The impact of applying product-modelling techniques in configurator projects

This paper aims to increase understanding of the impact of using product-modelling techniques to structure and formalise knowledge in configurator projects. Companies that provide customised products increasingly apply configurators in support of sales and design activities, reaping benefits that include shorter lead times, improved quality of specifications and products, and lower overall product costs. The design and implementation of configurators are a challenging task that calls for scientifically based modelling techniques to support the formal representation of configurator knowledge. Even though extant literature has shown the importance of formal modelling techniques, the impact of utilising these techniques remains relatively unknown. Therefore, this article studies three main areas: (1) the impact of using modelling techniques based on Unified Modelling Language (UML), in which the phenomenon model and information model are considered visually, (2) non-UML-based modelling techniques, in which only the phenomenon model is considered and (3) non-formal modelling techniques. This study analyses the impact to companies from increased availability of product knowledge and improved control of product variants. The methodology employed is an exploratory survey, followed by interviews with 18 manufacturing companies providing customised products. The results indicate that companies using UML-based modelling techniques tend to have improved documentation of their product knowledge and an improved ability to reduce the number of product variants. This paper contributes to an increased understanding of what companies can gain from using more formalised modelling techniques in configurator projects, and under what circumstances they should be used.
Achieving long-term modularization benefits: A small- and medium-sized enterprise study

Long-term commonalities and experiences with modularization in comparable small- and medium-sized enterprises have been identified as a research gap. This article contributes by describing a unique collection of experiences from companies that received a similar introduction to the same core modularization topics through a series of introductory initiatives. This shared introduction makes the projects and processes of the companies comparable. The study reveals three main aspects of achieving significant long-term benefits from modularization initiatives: the company must (1) aim big and be willing to change its foundation accordingly, (2) draw on the right positional strength and have broad organizational inputs, and (3) properly coordinate work and then actively seek to preserve the focus and results over a long period of time. Interviews were conducted with representatives from 12 of these companies. Qualitative and quantitative data obtained from the interviews were used to draw parallels between the definition, execution, and impact of modularization. The stated results and project circumstances show commonalities for the successful implementation of modularization. They indicate which actions lead to the desired changes and secure the results persistently. The participants have achieved various results, such as strategic changes, new architectures, fewer variants, higher product earnings, and new development processes. Some have also introduced maintenance plans to secure the results, such as establishing configurators, performing weekly analyses, recruiting dedicated personnel, and so on. The interviews revealed several influencing factors, such as management support, internal communication, organizational drive, proper facilitation, and prioritized project management. They also indicated that significantly more improvement can be achieved with proper goal setting and commitment to specific goals. These are the factors that can help future small- and medium-sized enterprises in the proper incorporation of modularization and in maximizing their exploitation of modularization theory.

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Application of a graphical scheme for representing the mode of action of products for identification of key characteristics

In order to identify where to focus the tolerance analysis during the product development process, it is beneficial to find the key characteristics. However, for highly integrated, multiple-state products, product designers have difficulties in efficiently communicating and tracking the complex mode of action. As a consequence, not all relevant key characteristics are found in the initial screenings. We propose a systematic graphical representation scheme for modelling the mode of action of products, and we apply this scheme on a case example, in order to illustrate its applicability and its usefulness for the identification of key characteristics.

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Assessing Increased Product Line Commonality’s Effect on Assembly

We present results of an experiment focused on quantifying effects on assembly productivity and product quality by introducing a product platform and increasing commonality between variants in a product family. The experiment was set up with 50 engineering students, who over three rounds produced a family of LEGO car models. Over the rounds a product platform was introduced and the Commonality Index was increased from 47.8% to 88.4%. Compared to productivity and quality results show an increased output of 118% and a decrease in product defects by 31% when applying a platform-based approach.

A study of cost implications from not maintaining a PCS

This article is a case study investigating the cost implications of using a Product Configuration System (PCS) that was not sufficiently maintained. It presents a case study that demonstrates and quantifies the potential financial loss of relying on a PCS to generate quotations without sufficient focus on updating and correcting the cost data and product offerings. The study finds that comparing quotations made from a not-maintained PCS, with recalculations of the same projects in a newer updated PCS that the company in a period of one year in average miscalculated the costs to be 20% lower than the real costs. We concluded that the cost of not maintaining a PCS can be far higher than the costs to update and maintain the system and furthermore that the success of PCS reported in the literature might not be consistent for long
time of use of PCS if the systems are not properly maintained.

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**Design for manufacturability of macro and micro products: a case study of heat exchanger design**

In this paper, a novel methodology in designing a micro heat exchanger is proposed by modifying a conventional design methodology for macro products with the considerations of differences between design of a micro and a macro product. The methodology starts with the identification of differences in design considerations for micro scale products compared to the macro scale. These design considerations consist of material selection, manufacturing process, physical phenomena and shape and geometry design. Manufacturability criteria are defined and various potential manufacturing processes for fabricating micro heat exchangers are ranked based on the defined criteria. Following the design methodology, primary design ideas for micro heat exchangers are generated according to the heat transfer principles for macro heat exchangers. Taking micro design considerations into account, the designs from next iteration are created. Finally, the performances of the designs for micro heat exchangers are compared with their macro counterparts. The most appropriate designs for micro heat exchangers are finalized. The micro specific design guidelines obtained by the designer through evaluating the modeling results and the design criteria are formulated in a knowledge-based unit called "Rules To Consider" (RTC). The proposed methodology provides an interactive design process through the RTC unit. The RTC data is used by the designer in the subsequent iterations of the micro-product design as well as can be used by designers/engineers in design of the same category of micro products. Furthermore, through utilization of the proposed methodology by designers/engineers for design of other micro products, the RTC unit can be enriched with micro-oriented design principles and accordingly provide a basic guideline for design of micro products.

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Design Thinking in Product Configuration Projects

Developers of product configuration systems (PCS) act as designers, albeit often not recognizing they are performing in a design process. These developers face challenges in developing and implementing PCS as the main enabler of mass customization. Main difficulties occur in knowledge management (KM) stage for domain experts and the configuration team as the internal stakeholders or users. Design Thinking (DT) is a human-centered approach that includes a wide perspective of stakeholders and aims at enhancing human experience and solving complicated problems. Therefore, it can be used to solve this challenge of KM in configuration projects which is mainly related to communication within the organization by following a systematic, iterative design approach. The aim of this paper is twofold. Firstly, to review the literature of DT to gain deeper understanding of its characteristics, processes and components. Secondly, to apply the findings from literature regarding DT to the KM stage in PCS. The authors’ ultimate goal is to outline what the contribution of DT to PCS can be and discuss its importance in promoting the collaboration and communication of knowledge within the organization.

The main challenges for manufacturing companies in implementing and utilizing configurators

Companies providing customized products increasingly apply configurators in supporting sales and design activities, thus improving lead-times, quality, cost, benefits perceived by customers, and customer satisfaction. While configurator advantages have been substantially investigated, the challenges of implementing and utilizing configurators have less often been considered. By reviewing relevant literature, the present study first categorizes the main challenges faced by manufacturing companies when implementing and utilizing configurators. Six main categories of challenges are identified: (1) IT-related, (2) product modeling, (3) organizational, (4) resource constraints, (5) product-related, and (6) knowledge acquisition. Second, through a survey, the importance of those categories of challenges is assessed, and the specific challenges within each of those categories are highlighted. Finally, it is investigated whether the importance of the main categories of challenges varies according to a number of potential context variables. The results of the survey, which studies manufacturing companies that use configurators in providing customized products, offer new insights into the importance of these categories of challenges. The findings contribute to the research on manufacturing companies’ utilization of configurators and will raise awareness of the main challenges associated with their implementation and use.
Using business critical design rules to frame new architecture introduction in multi-architecture portfolios

When introducing new architectures to an industrial portfolio, counting multiple existing product and manufacturing solutions, time-to-market and investments in manufacturing equipment can be significantly reduced if new concepts are aligned with the existing portfolio. This can be done through component sharing, or sharing critical design principles. This alignment is not trivial, as extensive design knowledge is needed to overview a portfolio with many, often highly different products and manufacturing lines. In this paper, we suggest establishing a frame of reference for new-product introduction based on several "game rules", or Business Critical Design Rules (BCDRs), which denote the most critical features of the product and manufacturing architectures, and should be considered an obligatory reference for design when introducing new architectures. BCDRs are derived from the portfolio, architecture and module levels, including modelling of the most critical links between the product and manufacturing domains. The suggested modelling principle has been tested as a frame for new-architecture introduction, capturing critical modularisation principles in a large and global OEM. Application of the suggested method revealed a potential for reducing time-to-market and potentially cutting 35% off investments in new manufacturing equipment when introducing new products in the portfolio.
A Framework for Determining Product Modularity Levels

The application of modular products is seen as an important enabler for delivering customized products competitively. However, many companies struggle to find ways to implement modular products in a manner that suits their particular business. The literature includes examples of how modular products have been implemented in specific types of companies (mostly mass producers), but little guidance exists on how to identify the right level of modularity for other types of companies (such as engineer-to-order companies). In this article, we address this gap by suggesting a framework that categorizes the different types of modularity, where the categories fit different types of companies. More specifically, we introduce The Modularity Application Matrix – a conceptual tool that leads to a better understanding of partial modularization in relation to products. Through four case studies its application in practice is illustrated. This paper thereby contributes with new theoretical developments as well as a practical tool for practitioners in industries using partial
Assessing the financial potential for modularization: A case study in a global OEM
Assessing the financial potential of implementing a strategy, based on sharing of key modules and interfaces across a portfolio is difficult. However, this is a critical input when deciding strategic direction in industrial organizations. Through a case study, this paper gives an example of how to map and evaluate the architectures in a portfolio to identify the financial potential for implanting a platform-based modularization strategy. The approach has been applied in a global world-leading OEM with 50,000+ product variants and a turnover of USD 3.5b (2015). The results show a potential for reducing the cost-base by up to 15% through systematically sharing of key design principles across 80% of the company's portfolio. This has supported the discussion of adjusting innovation strategy in the organization. The core contribution of the paper is the operational application of the systematic Architecture Mapping and Evaluation approach (AME) and discussion of how it can support strategic decision-making related to modularization. The approach builds on the understanding that a top-down assessment can give a starting point for implementing a level of modularity across a portfolio.
Construction of Lightweight Loudspeaker Enclosures

On the basis of bass cabinets, this paper deals with the problem of reducing loudspeaker enclosure weight. An introductory market analysis emphasizes that lighter cabinets are sought, but maintenance of sound quality is vital. The problem is challenged through experiments and simulations in COMSOL Multiphysics, which indicate that weight reduction and sound quality maintenance is possible by reducing wall thickness and using adequate bracing and lining.
Empirical study of ill-supported activities in variation risk identification and assessment in early stage product development

The purpose of this paper is to present findings from an industrial case study about the support of activities related to identifying and assessing variation-related issues in the design during the concept- and embodiment design stages. The case study investigates a large world-leading mechanical medical device company by interviewing six key employees that work in the variation risk identification and assessment process. It is found that there are several ill-supported activities, and that the project teams rely heavily on tolerance experts’ assistance and experience in order to identify and assess the variation risk. Ill-supported activities are found to be: Balancing hardness of requirements and the screening; communicating mechanism understanding; predicting user input and internal component movement; documenting and communicating tolerance analysis; implementing robustness in the early definition of the projects; and implementing statistical information in the calculations. It is suggested these areas should be supported further.

Identification of critical technology building blocks

In order to have a better base for decisions, R&D managers need to know what the critical areas of development are in relation to the technologies they develop, mature, and include in the portfolio. As most of the technologies in a company have the potential to have a significant impact on competition, the challenge is to know how to identify and prioritize the development tasks. If possible, an effective strategy can be defined. This article suggests a framework for identification and analysis of a product portfolio, with special emphasis on identifying critical technology building blocks based on reasoning about product properties. Current approaches lack such views, and by focusing on these, potential make or break decisions are better supported. It is suggested to adopt the proposed framework to clarify where in the portfolio the technology needs critical attention for the next development steps. The framework is based on methods and theories in literature. The analysis of the portfolio is carried out through the framework in three steps: by creating an overview of the portfolio encompassing product and technology, assessing the elements in the overview with assessment metrics, and...
using property chains to identify critical technology building blocks.

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Including product features in process redesign

This article suggests a visual modelling method for integrating models of product features with business process models for redesigning the business processes involving specifications of customer-tailored products and services. The current methods for redesigning these types of business processes do not take into account how the product features are applied throughout the process, which makes it difficult to obtain a comprehensive understanding of the activities in the processes and to generate significant improvements. The suggested approach models the product family using the so-called product variant master and the business process modelling notation for modelling the process flow. The product model is combined with the process map by identifying features used in each step of the process flow. Additionally, based on the information absorbed from the integrated model, the value stream mapping modelling technique is applied to the specification process to evaluate its performance in quantifiable terms. The proposed modelling approach was investigated through three case studies. Experiences from the case studies were that the suggested modelling techniques gave additional insight into the specification processes and formed a good basis for process improvement. Furthermore, the case studies indicated that the suggested modelling techniques were applicable and easy to use.

