Modellbasierte Umsetzung des Anforderungsmanagements zur Unterstützung der Entwicklung eines Experimentalsatelliten
(*Emir Gadzo, Universität der Bundeswehr München*)

12:00 - 13:00 Uhr — Mittagspause

13:00 - 13:05 Uhr — Technisches Setup

13:05 - 13:55 Uhr — **Session 8 „ Design for X"**

- Der Einfluss der Fügetechnik auf die Konstruktion von Produkten für das Kreislaufwirtschaftssystem
(*Phillip Wallat, Technische Universität Clausthal*)
- Integration eines digitalen Maschinenparks in ein Forschungsdatenmanagementsystem
(*Osman Altun, Leibniz Universität Hannover*)

13:55 - 14:10 Uhr — Kaffeepause

14:10 – 14:40 Uhr — Verabschiedung mit Preisverleihung

A data model for linking testbed and field test data

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With the help of data-driven methods such as machine learning, the development of the current product generation can be supported and improved through the early use of data from previous products and product generations. For example, machine learning can be used to predict later product behaviour in field tests from testbed data. This can significantly shorten the development time and save expensive field tests. To implement this data provision for the development processes, uniform data models enable the use of data-driven methods and are of central importance. This paper presents a data model using the example of a testbed for electric vehicle transmissions. Here, potentials for a later data-driven prediction of the product behaviour in the field test for the optimisation of the existing development are shown.

Keywords: *Graph databases, machine learning, digital engineering*

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Methodik zur frühzeitigen Integration prozessspezifischer Einflussfaktoren aus der automatisierten Montage in die Auslegung funktionskritischer Komponenten

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Dimensioning function-critical components in automated manufacturing systems is critically and depends on the handled objects as well as the handling processes. The processes lead to mechanical forces and torques on the components. During engineering, these process-depending forces are mostly unknown and thus, are taken into consideration by using high safety factors. In order to reduce the resulting over-dimensioning a novel methodology, which facilitates all available information and new methods, is presented. By combining a Co-Simulation, consisting of FEM- and Multi-Physics-Simulations, with MBSE-approaches the digitized workflow iteratively converges the parameters of these critical components. A hardware-in-the-loop-approach assists gathering specific data and validating the final design-parameters.

Keywords: automated manufacturing, methodic design/dimensioning, process-effects, Model based Systems Engineering, Co-Simulation

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Erweiterung des Nutzens von Sensordaten durch Verwendung in simulationsgestützten virtuellen Sensoren auf Basis der Finite-Elemente-Analyse

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Within the framework of digital engineering, the digital development of products is always advanced. Extensive knowledge of the designed product and its properties is necessary for this purpose. Simulation-based virtual sensors are suitable for reducing the costs of test benchmark trials by making maximum use of the sensor data obtained there. These sensors, which are based on finite element analysis, are used in the same way as physical sensors after they have been applied digitally. In this paper, methods are presented how these sensors can be applied and which limitations they have.

Keywords: *Digital Engineering, Finite Element Analysis, Virtual Sensor*

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Procedure for the transferability of application-specific boundary conditions for the testing of components and products

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Testing plays an important role in the product development process in order to verify the safety and functionality of products and components. Application-specific boundary conditions must be transferred between different model layers and structural complexity levels in order to obtain a close representation of reality. Hereby the view on the overall test system as well as the superordinate problem definition is made difficult for the product developer. In this article a procedure is presented, which builds up on the product component test pyramid. The application of the procedure is shown in the contribution for the virtual testing of sandwich structures, the development of physical models in medical radiotherapy as well as the dynamic testing with combined environmental conditions.

Keywords: *Testing Approach, Boundary Conditions, Virtual Testing, Combined Environmental, Radiotherapy Phantom*

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Herausforderung Methodeneinsatz – Erklärungsansätze aus der Akzeptanzforschung

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2 Technische Universität Dresden, Institut für Maschinenelemente und Maschinenkonstruktion, Dresden

Whilst there is broad agreement that methods can efficiently support development work, new methods often find little acceptance in industrial practice in terms of consistent use. Therefore, this paper aims to identify factors influencing the formation of acceptance that help successfully design and implement methods. To this end, a literature review of acceptance research identifies relevant models for product development and describes their application context, dominant and moderating variables, and explananda. Subsequently, a disciplinary-historical research map for the explanatory power of each acceptance-forming step is derived. Finally, this article deduces possible points of connection and requirements for the specific adaptation of the findings to methods as an object of acceptance.