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Increased accuracy of cost-estimation using product configuration systems

This article describes an approach for utilizing Product Configuration Systems (PCS) for quantifying project costs in project-based companies. It presents a case study demonstrating a method of quantifying costs in a way that makes it possible to configure cost- and time estimates. Piecework costs, material costs and sub-supplier costs are used as principle cost elements and linked to structural and process elements to facilitate configuration. The cost data are used by the PCS to generate fast and accurate cost-estimates, quotations, time estimates and cost summaries. The described cost quantification principles have been used in a Scandinavian SME (Small and Medium-sized Enterprise) since the 90’s, but
have since 2011 been adopted to be used in a configuration system. A longitudinal case study was conducted to compare cost and time-estimation accuracy before and after implementation. We conclude that the proposed method for grouping costs, combined with a PCS, can be used in project-based construction industries to make more accurate estimates of project costs. Reasons for improved accuracy are, according to company experts, the increased documentation and visibility of cost-estimates, dynamic allocation of variable costs, version control of cost-agreements and the ability to handle an increased level of cost details.

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Information rich mapping requirement to product architecture through functional system deployment: The multi entity domain approach
Successful transformation of design information from customer requirements to design implementation is critical for engineering design. As systems become complex the tracking of how customer requirements are implement becomes difficult. Existing approaches suggest so called domain modelling for mapping requirements to architecture. These approaches do not fully support the steps and information created during product design synthesis. Design Specifications used to guide the design are often documented in text based documents, outside the design models. This results in lack of traceability which may impede the ability to evolve, maintain or reuse systems. In this paper the Multi Entity Domain Approach (MEDA) is presented. The approach combines different design information within the domain views, incorporates both Software and Hardware design and supports iterative requirements definition. The results suggest that it is possible to present design information in structural domain views, presenting more elaborate information of the design synthesis than provided by previous approaches. However, further validation in a practical project setting is required to validate the approach.

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A multi-layered approach to product architecture modeling: Applied to technology prototypes
Companies that wish to include novel technology in the product portfolio may need to test and evaluate the technology with the use of prototypes to learn its benefits. Without clear knowledge of the benefits of the technology to the products in the portfolio, in the form of increased performance, added functions, or material savings, the prototype development can be hard to manage. In this article, two contributions are made. The first adds to the vocabulary of prototyping, defining technology prototype, a prototype used for testing a novel technology in the context of an existing product. The second is a tool to model and manage technology prototypes: the Technology Prototype Product Architecture Tool (TePPAT). The TePPAT is a product architecture tool with three main sections: Purpose, Concept, and Architecture. The TePPAT was tested in four industry cases, all part of a public–private partnership project to support the development of technology prototypes using electro-active polymer transducer technology. The findings showed that the TePPAT supported the development teams in the four cases. It is concluded that the TePPAT can support multidisciplinary development teams in modeling and managing technology prototypes and can be correlated with improvements in the team collaboration, communication, and development performance.
Assessing the cost saving potential of shared product architectures

This article presents a method for calculating cost savings of shared architectures in industrial companies called Architecture Mapping and Evaluation. The main contribution is an operational method to evaluate the cost potential and evaluate the number of product architectures in an industrial company. Experiences from the case company show it is possible to reduce the number of architectures with 60% which leads to significant reduction in direct material and labor costs. This can be achieved without compromising the market offerings of products. Experiences from the case study indicate cost reductions between 0.5% and 2% of turnover. The main implication is that the method provides a quantitative basis for the discussion on whether or not to implement shared product architectures. This means a more fact-based approach is introduced.

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Defining Interactions and Interfaces in Engineering Design

This PhD thesis focuses on the understanding and definition of interactions and interfaces during the architectural decomposition of complex, multi-technological products. The Interaction and Interface Framework developed in this PhD project contribute to the field of engineering design research.

Developing complex, multi-technological products involves the joint effort of multiple engineering disciplines in order to arrive at an end product, which satisfies its requirements. A major challenge is however the fact that bringing together engineers from different technical backgrounds means that they have different conceptual viewpoints on the product and use different ‘technical languages’ to communicate. Some terms like an interface, is used frequently in engineering however with no commonly declared meaning and is thus subject to much interpretation across engineering disciplines. It is well-known that most problems arise at the interfaces during product development, which is why there is a need for a rigorous and multi-disciplinary treatment of the concept of interfaces as well as interactions.

On the basis of a two-year case study at a medical device manufacturer, the role of interactions and interfaces in product family development has been investigated. The case study showed that for this particular case, interaction and interface descriptions represents the rationales needed to reuse documentation across multiple product variants. The interaction and interface descriptions thus become documents of legal matter and must therefore be unambiguously and completely

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described.

Following this observation, a comprehensive and systematic literature review has been performed in order to investigate the definition and perception of an interface. The review resulted in a classification revealing 13 dominant perceptions of what an interface is from an academic perspective including the observation of an apparent confusion between the terms interaction and interface. In addition, a case example of a solenoid valve was examined in order to reason out the likely causes of problems occurring at interfaces. The case example showed that interfaces that reside at the boundary between engineering disciplines are vulnerable to misinterpretation and rework.

Based on this understanding, this thesis presents a first principles, physics–based Interaction and Interface Framework, which provides a ‘common language’ across any engineering discipline for describing and communicating about interactions and interfaces in engineering design. The framework contains classifications of three key terms; interaction, interaction mechanism, and interface. Due to the first principles, physics–based approach to deriving the framework, it has been possible to arrive at a classification of interaction mechanism, which is mutually exclusive (no overlap) and collectively exhaustive (no gaps). This contribution changes the existing paradigm of reasoning about interactions and allows for an unambiguous architectural decomposition of a product.

The framework further proposes an 8–step architecting approach explicitly articulating how to systematically apply the framework top–down thus enabling complete and unambiguous descriptions of interactions and interfaces throughout the system. A tool called an Interaction Specification Wheel (ISW) is introduced to support consistency in writing requirements and specifications. All of the contributions have been evaluated in an initial test, which indicated a positive effect on their ability to capture interactions and unambiguously specify them. Further research is needed to obtain statistical significance. Future research may investigate how to incorporate the framework into practice and further evaluate the high level effects. This will most likely require two or more case studies in real-life projects.

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Establishing Reusable Requirements Derived from Laws and Regulations for Medical Device Development
For many industries a key activity in product development is to demonstrate legislative compliance by showing, explicitly, that all relevant requirements from regulatory documents have been identified and addressed. The analysis and interpretation of standards and regulations requires considerable skills and consumes significant effort in product development. Therefore initiating reuse from the analysis and elicitation of requirements from standards and regulations may provide promising potential for gaining efficiency in development and also for assuring sufficient quality of the work. In this paper, a method to manage requirements from standards, by establishing a reusable requirements catalogue, is suggested and a metamodel illustrating the information needed for tractability between derived requirements and legal texts, needed to facilitate reuse, is demonstrated. The paper presents a case study, where reusable requirements covering secondary packaging for medical injection devices were established, using a spreadsheet layout to capture and document the information presented in the metamodel.

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Modelling production system architectures in the early phases of product development

This article suggests a framework for modelling a production system architecture in the early phases of product development. The challenge in these phases is that the products to be produced are not completely defined and yet decisions need to be made early in the process on what investments are needed and appropriate to enable determination of obtainable product quality. In order to meet this challenge, it is suggested that a visual modelling framework be adopted that clarifies which product and production features are known at a specific time of the project and which features will be worked on – leading to an improved basis for prioritizing activities in the project. Requirements for the contents of the framework are presented, and literature on production and system models is reviewed. The production system architecture modelling framework is founded on methods and approaches in literature and adjusted to fit the modelling requirements of a production system architecture at an early phase of development. The production system architecture models capture and describe the structure, capabilities and expansions of the production system architecture under development. The production system architecture modelling framework is tested in a case study, and the results indicate that the modelling process facilitates identification of critical factors of the production system architecture, that the production system architecture models capture and describe the structure, capabilities and expansions of a production system architecture under development, and that the production system architecture models can facilitate dialogue on the production system architecture between heterogeneous stakeholder groups.

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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.08 SJR 0.386 SNIP 0.826
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Prototypes in engineering design: Definitions and strategies

By reviewing literature, we investigate types, purposes and definitions of prototypes. There is no overarching definition of a prototype, but we identify five categories of prototypes in literature. We further synthesize and reference previous work to create an overview of aspects in prototyping strategies. Due to rapid changes and progressions in the use of prototypes, we conclude that there is a need for more holistic and overview generating research about prototyping. This for product developers to properly manage, select and apply the optimal prototyping process.

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Towards a framework for modular service design synthesis
This paper seeks to improve the understanding of how service-based companies can benefit from developing and delivering service offerings from a standardised core of service modules, which are organised through a service architecture. Research within the field is relatively sparse, and there is scope for an explicit definition of elements related to the development of modular service platforms and architectures. A study of the existing literature, combined with a comprehensive case study in a global engineering consultancy, has created the basis for development and evaluation of the conceptual model for modular service design synthesis presented in this paper. The case study is based on internal documentation and a high level of interview data. Inductive research methods have been used for the analysis. The presented conceptual model defines three suggested dimensions (Market Segmentation, Service Roadmap and Service Architecture Layout) to be included in development of modular service platforms and architectures. Testing indicates a significant standardisation potential for service configuration across service families. Our understanding is that the approach can increase strategic flexibility and adaptability to changes in a quick evolving service market. The empirical part of this paper is exploratory in nature and is limited to one provider of high-end engineering consultancy services. Thus, further research will be needed to verify the aspects of the presented methodology to allow a further generalisation of our findings. Nevertheless, this paper contributes to the emerging literature on service modularity by presenting a specific operational approach for description and utilisation of modular service platforms and architectures.

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Web of Science (2015): Impact factor 1.786
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
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Web of Science (2014): Impact factor 1.233
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BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.48 SJR 1.268 SNIP 2.524
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**Coherent Architecture Development as a Basis for Technology Development**

The subject of this PhD thesis is architecture-centered design. It elaborates especially on two specific areas: the coherence in architectures in a technology development context and the identification of critical development areas via property-based reasoning, based on an understanding of this coherence.

Despite the acceptance and results presented in multiple studies from the application of architectures, the research on architecture work in a technology development context is limited.

Technologies are often developed and represented in the form of product sub-systems that are made available for product developers. Technologies, which in their infancy indicate a 'jack of all trades, master of none', have a risk of being developed without a clearly defined need or identification of which products it can be used in.

A common approach for developing such a technology includes exploration of what the sub-system that carries the technology is, how the sub-system is produced, and how it can be used in new products by means of early prototypes. Developing the prototypes will help identify the needs and requirements to which the technology must prove successful. This coherence between product sub-system, production, and testing in prototypes is essential for identifying the critical areas for development.

This research contributes to the vocabulary and understanding of coherent architecture development in a technology development context, where novel technology is developed.

In order to study coherent architectures in a technology context as a basis for identification of critical development areas, this research has been focused around the following three areas:
1. Product architecture instances for prototypes testing novel technology.
2. Product architecture definition for a sub-system based on a novel technology and the appertaining production architecture needed to realize this sub-system in a given solution space.
3. Coherent architecture as a basis for identification of critical technology development areas.

The two main contributions that are found in this thesis are: The Technology Prototype Product Architecture Tool, developed as part of point number one, and the framework for identification of critical technology building blocks, developed as part of point number three. Additional contributions are found as part of point number two through research on product architectures and production architectures represented through the Conceptual Product Platform tool and the Production Architecture Framework.

The frameworks and tools developed as part of this thesis were developed as part of deep industrial involvement in the Innovation Fund Denmark DEAP project from 2012 to 2015. The results presented in this PhD thesis were gained through active participation in the project.

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Enabling Mass Customization in Engineer-To-Order Industries: A multiple case study analysis on concepts, methods and tools
Choosing goods and services that satisfy individual needs has become possible in many consumer markets today. Technological advancement in sales and production enabled a variety of products, from automotive to apparel, to be mass customized in a profitable manner. Over time, these companies learned to handle the negative impact of a resulting increase in architecture complexity. In contrast, engineer-to-order firms, which core business is to create bespoke product variants engineered to specific needs, could not benefit to the same degree from the progress towards mass customization. Though customizing engineering products has a wide-ranging impact on companies’ architecture. The interconnected and hardly standardized design combined with highly varying processes makes the specification and fulfillment of customization requests difficult to handle. Moreover, although likewise affected with rising complexity levels and stronger customization responsiveness, their challenges and motivations towards mass customized solutions have seldom been discussed. To address this challenge, this thesis elaborates on state-of-the art research in architecture design and specification processes development and defines general capabilities to facilitate mass customization in engineer-to-order firms. The established understanding is complemented with interviews of practitioners from 18 engineering companies to obtain further insight into essential aspects of the research field. Based on the gained experience, eleven empirical studies have been conducted to develop relevant concepts and methods aiming at enhancing the identified capabilities. This close collaboration with industries ranging from construction to process plants and machinery applications promoted the development of a practical tool, termed Integrated Design Model (IDM). The IDM tool integrates adjacency matrices, node-link diagrams and generic modelling methods, to improve the explicitness and visibility of architectures. Connected to advanced expert systems, such as product configuration systems, the tool enables a formalized procedure for managing the design of complex architectures using aspects of visual analytics and computational structural analyses. Finally, the evaluation of the obtained results indicates a strong managerial and theoretical potential for the establishment of mass customization in engineer-to-order industries and pinpoints areas for further investigation.