Keywords: *acceptance research, method application, method acceptance, theory concept*

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Objective evaluation of vibration comfort through the design of a vibration filter - Implementation of a study design for vibration comfort evaluation

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In order to design products that are optimised for the user, it is important to take the user's perception of the product into account as early as possible, whereby this is strongly influenced by the vibrations that occur. For the use of power tools, there is currently a lack of knowledge about possible influencing factors and the resulting perception of the user. Within this manuscript, a study design is presented with which potential influences on vibration perception can be investigated. The implementation of study design is based on the most important influencing factors within the perception and judgement process of vibration comfort, which originate from an expert workshop and a literature research in the field of psychology.

Keywords: *User Studies, Influencing Factors, Perception and Judgement Formation of Stimuli, Human-Machine Systems*

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Potentiale additiv gefertigter Gitterstrukturen – ein Review

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2 Institute for Technical Product Development, University of the Bundeswehr Munich

Additive manufacturing (AM) offers a variety of potentials, especially the fabrication of lattice and cellular structures. The properties of lattices and cells can be influenced on purpose by designing their defined structure. To utilise the potentials in applications, it is important to identify them and point out possible applications with successful examples, which allow transferring approaches for the integration of lattice structures in components to new applications. Therefore, this contribution provides a collec-tion of potentials of additively manufactured lattice structures from the state of research in a systematic review and examines their transferability to different applications.

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Konstruktive Potentiale einer Mikrostrukturgradierung von topologieoptimierten L-PBF-Bauteilen

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The design space of topology optimizations is often limited by installation space limitations and interfaces to other components, which can result in local stress concentrations in the resulting notches. In this paper, the potential of microstructure grading was investigated by means of FE analyses on the basis of two components. In experimental investigations of L-PBF manufactured tensile specimens made of AlSi10Mg, a producible variation range of the Young's modulus from 46 to 62 GPa could be determined. By grading the Young's modulus, a local stress reduction of 18.6% and 25% could be achieved by means of FE analysis, as well as a slight displacement of the stresses around the critical area.

Keywords: *Additive Manufacturing, Laser Powder Bed Fusion, Microstructural Grading, Finite Element Analysis*

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Systematische Erfassung von Einflussfaktoren für das Additive Tooling von Spritzgusswerkzeugen

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Additive tooling is a quick and cost-effective way of producing injection molded products and high fidelity prototypes using the injection molding process. As part of product development, additive tooling is integrated into a complex process. A lack of design and application knowledge represents a barrier in its use. The present work shows how a Design-Structure-Matrix (DSM) can be used to systematically record and analyze influencing factors and their interrelationships. A systematic literature search is carried out to identify the factors and relationships.specific data and validating the final design-parameters.

Keywords: *Additive Tooling, Injection Molding, Rapid Tooling, Design-Structure-Matrix*

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Architecture of the Digital Twin in Product Validation for the Application in Virtual-Physical Testing to Investigate System Reliability

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The digital twin offers new possibilities for product validation in the application of virtual-physical testing. A more concrete description of the digital twin in product validation is missing and therefore will be specified here. For this aim, a single-case study was conducted using an electrohydrostatic actuator. This system is influenced by many interactions due to its integral design and is thus representative of a complex system. The characterization of the digital twin in product validation is done by specifying the model quality, interoperability and integration levels. The research results of the digital twin are used and linked to the state of research from product validation. An architecture represents these characteristics and thus allows transferability to other systems.

Keywords: *Digital Twin, Product Validation, Testing, System Reliability, Electrohydrostatic Actuator*

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Synthetic Data Generation for Deep Learning Models

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The design freedom and functional integration of additive manufacturing is increasingly being implemented in existing products. One of the biggest challenges are competing optimization goals and functions. This leads to multidisciplinary optimization problems which needs to be solved in parallel. To solve this problem, the authors require a synthetic data set to train a deep learning metamodel. The research presented shows how to create a data set with the right quality and quantity. It is discussed what are the requirements for solving an MDO problem with a metamodel taking into account functional and production-specific boundary conditions. A data set of generic designs is then generated and validated. The generation of the generic design proposals is accompanied by a specific product development example of a drone combustion engine.