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Enabling Reuse of Documentation in New Medical Device Development: A Systematic Architecting Approach

Medical device companies are continuously challenged with the ability to prove compliance with increasingly complex regulatory frameworks. Operating under heavy regulatory requirements may therefore cause significant delays to the lead time of new medical devices and thus contribute significantly to time-to-market for even simple medical device development projects. In this paper we illustrate how medical device companies can reduce their research and development (R&D) efforts needed to prove compliance when developing new product families by means of platforming and modularization. The results presented in this paper are based on a two-year empirical case study of a European manufacturer of arterial blood gas (ABG) sampling devices. The core contribution of this paper is a systematic architecting approach that applies the concept of a delta-multi-domain matrix (ΔMDM) to support companies in justifying the reuse of verification and validation (V&V) test documentation packages across new product family designs. The paper introduces an approach to aligning product and documentation architectures by architecture mirroring, and emphasizes the need for having a one-to-one mapping between the product and V&V test view. This will allow for V&V-related documentation to follow the product platform, and thereby enable carry-over of test documentation packages from one product family to another. Hence, this approach can provide significant competitive advantages to companies as it increases R&D efficiency while reducing time-to-market for new medical device development.

Interface definitions in literature: A reality check

Companies that develop multi-technological products are challenged on their ability to obtain high product quality and short development lead times in today’s highly competitive and globalized markets. One of the main reasons for poor product quality is due to unidentified or poorly defined product interfaces during the design phase leading to unintended product behavior. In an effort to reduce the lead time and increase quality, companies may apply a modular product architecture, thus enabling parallel development and maturing of modules. Achieving a successful integration of the modules at the end of a design phase requires, however, an understanding of how the modules disintegrate from an early stage. This implies having a fundamental understanding of what an interface is. Despite the apparent academic consensus on the importance of product interfaces during design, very little research has been done on the definition and perception of a product interface within engineering design research which is the objective of this article. A structured literature review of interface definitions found within engineering design literature has been carried out. The different definitions were tabulated against four key issues concerning the nature of an interface. These were later discussed with use of a case example in order to reason out the implications to design. The literature review revealed an inconsistency in the perceptions of an interface with regard to how it manifests itself, whether it is a design object, and the use of element types. These key issues were justified using a case example of a solenoid valve. In light of the findings from the literature review, it is argued how interfaces between modules as well as interfaces that reside in the tension field between different engineering disciplines may require great attention since they are subject to negotiation and interpretation between disciplines, which could lead to miscommunication and inefficiency.
Modelling architectures in multi-product oriented technology development

This thesis investigates the use of architecture modelling in a technology development context. This context presents greater uncertainties than more mature new product development. Applications—the use of products based on the technology being developed—are not fully identified and the requirements to be fulfilled are not completely defined. The products to be based on the technology and derivative products are not completely defined. Yet, decisions need to be made during technology development on the capabilities to be provided through the development to fulfil future application requirements, provide a foundation for future products, and development of a production system capable of producing future products and supporting technology development through prototype production. To support technology development aimed at a broad range of application requirements, two modelling frameworks are introduced: the product technology architecture modelling framework and the production architecture modelling framework—both developed for implementation within a technology development context. Both frameworks model both structural aspects and functional aspects of their respective phenomena. The Product Technology Architecture modelling framework enables modelling a product technology architecture including the structure and breakdown of product technologies based on a generic product technology architecture as organs and organ alternatives and links these through product concepts to application concepts and requirements. The Production Architecture modelling framework enables modelling a Production Architecture from three perspectives: structure, capabilities, and expansions. These perspectives provide the means to model what the Production Architecture is, what the Production Architecture does, and what the Production Architecture has the potential to do within the planning horizon. The results of implementing the modelling frameworks in a technology development project are presented, along with descriptive results on the context of technology development gained through active participation in the case project.

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PLM support to architecture based development: Contribution to computer-supported architecture modelling

Designers doing product architecture based development look to convert desired behaviour to solutions for a portfolio of products, and through modularisation pursue commonality among different variants without increasing the internal task proportional to handling variety. To develop product architectures for a portfolio of products that support the right balance between commonality and variety is today a foremost part of most large companies’ development operations. A challenge is that product architectures are influencing external and internal performance of markets, production, technology, organisation, processes, etc. To identify, evaluate, and align aspects of these domains are necessary for developing the optimal layout of product architectures. It is stated in this thesis that architectures describe building principles for products,
product families, and product programs, where this project focuses on architecture’s ability to describe product families. Architectures are developed with different objectives in mind, i.e. to obtain a certain effect for a company, such as reducing time-to-market, reducing product cost, increasing R&D efficiency, etc. Visual models with cross functional languages are, in architecture design, seen as key means for supporting designers from different domains and with different backgrounds, in accessing the structures of architectures and their behavioural effects. This PhD project focuses on prescribing how to model structural elements and address behavioural effects in graphical modelling formalisms of architectures. The objective of using the product architecture formalisms is to support designers in identifying, evaluating, and optimising the architecture satisfying the goals of the company in the best way in the view of the resource constraints. This thesis is particularly focusing on one product architecture modelling formalism - The Interface diagram. The formalism has an objective of supporting interdisciplinary designers in developing a product architecture for a product family. However, the large amount of information generated when identifying and developing architectures can be difficult to manage, update, and maintain during development. The concept of representing product architectures in computer-based product information tools has though been central in this research, and in the creation of results. A standard PLM tool (Windchill PDMLink©) is applied for representing a model of a product architecture, and for enabling fast, precise, and safe data transfer, as well as reducing the effort to replicate and modify information. This PhD thesis describes research into the phenomena of developing products based on architectures and how to represent architectures in computer systems. Presented results build on research literature and experiences from industrial partners. Verification of the theory contributions, approaches, models, and tools, have been carried out in industrial projects, with promising results. This thesis describes the means for: (1) Identifying and modelling architectures, (2) Multi-viewpoint modelling for supporting reasoning in converting desired product behaviour (given by requirements and/or functions) into a solution (given by components), (3) Assessing product cost and cost deviations during design, and (4) Assessing completeness of designs during development.

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PLM system support for modular product development
A modular design strategy both enables, but also demands, parallelism in design activities and collaboration between a diversity of disciplines in companies, which often involves supporting computer-based tools for enhancing interaction, design management, and communication. Product data management (PDM) and product lifecycle management (PLM) systems offer support by automating and managing some of the operational complexity of modular design activities. PLM system tools are used for handling a variety of product definitions, to manage workflow of development activities, and to measure relational properties such as cost and performance. Companies often use a PLM tool for management of CAD files, documents, and drawings, but they do not take advantage of the full potential of the PLM system to support the development activities of modular product designs. The key result of this paper is the description of an empirical tested approach using a visual product architecture representation in combination with a PLM system to support the development of a product family of products. The results from the study encompass new PLM capabilities for handling multiple product structures, visualising multiple architectural views on products, controlling interfaces, and quantifying and communicating the status and progress of product-related resources. © 2014 Elsevier B.V. All rights reserved.

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Tasks and challenges in prototype development with novel technology - an empirical study
This paper presents a thematic analysis of 138 monthly reports from a joint industrial and academic project where multiple prototypes were developed based on the same technology. The analysis was based on tasks and challenges described in the reports by project managers over a period of three years. 17 task themes and 9 challenge themes were identified. It was found that test, implementation, and project management were prominent tasks. Familiarization with the technology was found to a very little degree, which was in opposition to literature. The main challenge was found to be system development. It was found that the predominant tasks and challenges are distributed over long periods of time, rather than in chunks linked to a specific development phase.

A proposal for a classification of product-related dependencies in development of mechatronic products
When designing mechatronic products 'complex dependencies' are often reported to be a major challenge. This paper focuses on managing dependencies between attributes of the product during the design process. The literature study shows that there is a gap in the literature with regards to the classification of product-related dependencies. Traditionally these dependencies have been described as appearing between the following product attributes: function, properties and structure. By analysing three mechatronic projects from industry we identified and classified 13 types of product-related dependencies. Each product-related dependency is described and illustrated using the practical examples from the industrial projects. The value of the classification is evaluated by applying it to an industrial development setting not used for the analysis. The evaluation shows that delays in the project schedule, loss of functionality and quality issues can be avoided if attention is directed toward the product-related dependencies in the development process.
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BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.83 SJR 1.024 SNIP 2.139
Web of Science (2017): Impact factor 2.625
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.78 SJR 1.489 SNIP 1.663
Web of Science (2016): Impact factor 2.297
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.61 SJR 0.991 SNIP 1.821
Web of Science (2015): Impact factor 1.786
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BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.38 SJR 1.241 SNIP 2.512
Web of Science (2014): Impact factor 1.233
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.48 SJR 1.266 SNIP 2.524
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Web of Science (2013): Indexed yes
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ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 2.37 SJR 1.032 SNIP 2.814
Web of Science (2011): Impact factor 1.243
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Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 0.627 SNIP 1.251
BFI (2008): BFI-level 1
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Scopus rating (2007): SJR 0.523 SNIP 1.282
Scopus rating (2006): SJR 0.6 SNIP 1.471
Scopus rating (2005): SJR 0.528 SNIP 1.776
Scopus rating (2004): SJR 2.76 SNIP 3.333
Scopus rating (2003): SJR 1.573 SNIP 1.523
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.012 SNIP 1.494
Scopus rating (2001): SJR 0.515 SNIP 1.063
Scopus rating (2000): SJR 0.382 SNIP 1.251
Scopus rating (1999): SJR 0.372 SNIP 1.305

The subject of this PhD dissertation is architecture-centric design and the description of production system architecture. Companies are facing demands for the development and production of new products at an ever increasing rate, as the market life of products decreases and the rate at which customers demand new product features and performance accelerates. Many of these companies are seeking to keep pace with market demands and the pressures of low cost production in other countries by adopting an architecture-centric or platform based approach to the design of their production systems. As companies seek to put the architecture at the center of design activities and let it be a focal point throughout the system life-cycle, they discover a need to change their view of the system design and how they handle it.

Applying an architecture-centric approach to production system design requires a proper understanding of the architecture phenomenon and the ability to describe it in a manner that allow the architecture to be communicated to and handled by stakeholders throughout the company. Despite the existence of several design philosophies in production system design such as Lean, that focus on the underlying principles of a production system’s design; and despite the existence of established architecture and platform theories and practices within product design, there is still a need for a better understanding of the architecture phenomenon itself, and certainly how it applies within production system design. This research contributes to the vocabulary and understanding of the architecture phenomenon. A conceptual framework is provided which allows for conceptualization of the architecture phenomenon, and how it applies within production system design. To aid the companies in the operational design and handling of production system architecture, research is conducted into the description of production system architecture, including what an architecture description contains in general and what it should describe for production systems specifically. The contribution in this area of research consists of three parts. First, a conceptual model of architecture descriptions is established based on the ISO/IEC/IEEE 42010 standard. Secondly, the stakeholders and architecture related concerns of relevance for descriptions of production system architectures are investigated, and requirements for the descriptive capabilities of production system architecture descriptions are formulated. Thirdly, a reference architecture framework is suggested. The reference architecture framework will allow system stakeholders to describe the architecture of production systems based on a common set of viewpoints. The viewpoints provide a set of model kinds to frame select architecture related concerns relating to the production capability and the design of the technical system. With the contribution to architecture description there follows a need to support exchange and processing of architecture information within a diverse set of stakeholder domains and tools, in such a way that the different representation systems are compatible. To support such activities, a contribution is made to the identification and referencing of production system elements within architecture descriptions as part of the reference architecture framework. The contribution consists of a reference designation system based on the ISO/IEC 81346 standard series. The system allows for identification and referencing of the system elements through identifiers generated based on the compositional structures present in the production system.

Assessment and Development of Engineering Design Processes

Many engineering companies are currently facing a significant challenge as they are experiencing increasing demands from their customers for delivery of customised products that have almost the same delivery time, price and quality as mass-produced products. In order to comply with this development, the engineering companies need to have efficient
engineering design processes in place, so they can design customised product variants faster and more efficiently. It is however not an easy task to model and develop such processes. To conduct engineering design is often a highly iterative, illdefined and complex process, which is not simply understood. A main proposition in this research project is that understanding an engineering design process fully requires understanding of the product being engineered. Only by understanding what product features are used and produced in every engineering design task the process can be fully understood and eventually improved. Taking its starting point in this proposition, the outcome of the research is an operational 5-phased procedure for assessing and developing engineering design processes through integrated modelling of product and process, designated IPPM – Integrated Modelling of Product and Process. By merging the areas of product and process modelling, additional insight into the engineering design processes is acquired. It becomes evident what product features and specifications are crucial for every step in the process. Utilising this insight enables configuring the process to specifically suit the product being engineered, thereby creating an optimal process flow for specific product in question. This optimisation is positively influencing the performance of the engineering design processes and supports the companies in complying with the increasing customer demands for customised products. The thesis at hand is based on six scientific articles. Three of the articles are written and presented at scientific conferences whereas the remaining three are submitted to scientific journals. The results of the six papers constitute the main contribution of the research, and the main conclusions will be presented throughout this thesis. In addition to this, the results are placed in a more holistic context as the theoretical and empirical backgrounds of the project are elaborated. Furthermore the research design and scientific approaches are described in details, and eventually the results are discussed, overall conclusions are made and future research is proposed. The results produced throughout the research project are developed in close collaboration with the Marine Low Speed business unit within the company MAN Diesel & Turbo. The business unit is the world market leader in developing and designing customer specific two-stroke marine diesel engines.