Keywords: *Multidisciplinary Optimization Problem, Synthetic Data, Deep Learning*

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Systematische Bewertung von Auswirkungsanalysen des Engineering Change Managements

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Challenges in decisions on technical changes are the lack of knowledge about the expected impact and change propagation. Currently, no literature study contains a systematic differentiation and evaluation of existing approaches, which is a prerequisite for practitioners to select a suitable approach.

This research aims at defining differentiation criteria as well as generally applicable requirements for evaluation. A four-step approach is used: systematic literature review on approaches for impact analysis of engineering changes (1), categorization and prioritization of approaches based on reoccuring elements (2), derivation of context specific requirements for evaluation (3), and evaluation of approaches (4). The result indicates existing potential of object-oriented modeling approaches.

Keywords: *Engineering Change Management, Impact Analysis, Engineering Changes, Model-based Systems Engineering, Product Development*

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Voraussetzungen für den Einsatz datengetriebener Methoden in der Produktentwicklung

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Data mining and machine learning are successfully applied in many business areas such as marketing or production. Due to the increasing complexity in data and information flows and the large amount of data, data-driven solutions have also great potential in product development. Nevertheless, many companies are not able to integrate data-driven methods into their product development process. In order to support the application of data-driven methods, this paper identifies necessary prerequisites for their integration in product development. Based on a data analysis process, the prerequisites are elaborated and, subsequently, levers for their design are derived.

Keywords: *Data-driven Methods, Product Development, Data Mining, Machine Learning*

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Methodischer Aufbau von Entwicklungsumgebungen nach dem Generative Parametric Design Approach

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Computer-aided development environments have increasingly found their way into product development over the last 20 years. Particularly in the development of different product variants for different requirements and target groups, they enable the partially or fully automated creation of component designs. The Generative Parametric Design Approach (GPDA) enables the generation of highly dynamic product models for complex components and assemblies by means of structural optimization and thus combines the advantages of parametric, knowledge-based and generative modeling methods. This paper generalizes the GPDA approach and demonstrates its applicability to functional assemblies and in the context of a manufacturing stage-based design model

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A semantic web approach for structuring data-driven methods in the product development process

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For the successful integration of data-driven methods in existing processes, it is first necessary to know these methods and their fields of application, potentials, and individual limits. This requires an easily accessible knowledge base. Depending on possible use cases and available data, this knowledge base should suggest methods that can lead to an optimization of the overall product development process. To prevent the knowledge base from being a rigid catalogue, it is essential to link it to the existing methods of the product development process. This contribution presents an approach based on the semantic web application Semantic MediaWiki, that ensures a connected representation of method knowledge and at the same time enables a link with use cases in the product development process.

Keywords: *digital engineering, data-driven-method, design-process, semantic-web*

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Ansatz zur belastungsgerechten Auslegung additiv gefertigter Meso-Strukturen in Bauteilen

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Additive manufacturing enables the production of defined cellular and lattice structures. These additively manufactured meso structures offer various potentials like lightweight design or defined inner properties. To reduce the design effort a methodological approach is derived to enable fit for purpose design of components with meso structures using analytical calculation rules. The analogy to the analytical calculation of solid components emphasises the relevant parameters for the design as well as their influence on the properties of meso structures. Furthermore, based on the streamlined preliminary design, indications for the selection of suitable elementary cells regarding arising, even inhomogeneous, stresses are provided. The design method is exemplary applied to a cantilever beam.

Keywords: *additive manufacturing, meso structures, lattice structures, systematic design, fit for purpose design, preliminary design, equivalent properties*

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Evaluation of design support tools for additive manufacturing and conceptualisation of an integrated knowledge management framework

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Over time, additive manufacturing (AM) has gained more and more adoption into series production. Software tools are developed to assist designers to incorporate specific design for additive manufacturing (DfAM) guidelines into their product development processes. In this paper, an overview of already existing DfAM functionality is given by a review of scientific publications and commercial software products. Additionally, interviews with members of development teams which design AM parts are carried out to assess specific workflows and problems in the current design process. In both investigations, the lack of an integrated and automated software solution emerged. Based on these results, a structure for an integrated design support toolchain is proposed

Keywords: *DfAM, review, design support tool, knowledge management, framework*

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Entwicklung eines Prozesses zur Konstruktion von Hybrid-Implantaten für die Herstellung mittels additiver Fertigung

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Additive manufacturing is characterized by a high degree of individuality and flexibility with regard to design and product layout. This enables the integration of different functions in a component. Application specific parameters such as load-bearing capacity, biocompatibility and manufacturing restrictions play a role of varying relevance. The combination of these parameters suitable for the individual patient case (implants) often cannot be realized with only one material. At time, however, only limited research has been done on design, manufacturing and application of hybrid implants (use of several materials). The aim is to develop and evaluate a process for designing hybrid implants depend-ing on individual requirements and to clarify whether automation of this is possible.