End-to-end requirements management for multiprojects in the construction industry
The research described in this PhD thesis focuses on the phenomenon that formalized requirements management, as many studies have shown, has yet to find its way into the construction industry, even though it is effectively used in other fields e.g. software development and the aerospace and defence industries. The research gives at the same time managers of construction projects a tool with which to manage their requirements end-to-end. In order to investigate how construction companies handle requirements, a case project – a Danish construction syndicate producing sandwich elements made from High Performance Concrete and insulation materials – is used. By means of action research and interviews of case project staff it has become evident that many elements of formalized requirements management are missing in the case project. To fill those gaps and be able to manage requirements end-to-end a requirements structure is developed and tested as a starting point. This requirements structure is able to handle the encountered standard and non-standard situations such as product development and technology development in parallel with executing a construction project. At the same time the requirements structure is aimed at covering the entire life cycle of a building by considering future events.

However, the developed requirements structure is not enough for managing requirements. Therefore an intensive literature study on requirements management in general and in particular requirements management in construction is performed. The results of this literature study show that very little has been written about applying requirements management to the field of construction even though some authors have proposed to do so. This is a first indication that the entire field of construction lacks research with regards to requirements management. As the literature study gives little new information, a series of interviews are initiated with experts from industry and universities. Those interviews reveal major shortcomings in the way requirements are handled in Danish construction companies today. In order to give managers of construction projects a useful and guiding tool for formally managing requirements that is rooted in practice, the “Conceptual requirements management framework”, is created. The framework builds upon the gathered empirical data, obtained by action research, interviews, and available literature and is therefore inductive in nature. The “Conceptual requirements management framework” is tested and validated by applying it to a building project and using additional methods of validation e.g. traces, extreme-condition tests, and face-validity.

The development and application of the requirements structure and the Conceptual requirements management framework mean that, for the first time structured requirements management and elements of systems engineering have been used in the construction industry. It is expected that this approach contributes some of the major challenges that are present in the industry by contributing to rework being avoided, shortened lead-times, less spending of resources, better quality, and a higher
degree of satisfaction of stakeholders. The results of the conducted research show that formal requirements management can successfully be applied to the construction industry that was examined. At the same time it is necessary to open doors to further research:

- The “Conceptual requirements management framework” has to be applied to additional building projects in order to gather more data for the improvement of the framework
- This research does not cover the long term effect of introducing requirements management to the construction industry and its customers. An investigation would be beneficial for the industry and academia

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Front-end conceptual platform modeling
Platform thinking has been the subject of investigation and deployment in many projects in both academia and industry. Most contributions involve the restructuring of product programs, and only a few support front-end development of a new platform in parallel with technology development. This contribution deals with the development of product platforms in front-end projects and introduces a modeling tool: the Conceptual Product Platform model. State of the art within platform modeling forms the base of a modeling formalism for a Conceptual Product Platform model. The modeling formalism is explored through an example and applied in a case in which the Conceptual Product Platform model has supported the front-end development of a platform for an electro-active polymer technology. The case describes the contents of the model and how its application supported the development work in the project. The conclusion is that the Conceptual Product Platform model supports stakeholders in achieving an overview of the development tasks and communicating these across multidisciplinary development teams, as well as making decisions on the contents of the platform and providing a link between technical solutions and market requirements.

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Identified adjustability dimensions when generating a product specific requirements specification by requirements reuse

A requirements reuse setups typically includes reusable requirement set(s) containing a collection of reusable requirements and a number of product specific requirements sets which are drawn from the reusable set(s). The ideal scenario when reusing requirements is that all the product requirements can be drawn directly from the reusable set. However, this is rarely the case in product development as new requirements are likely to surface. A critical issue in requirements reuse therefore becomes how to enable products to efficiently reuse requirements as well incorporating
changes to the product set. In this paper the objective is not to present a specific method for requirements reuse but to
introduce and discuss the possible dimensions of adjustability when generating a product requirement set by reusing
requirements from a reusable set. Six adjustability dimensions have been identified. An extensive state of the art is
included to introduce the presented methods related to each adjustability dimensions. The options for implementing each
adjustability dimensions in a requirement reuse approach are illustrated along with a discussion regarding the benefits and
issues resulting from each option. This discussion should help practitioners to better understand the possible methods that
can be implemented and to design a user friendly and sustainable approach. A case study, describing how the dimensions
are incorporated in two requirements reuse approaches, for Danfoss Solar Inverters (SI) and Danfoss Frequency Drives is
provided. As a result an overview of how each adjustability dimensions is implemented in each case is presented. The
case study demonstrates that all the identified adjustability dimensions were important elements in requirements reuse
implementation. The case study furthermore highlights the need, not only to understand the effects of each adjustability
dimension but also of the dependencies to case specific criterions. The classification of adjustability dimensions in
requirements reuse and the options for their implementation has not been outlined by previous research and should be
a useful contribution both to researchers and practitioners working in the field of requirements reuse. (C) 2014 Elsevier B.V.
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Interface diagram: Design tool for supporting the development of modularity in complex product systems

For products with a myriad of systems, groups of specialised engineers develop entire technical sub-systems, and great effort is needed to integrate these systems for fulfilling the product’s intended properties describing its purposeful behaviour. This way of developing products gets even more complex when using a mass customisation strategy because standard designs (reusable modules) have to be designed to fit a range of products. This product development set-up requires that engineers working in different technical domains collaborate and are able to share information in a unified way. This article presents a visual design tool—the Interface diagram—which aims to support the engineering process of developing modularity in complex product systems. The tool is a model of a product system representing the arrangement of its elements and their interfaces. The tool has similar characteristics to a high-level product architecture model, aiming at supporting integration of technical sub-systems by documenting interfaces and interactions among components from different functional sub-systems and among different physical modules. One of the objectives for using the design tool is to support the activity of decomposing a product system into modules consisting of components developed by different engineering teams. The usefulness of the Interface diagram has been tested in an industrial development project showing positive results of shortening the lead time and minimising rework. Moreover, the Interface diagram has been used in interplay with a broader Product Lifecycle Management system. This allows the product structures from the Interface diagram to be enriched with detailed product documentation like computer-aided design, requirements, view models, design specifications and interface descriptions.
Mapping requirements to a product architecture supported by a PLM system

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Proactive identification of scalable program architectures: How to achieve a quantum-leap in time-to-market

This paper presents the Architecture Framework for Product Family Master Plan. This framework supports the identification of a program architecture (the way cost competitive variance is provided for a full range of products) for a product program for product-based companies during the early stages of a product development project. The framework consists of three basic aspects: the market, product program, production and a time aspect—captured in the multi-level roadmap. One of the unique features is that these aspects are linked, allowing for an early clarification of critical issues through a structured process. The framework enables companies to identify a program architecture as the basis for improving time-to-market and R&D efficiency for products derived from the architecture. Case studies show that significant reductions of development lead time up to 50% is possible. Significance: Many companies are front-loading different activities when designing new product programs. This paper suggests an operational framework for identifying a program architecture during the early development phases, to enable a significantly improved ability to launch new competitive products with fewer resources.

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Developing product configuration system (CS) requires extracting and representing domain expert knowledge in appropriate product models. As acknowledged by researchers, this is often one of the most challenging activities in configuration projects, where only little empirical insights have yet been reported. This article investigates the challenge on how industrial companies model their product CSs. The study is based on interviews of 18 industrial companies using CSs for configuring customer-tailored products. It investigates the relationship between using a structured modelling technique for modelling product families relative to less or no formal approaches. Furthermore, the study explores the specific characteristics of configuration set-ups with respect to size and complexity and their effect on product variant management and availability of product knowledge in organizations. The results empirically validate the need for a suggested systematic modelling approach for large and complex configuration projects and its positive effect on the overall performance of companies.
Challenges in Designing Mechatronic Systems
Development of mechatronic products is traditionally carried out by several design experts from different design domains. Performing development of mechatronic products is thus greatly challenging. In order to tackle this, the critical challenges in mechatronics have to be well understood and well supported through applicable methods and tools. This paper aims at identifying the major challenges, by conducting a systematic and thorough survey of the most relevant research work in mechatronic design. Solutions proposed in literature are assessed and illustrated through a case study in order to investigate if the challenges can be handled appropriately by the methods, tools, and mindsets suggested by the mechatronic community. Using a real world mechatronics case, the paper identifies the areas where further research is required, by showing a clear connection between the actual problems faced during the design task, and the nature of the solutions currently available. From the results obtained from this research, one can conclude that although various attempts have been developed to support conceptual design of mechatronics, these attempts are still not sufficient to help in assessing the consequences of selecting between alternative conceptual solutions across multiple domains. We believe that a common language is essential in developing mechatronics, and should be evaluated based on: its capability to represent the desired views effectively, its potential to be understood by engineers from the various domains, and its effect on the efficiency of the development process.
Bibliographical note
This paper is an extension to the article published in the proceedings of the ASME 2011 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference, IDETC/CIE 2011. The literature study has been expanded from three to five years which revealed an additional 10 articles, thus adding 200 references to be included in the data processing. Furthermore, structured searches in seven relevant journals have been added to the literature study to identify mechatronic challenges. As a result, additional researchers and solutions have been identified and included.

Conceptualizing the use of system products and system deliveries in the building industry
This article describes the concepts system products and system deliveries based on the use of product modularization and product configuration. The concepts are outlined and discussed based on examples from both the construction industry and related industry. The description focuses partly on the product architecture and partly of the setup of the business processes by using e.g. Configure to Order processes and Engineer to Order processes. Furthermore the potential impacts from using system products and system deliveries are discussed based on the examples included.

EAP high-level product architecture
EAP technology has the potential to be used in a wide range of applications. This poses the challenge to the EAP component manufacturers to develop components for a wide variety of products. Danfoss Polypower A/S is developing an EAP technology platform, which can form the basis for a variety of EAP technology products while keeping complexity under control. High level product architecture has been developed for the mechanical part of EAP transducers, as the foundation for platform development. A generic description of an EAP transducer forms the core of the high level product architecture. This description breaks down the EAP transducer into organs that perform the functions that may be present in an EAP transducer. A physical instance of an EAP transducer contains a combination of the organs needed to fulfill the task of actuator, sensor, and generation. Alternative principles for each organ allow the function of the EAP transducers to be changed, by basing the EAP transducers on a different combination of organ alternatives. A model providing an overview of the high level product architecture has been developed to support daily development and cooperation across development teams. The platform approach has resulted in the first version of an EAP technology platform, on which multiple EAP products can be based. The contents of the platform have been the result of multi-disciplinary development work at Danfoss PolyPower, as well as collaboration with potential customers and research institutions. Initial results from applying the platform on demonstrator design for potential applications are promising. The scope of the article does not include technical details. © 2013 SPIE.
Identification of a reusable requirements structure for embedded products in a dynamic market environment

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Observed benefits from product configuration systems

This article presents a study of the benefits obtained from applying product configuration systems based on a case study in four industry companies. The impacts are described according to main objectives in literature for implementing product configuration systems: lead time in the specification processes, on-time delivery of the specifications, and resource consumption for making specifications, quality of specifications, optimization of products and services, and other observations. The purpose of the study is partly to identify specific impacts observed from implementing product configuration systems in industry companies and partly to assess if the objectives suggested are appropriate for describing the impact of product configuration systems and identifying other possible objectives. The empirical study of the companies also gives an indication of more overall performance indicators being affected by the use of product configuration systems e.g. increased sales, decrease in the number of SKU's, improved ability to introduce new products, and cost reductions.

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PLM Support for Development of Modular Product Families

Most modern manufacturing companies use a PLM/PDM system for documenting and managing product data. Companies use their PLM/PDM system for management of CAD files, documents, and drawings, but they do not take advantage of the full potential of the system to support modularisation. The objective of this research is to develop an approach for improving the role of PLM/PDM systems as supporting tools for developing modular product families. The approach is based on a visual product architecture model, representing a product family seen from a functional system perspective and a physical modular perspective. By means of a software program, product structures visual modelled can be imported to a PLM system, forming so called upper structures. Data associativity between upper structures in the PLM system and CAD models is described, as well as other types of associated product information. The key result of the research is the approach of using companies' PLM systems to build up and define product structures that support the activities of creating modular product families.

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Contributors: Bruun, H. P. L., Mortensen, N. H., Harlou, U.
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Product platform considerations on a project that develops sustainable low-cost housing for townships

Construction companies in Denmark are often working with profit margins as little as 1-3% in situations where they deliver high-end buildings to the local market. Even though customers are willing to pay a premium price for high quality, construction companies earn very little on their products. Consequently one Danish company took the decision to produce sustainable low-cost houses and to sell them to development countries that have township housing programs. Why does this company believe in still making profit in the low-cost housing segment abroad, when there is almost no profit in the high-end segment at home? As the research described in this article shows there are three main reasons for their optimism: 1) The successful introduction of a product platform for low-cost houses, 2) a modular approach to the design of low-cost houses, and 3) the application of requirements management as described by INCOSE. 1) to 3) have been studied using action research on a case project.

The case company’s success in their endeavor contributes to people currently living without decent housing getting insulated low-cost houses based on the latest technology. The fact that those low-cost houses are solid gives their new owners the possibility to take a loan in their building which is expected to contribute to more businesses being started up and thereby strengthening the domestic economy. As a consequence of this, additional research is needed in how to further optimize the economy of sustainable low-cost housing based on life cycle considerations. Moreover it has to be examined how the gained experience can support in maximizing the high-end segment in countries like Denmark?

Reducing variety in product solution spaces of engineer-to-order companies: The case of Novenco A/S

Today many companies are experiencing increasing demands from customers for shorter delivery times and more competitive prices. In order to increase competitiveness from a price and time-to-market perspective, many companies initiate projects to reduce their internal product complexity by eliminating the product variety that do not create customer value. However, for Engineer-to-Order (ETO) companies, elimination of variety is particularly challenging, since it is about reducing variety in a complex product solution space, rather than just eliminating already produced product variants. To support ETO companies in achieving more efficient product solution spaces, this paper presents a procedure for reducing product solution spaces in ETO companies. The procedure is demonstrated through an action research study at the Danish ETO company, Novenco, which develops and manufactures heating, ventilation, air-conditioning and refrigeration solutions for land and marine applications. Copyright © 2013 Inderscience Enterprises Ltd.
Calculation of Complexity Costs – An Approach for Rationalizing a Product Program

This paper proposes an operational method for rationalizing a product program based on the calculation of complexity costs. The method takes its starting point in the calculation of complexity costs on a product program level. This is done throughout the value chain ranging from component inventories at the factory sites, all the way to the distribution of finished goods from distribution centers to the customers. The method proposes a step-wise approach including the analysis, quantification and allocation of product program complexity costs by the means of identifying a number of suggested Life Cycle Complexity Factors (LCCFs). The suggested method has been tested in an action based research study with promising results. The case study shows how the allocation of complexity costs on individual product variants provides previously unknown insights into the true cost structure of a product program. These findings represent an improved decision basis for the planning of reactive and proactive initiatives of rationalizing a product program.

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Definition and evaluation of product configurator development strategies

Product configurators represent one of the most successful applications of artificial intelligence principles. Product configurators are a subtype of software-based expert systems with a focus on the creation of product specifications. The use of product configurators has resulted in many positive effects in engineering-oriented companies such as reduced lead times, fewer errors, shorter learning periods for new employees, etc. Unfortunately, many configuration projects also fail because the task of developing the configurator turns out to be much more difficult and time-consuming than anticipated. Thus, it is crucial to apply the appropriate strategy. However, the literature does not discuss different strategic alternatives in a detailed manner; it only provides generalised recommendations of single strategies. To deal with this issue, this paper defines and compares seven different strategies for the development of product configurators. The relevance of the defined strategies is supported by seven named case studies.

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Modelling and using product architectures in mechatronic product development

The objective for the paper is to determine the role of a product architecture modelling tool to support communication and to form the basis for developing and maintaining product structures for improving development practices of complex products. This paper contains descriptions, observations, and lessons learned from a case study in which the author tested a modelling tool to represent a product’s architecture during product development in a larger Danish company. The reasons leading to the use of the specific model and its terminology is described and illustrated. The paper supports two fundamental theoretical viewpoints; Theories of technical systems and theories of design processes. In this framing, the paper addresses the engineering activity of developing products supported by product architecture representations. The paper includes the description of a visual architecture representation, experiences by using the architecture representation in a mechatronic development project, and the scope of using the architecture model as a skeleton for a data structure in a PLM system. The fundamental idea for planning and modeling holistic architectures is that an improved understanding of the whole product system, will lead to better decision making. Moreover, it is discussed how the sometimes intangible product structures within an architecture can be visually modeled based on the assumption that knowledge about a product’s architecture has to be tangibly instantiated, in order for people and decision makers to successfully share it and use it.

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On the Market Aspect of Product Program Design: Towards a Definition of an Architecture of the Market
An often overlooked aspect of architecture based product development is the market aspect. However, without focusing the scope of the product family and ensuring an appropriate layout of product families, variants and features across the product program offerings, experiences show that architecture based product families become rigid, unfocused, prepared for yesterday's market situation, and ultimately lack profitability. This paper will propose to expand the existing notion of coordinating product and production architectures as a means to develop profitable architectures by including an architecture of the market. This is to be interpreted as the ‘market perspective’ of the product family referring to the design of the product family from the market’s point of view. The main result of this paper is the suggestion of a definition of a market architecture with an articulation of its elements, relations, hierarchical nature and raison d’être. Three action research studies show that defining the market architecture serve as a feasible and operational means of addressing the market aspects in architecture development.

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Product Platform Screening at LEGO
Product platforms offer great benefits to companies developing new products in highly competitive markets. Literature describes how a single platform can be designed from a technical point of view, but rarely mentions how the process begins. How do companies identify possible platform candidates, and how do they assess if these candidates have enough potential to be worth implementing? Danish toy manufacturer LEGO has systematically gone through this process twice. The first time the results were poor; almost all platform candidates failed. The second time, though, has been largely successful after a few changes had been applied to the initial process layout. This case study shows how companies must focus on a limited selection of simultaneous projects in order to keep focus. Primary stakeholders must be involved from the very beginning, and short presentations of the platform concepts should be given to them throughout the whole process to ensure commitment. © International Journal of Industrial Engineering.

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Towards a Classification of Architecture Initiatives: Outlining the External Factors

This paper introduced a set of external factors capturing the contextual differences that set the stage for architecture initiatives. These are derived from a systems theoretical approach recognizing the fact that architecture initiatives should respond to the challenges posed by the external environment in which the company and the future product program is operating. The outlining of the factors are based on the conviction that no one-fits-all exists, when it comes to architecture initiatives, and the notion that it is impossible to truly evaluate whether an architecture initiative is good or bad, without including the contextual differences. The purpose of the external factors is to improve scoping and goal setting of architecture initiatives, and improve comparability between- and transferability of knowledge from architecture initiatives. The external factors are a first step towards an actual classification of architecture initiatives.

Visual product architecture modelling for structuring data in a PLM system

The goal of this paper is to determine the role of a product architecture model to support communication and to form the basis for developing and maintaining information of product structures in a PLM system. This paper contains descriptions of a modelling tool to represent a product architecture in a company to support the development of a family of products, as well as the reasons leading to the use of the specific model and its terminology. The fundamental idea for using the architecture model is that an improved understanding of the whole product system, will lead to better decision making. Moreover, it is discussed how the sometimes intangible elements and phenomena within an architecture model can be visually modeled in order to form the basis for a data model in a PLM system. © 2012 International Federation for Information Processing.
Product Platform Performance: Achieving internal effects

The aim of this research is to improve understanding of platform-based product development by studying platform performance in relation to internal effects in companies. Platform-based product development makes it possible to deliver product variety and at the same time reduce the needed resources, and the subject has gained increased attention in industry and academia the past decade. Literature on platform-based product development is often based on single case studies and it is sparsely verified if expected effects are achieved. This makes it difficult to put forward realistic expectations for companies engaging in platform-based product development. Similarly platform assessment criteria lack empirical verification regarding relevance and sufficiency. The thesis focuses on • the process of identifying and estimating internal effects, • verification of performance of product platforms, (i.e. if the expected results are achieved), and • reasons for possible deviations between these, comparing them to existing platform assessment criteria. The research results are based on 8 comprehensive case studies of product platforms in LEGO Company in the period of 2004-2009 (involving participant observation, observation, interviews and data analysis) and are validated by a series of interview with representatives from 12 Scandinavian companies. A descriptive model of the process of identifying and estimating internal platform effects has been developed. It involves analysis of past data and estimates from experienced representatives from the different life systems phase systems of the platform products. The effects are estimated and modeled within different scenarios, taking into account financial and real option aspects. The model illustrates and supports estimation and quantification of internal platform effects. The model empirically verifies findings in literature and received moderate support from industry in the validation study. The research findings document that product platforms achieve significant internal effects in terms of • reduced development time (often around 25 %), • reduced number of components (often around 50%) and • reduced production cost and investments (often around 25%). This verifies a significant, general improvement potential, a verification which has lacked in the literature. These findings underline the potential in platform-based product development as a way of creating competitive advantage. The findings also reveal that between half and two thirds of the platforms do however do not achieve the expected effects, despite that they do deliver some effects. This is mainly because of 1) lack of use of the platform assets, 2) technical reasons and 3) changed market conditions. These reasons are mentioned in literature, but only the two latter are addressed in platform assessment criteria. Hence a new platform assessment criterion is introduced, the platform user incentive criterion. Alongside with the introduction and recommendation of a platform user incentive criterion, recommendations are also made regarding focus on down-stream effects, modeling and viable estimation and quantification of effects, facilitation of performance tracking and goal-setting and finally to understand a product platform as an internal system in the company. A platform system model is introduced to support this understanding. Finally a categorisation of different approaches to platform-based product development is introduced, based on the companies from the industrial study.
A MECHATRONIC CASE STUDY HIGHLIGHTING THE NEED FOR RE-THINKING THE DESIGN APPROACH

Developing mechatronic products is a great challenge for many companies due to the multi-disciplinary nature of the development process. In this article the main objective is an investigation of seven aspects related to the synthesis process of developing mechatronic products. The role and effects of these aspects are illustrated by a case study. A literature study is performed regarding how well the seven aspects have been covered in the literature. It reveals that some suggestions for support can be found in terms of semi-formal modelling suggestions and proposal for procedures, but that the context of the proposed support often originates from a control engineering dominated research area. This circumstance leaves a vast amount of other types of mechatronic products with only sparse development support with the potential of being made operational.

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Improving decision making in the early phases of configuration projects
During the early phases of configuration projects very important decisions are made which will heavily influence the performance of the company, benefits in different functional areas (production, sales, purchase, product development, service etc.), maintenance of the configuration system and quality of the dialogue between the configuration system and the users. Today there exists very sparse tools and procedures which can assist the early phases, i.e. conceptual modeling of the products and product assortment. This paper presents a five-phase procedure for conceptual modeling in configuration projects. Each of the five phases is supported by a set of tools. The main idea of the procedure is utilization of a so-called Product Family Master Plan, which is a formal description of the product assortment and its variation. The procedure has been tested at one of Baan’s (SSA Global) customers with very convincing results. © International Journal of Industrial Engineering.

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Innovation and Entrepreneurship in the Automotive Business: ICED11 Automotive Keynote

The global automotive business is one of the most competitive environments you can imagine. As an independent inventor or as a small development company, it is very challenging to be successful in implementing new ideas and components. In this mature and somewhat conservative technical environment, you really need to have a strong and revolutionary proposal. The big global manufacturers of vehicles have tried almost everything when it comes to new technology. When approaching them, you need to have your idea well protected by patents and also reliable data to prove and convince that your invention has appropriate benefits. The timing of the dialog with a potential user or business partner is important when it comes to which issues that have highest priorities or are most frequently discussed in the organization of said user or business partner. If there exist a special issue that your idea addresses, you will have a much better access to the decision-making process and get enough interest for a potential business deal. After 20 years as a supplier of engineering services to the automotive industry and 10 years as head of Global R&D at Scania CV AB, I have experienced pros and cons both from a supplier perspective as well as from a vehicle manufacturer perspective.

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**Mechatronic Design - Still a Considerable Challenge**

Development of mechatronic products is traditionally carried out by several design experts from different design domains. Performing development of mechatronic products is thus greatly challenging. In order to tackle this, the critical challenges in mechatronics have to be well understood and well supported through applicable methods and tools. This paper aims at identifying the major challenges, by conducting a survey of the most relevant research work in mechatronic design. Solutions proposed in literature are assessed and illustrated through a case study in order to investigate, if the challenges can be handled appropriately by the methods, tools, and mindsets suggested by the mechatronic community. Using a real world mechatronics case, the paper identifies the areas where further research is required, by showing a clear connection between the actual problems faced during the design task, and the nature of the solutions currently available. From the results obtained from this research, one can conclude that although various attempts have been developed to support conceptual design of mechatronics, these attempts are still not sufficient to help in assessing the consequences of selecting between alternative conceptual solutions across multiple domains. We believe that a common language is essential in developing mechatronics, and should be evaluated based on: its capability to represent the desired views effectively, its potential to be understood by engineers from the various domains, and its effect on the efficiency of the development process.