Keywords: *Hybrid-Implants, Individual-Implants, Implant-Design, Process- Automatisation for Hybrid-Implants, Additive Manufacturing*

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Ansatz eines holistischen Datenstamms zur modellbasierten, domänenübergreifenden Nutzung in der Produktentstehung

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The current rise of interdisciplinarity in product creation leads to data sets that are characterised by different point of views which often come with inconsistencies. Furthermore, there is a trend towards using such data sets for innovative data-based product development processes, which require a holistic data representation. However, inconsistencies exacerbate these efforts. This paper presents an approach for a holistic data base for product creation that enables different point of views while also allowing for traceability and uniqueness. This approach uses model-based systems engineering techniques and consists of a model with two levels of detail, which allow for different point of views to coexist on a specific level while being connected on a generic level.

Keywords: *product creation, point of view, inconsistencies, holistic data base, MBSE*

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Heterogene Modellierung - Verknüpfung und Integration von Systemmodellen der SysML mit CAD-Modellen

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The development of mechatronic systems requires domain-specific and domain-independent models. Missing approaches to consistently link domain-independent and domain-specific mod-els leads to a lack of acceptance of modelling languages, like SysML. Heterogeneous models present an approach to integrate detailed domain-specific and abstract domain-independent model elements into one model. This paper introduces the heterogene-ous modelling approach and presents a technical concept for linking (representation) and integrating (presentation) model el-ements from SysML-diagrams and CAD-models. In addition, the advantages of heterogeneous models for specific development use cases are explained.

Keywords: *Model-based systems engineering, heterogeneous modelling, SysML, CAD, Data exchange*

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Modellbasierte Umsetzung des Anforderungsmanagements zur Unterstützung der Entwicklung eines Experimentalsatelliten

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Dimensioning function-critical components in automated manufacturing systems is critically and depends on the handled objects as well as the handling processes. The processes lead to mechanical forces and torques on the components. During engineering, these process-depending forces are mostly unknown and thus, are taken into consideration by using high safety factors. In order to reduce the resulting over-dimensioning a novel methodology, which facilitates all available information and new methods, is presented. By combining a Co-Simulation, consisting of FEM- and Multi-Physics-Simulations, with MBSE-approaches the digitized workflow iteratively converges the parameters of these critical components. A hardware-in-the-loop-approach assists gathering specific data and validating the final design-parameters.

Keywords: *Model based systems engineering (MBSE), requirements management, satellite research project, model based approach, systems engineering*

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Der Einfluss der Fügetechnik auf die Konstruktion von Produkten für das Kreislaufwirtschaftssystem

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To transform the current economic system towards a circular economy it is necessary to design products accordingly. Many information regarding the suitability of those products are already in existence. Structuring those information and embedding them into the engineering design process will aid the transformation towards a circular economy.

The compatibility of materials during the recycling process is crucial for an efficient recycling, therefor the non-compatible materials have to be separated manually beforehand. Joint technology is the key to be able to do so. Depending on the circular approach the joint technologies differ in their suitability.

By link all those information, the engineer can be provided with a tool to directly show the effects of his decisions for the product.

Keywords: *Circular Economy, Joint Technology, Engineering Design, Materials, Recycling Technology*

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Integration eines digitalen Maschinenparks in ein Forschungsdatenmanagementsystem

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The global trend towards comprehensive digitization of technologies in product manufacturing leadings to radical changes in engineering processes and requires a new, expanded understanding in the handling of data. Especially in large interdisciplinary projects with several subprojects, the use of a research data management (RDM) system is necessary.

This paper describes the concept to realise a FDM system according to FAIR (Findable, Accessible, Interoperable, Reusable) data principles and using open source systems. The approach is explained on the example of a digital machine park within the Collaborative Research Centre Oxygen-free production (CRC 1368).

Keywords: *Research data management, knowledge management, semantic information linking, FAIR data principles, digitization of scientific data*

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