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**Proactive Modeling of Market, Product and Production Architectures**

This paper presents an operational model that allows description of market, products and production architectures. The main feature of this model is the ability to describe both structural and functional aspect of architectures. The structural aspect is an answer to the question: What constitutes the architecture, e.g. standard designs, design units and interfaces? The functional aspect is an answer to the question: What is the behaviour or the architecture, what is it able to do, i.e. which products at which performance levels can be derived from the architecture? Among the most important benefits of this model is the explicit ability to describe what the architecture is prepared for, and what it is not prepared for - concerning development of future derivative products. The model has been applied in a large scale global product development project. Among the most important benefits is contribution to: Improved preparedness for future launches, e.g. user interface and improved energy efficiency Achievement of attractive cost- and technical performance level on all products in the product family On time launch of the first generation of the product family"

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The impact of product configurators on lead times in engineering-oriented companies

This paper presents a study of how the use of product configurators affects business processes of engineering-oriented companies. A literature study shows that only a minor part of product configuration research deals with the effects of product configuration, and that the ones that do are mostly vague when reporting the effects of configurator projects. Only six cases were identified, which provide estimates of the actual size of lead time reduction achieved from product configurators. To broaden this knowledge, this paper presents the results of a study of 14 companies concerning the impact of product configurators on business processes related to the creation of quotes and detailed product specifications. The study documents impressive results of the application of configurator technology. For example, in the data retrieved the use of configurators was estimated to have implied up to a 99.9% reduction of the quotation lead time with an average estimated reduction of 85.5%.

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Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 1.09 SJR 0.486 SNIP 0.901
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BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 0.81 SJR 0.538 SNIP 1.261
Web of Science (2015): Impact factor 0.877
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.27 SJR 0.599 SNIP 1.172
Web of Science (2014): Impact factor 0.604
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.19 SJR 0.768 SNIP 1.374
Web of Science (2013): Impact factor 0.553
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.05 SJR 0.471 SNIP 1.469
Web of Science (2012): Impact factor 0.407
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.6 SJR 0.586 SNIP 1.96
Web of Science (2011): Impact factor 0.786
A layout technique for class diagrams to be used in product configuration projects

For several companies the use of product configurators has produced a range of benefits such as minimising the use of resources and shortening the lead times in product specification processes. When developing a product configurator, two kinds of models are often created, namely analysis and design models. The task of describing product knowledge in analysis models involves domain experts, for which reason the analysis language has to be easily understandable in order to avoid extensive training. For this task the so-called Product Variant Master (PVM) diagramming technique is often applied. On the other hand, the requirements for the design language are more focused on having a formalised and rich language. For this task class diagrams are often applied. To avoid the use of different modelling languages in the analysis and design phase, this paper proposes and tests a layout technique that incorporates the usability of PVMs into class diagrams.

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Web of Science (2017): Impact factor 2.85
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.95 SJR 0.861 SNIP 1.907
Web of Science (2016): Impact factor 2.691
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.82 SJR 0.834 SNIP 1.914
Web of Science (2015): Impact factor 1.685
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.66 SJR 0.948 SNIP 2.309
Web of Science (2014): Impact factor 1.287
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 3.08 SJR 1.021 SNIP 3.096
Web of Science (2013): Impact factor 1.457
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.98 SJR 1.104 SNIP 3.053
Web of Science (2012): Impact factor 1.709
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 3.29 SJR 1.129 SNIP 3.034
Web of Science (2011): Impact factor 1.529
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.006 SNIP 2.459
Web of Science (2010): Impact factor 1.62
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.002 SNIP 2.228
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.093 SNIP 2.123
Scopus rating (2007): SJR 1.125 SNIP 1.895
Scopus rating (2006): SJR 0.832 SNIP 2.019
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.623 SNIP 1.795
Scopus rating (2004): SJR 0.637 SNIP 1.502
Scopus rating (2003): SJR 1.006 SNIP 1.757
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.673 SNIP 1.439
Web of Science (2002): Indexed yes
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Scopus rating (2000): SJR 0.34 SNIP 0.656
Scopus rating (1999): SJR 0.3 SNIP 0.44
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Assessment of Benefits from Product Configuration Systems

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Assessment of Benefits from Product Configuration.pdf

Making Product Customization Profitable
The main result presented in this paper is the Framework for Product Family Master Plan. This framework supports the identification of a product architecture for companies that customize products and services. The framework has five coherent aspects, the market, product assortment, supply-production, organization and work processes. One of the unique results is that these aspects are linked, which make it possible to make explicit recommendations for an architecture (the way a product family should be structured with clear interfaces), architecture elements and consequences. By means of a case study it is shown that the potential EBIT (Earning Before Interests and Taxes) improvement of the case company is 10%.

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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.63
Web of Science (2017): Impact factor 0.565
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.51
Web of Science (2016): Impact factor 0.537
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 0.5
Web of Science (2015): Impact factor 0.385
BFI (2014): BFI-level 1
Modelling Product Families for Product Configuration Systems with Product Variant Master

This article presents an evaluation of applying a suggested method for modelling product families for product configuration based on theory for modelling mechanical products, systems theory and object-oriented modelling. The modelling technique includes a so-called product variant master and CRC-cards for modelling and visualising the parts and properties of a complete product family. The modelling techniques include: Customer, engineering and part views on the product assortment to model the properties, functions and structure of the product family. This also makes it possible to map the links between the three views. Modelling of characteristics of the product variants in a product family Modelling of constraints between parts in the product family Visualisation of the entire product family on a poster e.g. 1x2 meters The product variant master and CRC-cards are means to bridge the gap between domain experts and IT-developers, thus making it possible for the domain experts (e.g. engineers from product development) to express their knowledge in a form that is understandable both for the domain experts and the IT-developers. The product variant master and CRC-cards have currently been tested and further developed in cooperation with several industrial companies. This article refers to experiences from applying the modelling technique in three different companies. Based upon these experiences, the utility of the product variant master and CRC-cards is evaluated. Significance. Product configuration systems are increasingly used in industrial companies as a means for efficient design of customer tailored products. The design and implementation of product configuration systems is a new and challenging task for the industrial companies and calls for a scientifically based framework to support the modelling of the product families to be implemented in the configuration systems.

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A classification of strategies for the development of product configurators

Product configurators are a subtype of software-based expert systems with a focus on the creation of product specifications. Product configurators are increasingly being applied by engineering-oriented companies, which has resulted in many positive effects, such as reduced lead times, fewer errors, shorter learning periods for new employees, etc. Unfortunately, also many configuration projects fail because the task of developing the configurator turns out to be much more difficult and time-consuming than anticipated. In order to minimize the chance of project failure, it is crucial to apply the right strategy. However, the literature does not discuss different strategic alternatives in a detailed manner, but only provides generalised recommendations of single strategies. To deal with this issue, this paper defines three main and four additional strategies for the development of product configurators. The strategies are defined based on literature, seven named case studies, and other case experiences of the authors. The paper deduces the advantages and disadvantages of the individual strategies, and gives a general recommendation of which type of strategy to pursue in different types of projects.

Implementation of conceptual product models into configurators: From months to minutes

For years the use of software-based product configurators has produced a number of benefits for engineering-oriented companies. However, achieving such benefits can be challenging, and often configurator projects do not succeed. A main reason for such failures is that the tasks of developing and maintaining configurators often are very challenging and time-consuming. With a focus on reducing the efforts needed for development and maintenance of product configurators, this paper describes an emerging technology that makes it possible to automate the conversion of conceptual product models made by ordinary product experts into the knowledge base of a configurator, and the other way around. Thus, this new technology enables new ways of carrying out the tasks of configurator development and maintenance. This paper defines the new use patterns that the technology enables and deduces the possible benefits compared to existing approaches. To investigate if the new technology can fulfil its great promises, a case study is presented in which the technology has been applied.
Platform Performance and Challenges - using Platforms in Lego Company

This article studies the performance and challenges of using nine implemented product platforms in LEGO Company. Most of these do produce results, but do not meet their goals due to challenges in their usage in the daily product. The main challenges are that the platforms are not being used by the product defining users (product developers) and platform erosion. When the platforms are not used it is due to: unsuitable calculation models, lack of goals, rewards or benefits from management, unattractive tradeoffs and difficulties in understanding the platform. This indicates that platform design needs focus on the incentive of using the platform. This problem lacks attention in literature, as well as industry, where assessment criteria do not cover this aspect. Therefore, we recommend including user incentive in platform assessment criteria to these challenges. Concrete solution elements ensuring user incentive in platforms is an object for future research.
Managing the New Product Portfolio: Towards an end-to-end approach

Product development companies are increasingly confronted with an unforgiving global marketplace, which urges the top management to pursue every product development opportunity that appears on the road. This situation incurs an important question: Which product development opportunities should a company choose to pursue in order to maximize the business results? Portfolio management is an essential means to accommodate this paradox. The three major contributions documented in this dissertation are a reference model for portfolio management, and a mindset together with three supporting tools. The research project has partially been carried out at the Massachusetts Institute of Technology (MIT). The results of the dissertation build on research literature and empirical studies. All contributions have been confronted with industrial portfolio management practices or industry professional’s judgement. The contributions encourage an improved understanding of the portfolio management concept and support industry professionals in their efforts to compose and continuously maintain a commercially strong product development portfolio.

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Managing the New Product Portfolio - Flemming Larsson PhD dissertation.pdf
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Implementing a product platform in 35 man-days: The visual thinking approach

This paper demonstrates how a company can implement a product platform in 35 man-days. Instead of developing a new platform, the main idea of this platform is to make decisions concerning good solutions to a product assortment,
essentially by determining what is value-creating variance. The main benefits are reduced costs, reduced lead time and increased ability to focus engineering resources on aspects providing value to the customer. A so-called visual approach has been utilised. By means of a Product Family Master Plan, the content and scope of the platform have been modelled and visualised. This has contributed to commitment on the management and operational levels in the whole chain, from customer to production and delivery.

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BFI (2014): BFI-level 1
BFI (2013): BFI-level 1
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
ISI indexed (2012): ISI indexed no
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ISI indexed (2011): ISI indexed no
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BFI (2008): BFI-level 1
Original language: English
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DOIs:
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Source: orbit
Source-ID: 251040
Research output: Research - peer-review › Journal article – Annual report year: 2008

**Improving decision making in the early phases of configuration projects**
During the early phases of configuration projects very important decisions are made which will heavily influence the performance of the company, benefits in different functional areas (production, sales, purchase, product development, service etc), maintenance of the configuration system and quality of the dialogue between the configuration system and the users. Today there exists very sparse tools and procedures which can assist the early phases, i.e. conceptual modeling of the products and product assortment. This paper presents a five-phase procedure for conceptual modeling in configuration projects. Each of the five phases is supported by a set of tools. The main idea of the procedure is utilization of a so-called Product Family Master Plan, which is a formal description of the product assortment and its variation. The procedure has been tested at one of Baan's customers with very convincing results.

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Scopus rating (2017): CiteScore 0.63
Web of Science (2017): Impact factor 0.565
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.51
Web of Science (2016): Impact factor 0.537
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 0.5
Web of Science (2015): Impact factor 0.385
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 0.25
Web of Science (2014): Impact factor 0.396
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 0.24
Web of Science (2013): Impact factor 0.165
ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 0.26
Web of Science (2012): Impact factor 0.284
ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 0.3
Web of Science (2011): Impact factor 0.154
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Web of Science (2010): Impact factor 0.203
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
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Web of Science (2003): Indexed yes
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Source-ID: 224631
Research output: Research - peer-review » Journal article – Annual report year: 2008
Modelling and visualising modular product architectures for mass customisation

Companies following a mass customisation strategy have to observe two prerequisites for success: they have to fulfil a wide variety of customer needs and demands, and to harvest the benefits from economies of scale within their organisation and supply chain. This leads to the situation that the companies are striving for variety from a commercial- and simplicity from a manufacturing one. A conscious structuring of product architectures and/or the use of product platforms can help overcome this challenge. This paper presents a new method for the synthesis and visualisation of product architecture concepts that puts emphasis on variety in markets while also treating the consequences in the manufacturing set-up. The work is based on the assumption that a graphical overview of a given solution space and relations between market demands, product architecture and manufacturing layout can support decision making and constitute a very powerful interaction between stakeholders in product development departments striving for mass customisation.

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Original language: English
Keywords: Modeling, Customization
DOIs:
10.1504/IJMASSC.2008.017141
Source: orbit
Source-ID: 243322
Research output: Research - peer-review › Journal article – Annual report year: 2008

Product Customization
For the majority of industrial companies, customizing products and services is among the most critical means to deliver true customer value and achieve superior competitive advantage. The challenge is not to customize products and services in itself – but to do it in a profitable way. The implementation of a product configuration system is among the most powerful ways of achieving this in practice, offering a reduction of the lead time for products and quotations, faster and more qualified responses to customer inquiries, fewer transfers of responsibility and fewer specification mistakes, a reduction of the resources spent for the specification of customized products, and the possibility of optimizing the products according to customer demands. This book presents an operational procedure for the design of product configuration systems in industrial companies, based on the experience gained from more than 40 product configuration projects in companies providing customer tailored products and services.

General information
A multi-perspective approach for the design of product configuration systems

This article presents a procedure for building a product configuration system. The procedure includes, at the first phase, an analysis and redesign of the business processes, which are to be supported with product configuration systems. The next phase includes an analysis of the product assortment, and the set up of a so-called product variant master. Finally, the product configuration system is designed and implemented using object-oriented modeling. The procedure has been tested at a Danish company making electronic switchboards with positive results.

General information

State: Published
Organisations: Operations Management, Department of Management Engineering, Engineering Design and Product Development
Contributors: Hvam, L., Mortensen, N. H.
Pages: 129-140
Publication date: 2007
Peer-reviewed: Yes
Improving decision making in the early phases of configuration projects

General information
State: Published
Organisations: Engineering Design and Product Development, Department of Management Engineering, Institute for Product Development
Contributors: Mortensen, N. H., Harlou, U.
Publication date: 2007

Host publication information
Title of host publication: The 2007 World Conference on Mass Customization & Personalization (MCPC) at MIT (Boston, USA) and HEC Montreal (Canada) October 7-12
Source: orbit
Source-ID: 224634
Research output: Research - peer-review › Article in proceedings – Annual report year: 2007

Produktkonfigurering: Kundetilpasning af produkter

General information
State: Published
Organisations: Department of Management Engineering, Engineering Design and Product Development, Department of Mechanical Engineering, GEA Process Engineering A/S
Contributors: Hvam, L., Mortensen, N. H., Riis, J.
Number of pages: 304
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Place of publication: København
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Original language: Danish
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Developing product families based on architectures: Contribution to a theory of product families

The subject of this PhD thesis is development of product families based on architectures. Companies are introducing more and more product variants to fulfill the market demands. These new variants add complexity to many of the processes and systems in the companies. Reuse of standard designs (i.e. design entities) and re-use of the way new products are developed can simplify the processes and systems. Case studies show that reuse can lead to reduction of cost and time-to-market of new products. One of the means for managing reuse of standard designs within product families are architectures. This research studies the phenomenon of product families that are developed based upon architectures. It is stated that an architecture describes the building principle of a product family and how the product family should evolve over time. This implies that an architecture should prescribe how standard designs are re-used in one or more products. This research contributes with a vocabulary for product families. The vocabulary distinguishes among architecture, platform, standard design and design unit. The contribution is based on the artefact theories the Theory of technical systems and the Theory of domains. The vocabulary distinguishes between design entities, which are reused (standard designs) and those that are not reused (design units). Also, this research distinguishes between architecture and platform. An architecture is the building principle for product families. A platform is the physical and re-usable realisation of the architecture. Two supporting tools are introduced in this research for modelling architectures and product families. The first tool is denoted Generic organ diagram. It aims at modelling the structures and interfaces of architectures. The second tool is denoted Product family master plan (PFMP). The PFMP aims at modelling product families and especially variety of product families. The results of this thesis build on research literature and experiences from the industrial partners. Extensive verifications of the theory contributions, models and tools have been carried out in industrial projects. The primary industrial partner has been Bang & Olufsen, but other industrial applications have been carried out at Vestas, Alfa Laval, LEGO and YORK Refrigeration.
Identification of platform levels
These years many companies are changing their product development from single to multi product development, meaning that not only one product is developed but product families. There are many reasons for this change, but among the most important ones are reduction of time to market, total cost reduction, ability to launch a wider product portfolio without increasing resources and reduction of complexity within the whole company. To support the multiple product development process, platform based product development has in many companies such as Philips, VW, Ford etc. proven to be a very effective and efficient tool. Transforming product development from single to multiple product development is a significant change in product development often involving major changes of product models, procedures and organization. In the area of product models a set of new models has to be introduced, e.g. models of the platform including interfaces are
necessary. Procedures change because platform based product development requires a clear distinction between preparation (i.e. development of the platform) and development of individual products (i.e. application of the platform). The organization often has to be changed because the nature of developing platforms and applications are very different. In single product development reuse is often determined by individual designers, in multiple product development reuse is to a large degree a management issue. It is difficult for a company to switch from single to multiple product development in one step and therefore the objective of this paper is to identify levels of platform based product development. The structure of this paper is as follows. First the applied terminology for platforms will be briefly explained and then characteristics between single and multi product development will be examined. Based on the identification of the above characteristics five platform levels are described. The research presented in this paper is a result of MSc, Ph.D projects at the Technical University of Denmark and consultancy projects within the organisation of Institute of Product Development.

Projects have mainly been carried out in Denmark, Norway, Sweden and Finland.

General information
State: Published
Organisations: Engineering Design and Product Development, Department of Mechanical Engineering
Contributors: Mortensen, N. H.
Number of pages: 16
Publication date: 2005

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Title of host publication: International Conference on Engineering Design (ICED05)
Place of publication: Melbourne
Publisher: The Institution of Engineers, Australia
ISBN (Print): 0-85825-788-2
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Source-ID: 184935
Research output: Research - peer-review › Article in proceedings – Annual report year: 2005

Method for alignment of product and production concepts
The right use of modular product architectures can help companies provide a great variety of customized products at a competitive price level, by reuse of knowledge, components, processes and utilization of economies of scale in many of the activities that are necessary to provide products for customers. Modular product architectures often serve as a basis for several products often referred to as product families. One or more product families may constitute a substantial amount of the total product portfolio of a company, and it is, therefore, of the greatest importance that concepts and solutions are evaluated thoroughly throughout the design phases because any design fault is likely to propagate to a large part of the business. Developing modular product architectures is therefore also the task of ensuring a fit between the products that can be made on the basis of the architecture and the production system upon which manufacturing will take place. This fit is referred to as alignment. The aim of this paper is to present a new design method that can help design aligned modular product and production architectures. The method has been applied and evaluated at the Danish company Danfoss Industrial Controls. The method consists of two tools and a guideline on how to use these tools.

General information
State: Published
Organisations: Engineering Design and Product Development, Department of Mechanical Engineering
Contributors: Pedersen, R., Kvist, M., Mortensen, N. H.
Publication date: 2005

Host publication information
Title of host publication: International Conference on Engineering Design : Proceedings of 2005
URLs:
http://www.iced2005.com
Source: orbit
Source-ID: 183921
Research output: Research - peer-review › Article in proceedings – Annual report year: 2005

Method for creating and visualizing product architectures
Over the past few decades the notion of product architectures in development has obtained increasing interest from many corporations conducting product development. Modular architectures and product platforms are often reported to have great potential to reduce internal complexity and total cost drivers within a company while increasing the product variety from a commercial standpoint. Modular product architectures have three interesting properties. The first is that the use of modular product architectures enables the company to split its execution and preparation of engineering tasks. The second is that several products can be developed from the same basis so that the company can base product families on the same basic set of design principles and technologies. The third is that modularization may support an alignment of market, product and production/supply chain aspects. This paper presents a new method for synthesis and visualization of product architecture concepts. The visualization represents the concept from a market, product assortment and production/supply chain point of view in order to support the complex process of making the right decisions. The work is
based on the assumption that a graphical overview of a given solution space and relations between market demands, product architecture and manufacturing layout can support decision-making and constitute a very powerful interaction between stakeholders in product development. The key feature of the method is two jigsaw puzzles that are used for concurrent modelling of product and production layout concepts, by combining sub-solutions into total concepts.

Multi-Produkt-Entwicklung - praxisorientierte Werkzeuge und praktische Erfahrungen

These years many companies are radically changing the way product development is carried out. One major change relates to a shift from single product development to multi product development, meaning that not only one product is developed but product families. There are many drivers for this change but among the most important ones are reduced time-to-market, increased product development capacity, and increased sales due more customized products. This change from single product development to multiple product development, e.g. by application of product platforms and modules is a major shift of paradigm in product development. One very important change is a division of product development into preparation and execution. Preparation means e.g. the development of a platform and the specification of interfaces, while execution means platform implementation and the development of individual products or product families. In production the split between preparation and execution has been one of the main reasons for increased productivity and quality. In product development the same phenomena may occur. The challenges in multiple product development are of many types e.g. strategic (portfolio planning, risk handling, market, etc.), organizational (transition from platform design to project execution, determining modern procedures, knowledge sourcing etc.) and modeling (requirement specification for a platform, platform definition, evaluation of solutions etc). This chapter is mainly focusing on the modeling challenge. We see the need for a whole new range of modeling tools to support multiproduct development. Compared to single product development the contents of all phases changes e.g. requirement definition, conceptualization, evaluation and documentation. As examples explicit product family definition and documentation of interfaces are very critical in multiple product development and less critical in single product development. The research carried out in the Technical University of Denmark is based on the fundamental hypothesis that if the characteristics (German: Merkmale) that determine a product family and its relation to market and supply chain can be identified and modeled properly, the ability to handle multiple product development in a more successful way can be achieved. In other words the design “degrees of freedom” for design of product families have to be made visible and explicit. The chapter presents two main results. First experiences from 12 multi product development projects in Danish industry are presented, along with a proposal for a language on multi product development. The aim being to explain words like reference architecture, product architecture, product platform, and standard design. Secondly five tools, which support decision making in multi product development projects, are presented. These tools have successfully been applied in a number of Danish companies. Finally, the chapter will report on the progress in the transition of the product development at Bang & Olufsen from single product development towards multi product development. Platform development at Bang & Olufsen is benchmarked with Philips Consumer Electronics.
Preparing for a Product Platform: Product Family Hierarchy Procedure

Experience in the industry as well as recent related scientific publications show the benefits of product development platforms. Companies use platforms to develop not a single but multiple products (i.e. a product family) simultaneously. When these product development projects are coordinated they lead to increased sales due to more customized product as well as decreased costs due to reuse, making a product development platform a very profitable strategy for product developing companies. A successful implementation of a product development platform is not straightforward though. The introduction of product platforms requires coordination of individual product development projects. This coordination requires the clarification of reuse and variance through the projects. But which parts of a project should be reused and which parts should vary? Reuse in product development platforms is based on commonalities and similarities in the product family, and variance should be based on customer demands. To relate these terms and to improve the basis on which decisions are made, we need a way of visualizing the hierarchy of the product family as well as the commonality and variance. This visualization method could then be used as a tool for creating the product families, which product development platforms depend upon. Experience also tells us that one of the primary negative aspects of product developments platforms is the risk factor. When creating product development platforms companies invest a lot of time in the planning of future activities and make major decisions effecting the future products and production facilities. If the product development platform then fails to meet its expectations the companies loose almost everything they have invested. A tool for verifying the stability of the platform or ensuring that the platform can meet future demands will be very useful in the preparation process of a platform synthesis as well as in the updating or reengineering of an existing product development platform.

General information
State: Published
Organisations: Engineering Design and Product Development, Department of Mechanical Engineering
Contributors: Fiil-Nielsen, O., Munk, L., Mortensen, N. H.
Publication date: 2005

Host publication information
Title of host publication: 15th International Conference on Engineering Design: Engineering Design and the Global Economy
Source: orbit
Source-ID: 183333
Research output: Research - peer-review › Article in proceedings – Annual report year: 2005

A Proposal for an event-based Approach to portfolio management for new products

General information
State: Published
Organisations: Engineering Design and Product Development, Department of Mechanical Engineering
Contributors: Larsson, F., Mortensen, N. H.
Number of pages: 10
Publication date: 2004

Host publication information
Title of host publication: Proceedings of DESIGN 2004
Source: orbit
Source-ID: 155618
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004

Recognizing the needs for improving the portfolio management for new products in the Industry

General information
State: Published
Organisations: Engineering Design and Product Development, Department of Mechanical Engineering
Contributors: Larsson, F., Mortensen, N. H., Andreasen, M. M.
Pages: 337-342
Publication date: 2004

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Title of host publication: Proceedings of the Design 2004 : 8th International Design Conference
Volume: 1
Source: orbit
Source-ID: 190429
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004
 Produktmodellering - procesanalyse, produktanalyse, objektorienteret analyse - Center for Produktmodellering

**Case study on the impact of modularization in Danish industry**

**Conceptual modelling of product families in configuration projects**

**Managing modularization**
On the way towards definition of product architecture

General information
State: Published
Organisations: Engineering Design and Product Development, Department of Mechanical Engineering
Contributors: Harlou, U., Mortensen, N. H., Andreasen, M. M.
Publication date: 2001

Host publication information
Title of host publication: Proceedings of Design for X
Place of publication: Erlangen-Nürnberg
Publisher: Lehrstuhl für Konstruktionstechnik, Friederich-Alexander-Universität
Source: orbit
Source-ID: 64217
Research output: Research - peer-review › Article in proceedings – Annual report year: 2001

The Need for Proper Understanding of Modularisation

General information
State: Published
Organisations: Department of Control and Engineering Design
Contributors: Mortensen, N. H.
Publication date: 2000

Publication information
Place of publication: Tampere
Publisher: TU-Tampere
Original language: English
Source: orbit
Source-ID: 175749
Research output: Research - peer-review › Book – Annual report year: 2000

Contribution to a Theory of Detailed Design

General information
State: Published
Organisations: Department of Control and Engineering Design
Contributors: Mortensen, N. H.
Publication date: 1999

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Title of host publication: Proceedings of "Fertigungsgerechtes Konstruieren"
Publisher: University of Erlangen-Nürnberg
Source: orbit
Source-ID: 174362
Research output: Research - peer-review › Book chapter – Annual report year: 1999

Critical Enthusiasm: Contribution to Design Science

General information
State: Published
Organisations: Department of Control and Engineering Design, Norwegian University of Science and Technology
Publication date: 1999

Publication information
Place of publication: Trondheim
Publisher: Tapir
Original language: English
Source: orbit
Source-ID: 174383
Research output: Research - peer-review › Book – Annual report year: 1999
Function Concepts for Machine Parts: Contribution to a Theory of Detailed Design

General information
State: Published
Organisations: Department of Control and Engineering Design
Contributors: Mortensen, N. H.
Publication date: 1999

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Title of host publication: ICED 99
Place of publication: Garching
Publisher: Technische Universität München
Source: orbit
Source-ID: 174360
Research output: Research - peer-review › Article in proceedings – Annual report year: 1999

Structuring as a Basis for Product Modelling

General information
State: Published
Organisations: Department of Control and Engineering Design
Contributors: Mortensen, N. H., Hansen, C. T.
Pages: 111-128
Publication date: 1999

Host publication information
Title of host publication: Critical Enthusiasm : Contributions to Design Science
Place of publication: Trondheim
Publisher: Tapir
Source: orbit
Source-ID: 174365
Research output: Research - peer-review › Book chapter – Annual report year: 1999

A design language for synthesis and systematization

General information
State: Published
Organisations: Department of Control and Engineering Design
Contributors: Andreasen, M. M., Mortensen, N. H.
Pages: 1-12
Publication date: 1998

Host publication information
Title of host publication: Proceedings of ’9 Symposium Fertigungsgerechtes Konstruieren
Place of publication: Erlangen
Publisher: Friedrich-Alexander Universität Erlangen-Nürnberg
Source: orbit
Source-ID: 171800
Research output: Research - peer-review › Article in proceedings – Annual report year: 1998

Design Prepartion - by means of a Design Handbook

General information
State: Published
Organisations: Department of Control and Engineering Design
Contributors: Mortensen, N. H.
Pages: 91-111
Publication date: 1998

Host publication information
Title of host publication: Proceedings Produktmodeller - 98
Place of publication: Linköping
Produktstrukturer og produktmodellering

General information
State: Published
Organisations: Department of Control and Engineering Design
Contributors: Mortensen, N. H.
Publication date: 1998

Host publication information
Title of host publication: Produktudviklingsdagen
Publisher: IPU
Source: orbit
Source-ID: 172014
Research output: Research - peer-review › Book chapter – Annual report year: 1998

Basic thinking patterns and working methods for multiple DFX

General information
State: Published
Organisations: Department of Control and Engineering Design
Contributors: Andreasen, M. M., Mortensen, N. H.
Publication date: 1997

Host publication information
Title of host publication: Report on Beiträge zum 7. Symposium "Fertigungsgerechtes Konstruieren"
Place of publication: Erlangen
Publisher: H. Meerkamm (publ. of preliminary edition) Lehrstuhl für Konstruktionstechnik, Universität Erlangen-Nürnberg
Source: orbit
Source-ID: 167782
Research output: Research - peer-review › Article in proceedings – Annual report year: 1997

Design Characteristics as Basis for Design Languages

General information
State: Published
Organisations: Department of Control and Engineering Design
Contributors: Mortensen, N. H.
Publication date: 1997

Host publication information
Title of host publication: World Class Design by World Class Methods
Place of publication: Tampere
Publisher: Tampere University of Technology
Source: orbit
Source-ID: 166866
Research output: Research - peer-review › Article in proceedings – Annual report year: 1997

Getting from Organ- to Part- Structure

General information
State: Published
Organisations: Department of Control and Engineering Design
Contributors: Andreasen, M. M., Mortensen, N. H.
Publication date: 1997

Host publication information
Title of host publication: Contributions from 13th WDK' Workshop Rigi
Place of publication: Zürich
Improving conditions for reuse of design solutions - by means of a context based solution library

General information
State: Published
Organisations: Department of Control and Engineering Design
Contributors: Mortensen, N. H., Grothe-Møller, T., Andreasen, M. M.
Publication date: 1997

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Title of host publication: Advances in Industrial Engineering Applications and Practice
Publisher: International Journal of Industrial Engineering
Source: orbit
Source-ID: 166873
Research output: Research - peer-review › Article in proceedings – Annual report year: 1997

Konstruktionsforberedelse hos Kværner

General information
State: Published
Organisations: Department of Control and Engineering Design, Institute for Product Development
Contributors: Mortensen, N. H., Radmer, J.
Publication date: 1997

Host publication information
Title of host publication: Konstruktionsforberedelse - multiprodukter, produktmodeller, modularisering
Publisher: Institut for Konstruktions- og Styreteknik
Source: orbit
Source-ID: 166874
Research output: Research › Article in proceedings – Annual report year: 1997

On the identification of Product Structure Laws

General information
State: Published
Organisations: Department of Control and Engineering Design
Pages: 1-26
Publication date: 1997

Host publication information
Title of host publication: Proceedings of the 3rd WDK Workshop on Product Structuring
Place of publication: Delft
Publisher: Delft University of Technology
ISBN (Print): 90-370-0169-6
Source: orbit
Source-ID: 165908
Research output: Research - peer-review › Article in proceedings – Annual report year: 1997

The Nature of Design Features

General information
State: Published
Organisations: Department of Control and Engineering Design
Contributors: Andreasen, M. M., Mortensen, N. H.
Number of pages: 128
Publication date: 1997

Host publication information
Designing in an Interplay with a Product Model - Explained by Design Units

General information
State: Published
Organisations: Department of Control and Engineering Design
Contributors: Mortensen, N. H., Andreasen, M. M.
Publication date: 1996

Host publication information
Title of host publication: Designing in an Interplay with a Product Model - Explained by Design Units
Source: orbit
Source-ID: 166589
Research output: Research - peer-review » Book chapter – Annual report year: 1996

On the Identification of design Feature Characteristics

General information
State: Published
Organisations: Department of Control and Engineering Design
Contributors: Mortensen, N. H., Andreasen, M. M.
Publication date: 1996

Host publication information
Title of host publication: Produkmodeller ’96
Place of publication: Linköping
Publisher: Linköping University
Source: orbit
Source-ID: 166875
Research output: Research - peer-review » Article in proceedings – Annual report year: 1996

Product Variant Master as a Means to Handle Variant Design

General information
State: Published
Organisations: Department of Control and Engineering Design, Norwegian University of Science and Technology
Contributors: Hildre, H. P., Mortensen, N. H., Andreasen, M. M.
Publication date: 1996

Host publication information
Title of host publication: Proceedings of Industrial Engineering Applications and Practice
Publisher: International Journal of Industrial Engineering
Source: orbit
Source-ID: 166877
Research output: Research - peer-review » Article in proceedings – Annual report year: 1996

Produktudvikling i et produktionsperspektiv

General information
State: Published
Organisations: Department of Control and Engineering Design, Technical University of Denmark
Pages: 45-84
Publication date: 1996

Host publication information
Title of host publication: Det udvidede produktionsbegreb
The structuring of products and product programmes

General information
State: Published
Organisations: Department of Control and Engineering Design
Pages: 15-44
Publication date: 1996

Host publication information
Title of host publication: Proceedings of the 2nd WDK Workshop on Product Structuring
Place of publication: Delft
Publisher: Delft University of Technology
Source: orbit
Source-ID: 165531
Research output: Research › Article in proceedings – Annual report year: 1996

Projects:

Planning Project Configuration System Projects
Ghosh, A., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
01/01/2019 → 31/12/2021
Project: PhD

Maintenance Strategy at Rockwool
Lemes, L. C., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Mortensen, N. H., Supervisor, Department of Mechanical Engineering
01/12/2018 → 30/11/2021
Project: PhD

Design by Prototyping - From Idea to Product Realisation
Hansen, C. A., PhD Student, Department of Mechanical Engineering
Özkil, A. G., Main Supervisor, Department of Mechanical Engineering
Mortensen, N. H., Supervisor, Department of Mechanical Engineering
01/12/2018 → 30/11/2021
Project: PhD

Systematic Maintenance Improvement - A Data Driven Approach
Soleymani, I., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
15/10/2018 → 14/10/2021
Project: PhD

Optimization of maintenance shutdown of large-scale equipment
Khalid, W., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
15/10/2018 → 14/10/2021
Project: PhD
Application of Product Configuration Systems in Engineering Companies
Kristjansdottir, K., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Mortensen, N. H., Supervisor, Department of Management Engineering
Thuesen, C., Examiner, Department of Management Engineering
Anusic, Z., Examiner
Jensen, L. J., Examiner
Samfinansieret - Andet
15/11/2014 → 14/11/2017
Award relations: Application of Product Configuration Systems in Engineering Companies
Documents:
PhD_Katrin Kristjansdottir
Project: Research

Quantitative Modular Maintenance Principles
Sigsgaard, K. V., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
Fonde
01/02/2018 → 31/01/2021
Award relations: Quantitative Modular Maintenance Principles
Project: PhD

Data Driven Analysis of Plant Operation
Bertram, C. A., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
Grundforskningsfonden
01/01/2018 → 31/12/2020
Award relations: Data Driven Analysis of Plant Operation
Project: PhD

Developing Product Architectures in Collaboration with Key-Customers
Askhøj, C., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
Grundforskningsfonden
01/01/2018 → 31/12/2020
Award relations: Developing Product Architectures in Collaboration with Key-Customers
Project: PhD

Complexity Management at DSV A/S
Schorr, F., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Mortensen, N. H., Supervisor, Department of Mechanical Engineering
Mortensen, N. H., Supervisor, Department of Mechanical Engineering
Rahimi, F., Supervisor, Department of Management Engineering
Hove, C., Supervisor
Industrial PhD
15/11/2017 → 14/11/2020
Award relations: Complexity Management at DSV A/S
Project: PhD

Developing Modular Product and Process Architectures in Engineer to Order (ETO) Companies
Christensen, C. K. F., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
Grundforskningsfonden
15/09/2017 → 14/09/2020
Award relations: Developing Modular Product and Process Architectures in Engineer to Order (ETO) Companies
Management of product and production data
Battistello, L., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Mortensen, N. H., Supervisor, Department of Mechanical Engineering
Forskningsrådsfinansiering m/virksomhed
01/09/2017 → 31/08/2020
Award relations: Management of product and production data
Project: PhD

End-to-end configuration
Rasmussen, J. B., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
Samfinansieret - Andet
01/10/2016 → 30/09/2019
Award relations: End-to-end configuration
Project: PhD

Diagnose på og specifikation af produktprogram og produktudviklingsprocessen
Kvist, M., PhD Student, Department of Management Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Andreasen, M. M., Supervisor, Department of Mechanical Engineering
Hildre, H. P., Examiner
Malmqvist, J., Examiner
Riitahuhta, A., Examiner
DTU, Samfinansiering
01/04/2004 → 14/04/2010
Award relations: Diagnose på og specifikation af produktprogram og produktudviklingsprocessen
Project: PhD

Strategi for produktinnovation - et værktøj til generering og udvælgelse af produktinnovationsprojekter
Larsson, F., PhD Student, Department of Management Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Andreasen, M. M., Supervisor, Department of Mechanical Engineering
Hein, L., Supervisor, Department of Control and Engineering Design
Hildre, H. P., Examiner
Hansen, N. S., Examiner
Johannesson, H. L., Examiner
Ansat eksternt
01/02/2003 → 08/07/2008
Award relations: Strategi for produktinnovation - et værktøj til generering og udvælgelse af produktinnovationsprojekter
Project: PhD

Genetisk produktmodellering og synteseværktøjer til konstruktionsstøttesystem med aluminiumstekn. som anvendt område
Mortensen, N. H., PhD Student, Department of Mechanical Engineering
Andreasen, M. M., Main Supervisor, Department of Mechanical Engineering
Gammel ordning u/skema-SU
01/04/1992 → 11/04/2000
Award relations: Genetisk produktmodellering og synteseværktøjer til konstruktionsstøttesystem med aluminiumstekn. som anvendt område
Project: PhD

Trafiksikkerhed i produktudvikling gennem brugercentreret design: En undersøgelse af teori og praksis
Christensen, M. E., PhD Student, Department of Mechanical Engineering
Howard, T. J., Main Supervisor, Department of Mechanical Engineering
McAloone, T. C., Supervisor, Department of Mechanical Engineering
Mortensen, N. H., Examiner, Department of Mechanical Engineering
Söderberg, R., Examiner
Håndtering af interfaces i højkomplekse og multidisciplinære produkter
Parslov, J. F., PhD Student, Engineering Design and Product Development
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
Malmqvist, J., Examiner
Weber, C., Examiner
Wörösch, M., Examiner, Department of Management Engineering
Malmqvist, J., Examiner
Weber, C., Examiner

Application of Architectures in SME’s
Rask, L. C., PhD Student
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor
Vestergaard, J., Supervisor
Industrial PhD
01/02/2016 → 01/08/2019
Award relations: Application of Architectures in SME’s
Project: PhD

Early application of tolerance design
Bjarklev, K., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Eifler, T., Supervisor, Department of Mechanical Engineering
Krause, D., Examiner
Krause, D., Examiner
Hildre, H. P., Examiner
Kiil, H., Examiner
Samfinansierede - Virksomhed
15/12/2015 → 14/12/2018
Award relations: Early application of tolerance design
Project: PhD

Analysis and modelling of Engineering Systems using Data Science and Complex Networks
Piccolo, S., PhD Student, Department of Management Engineering
Maier, A., Main Supervisor, Department of Management Engineering
Jørgensen, S. L., Supervisor, Department of Applied Mathematics and Computer Science
Lindemann, U., Supervisor
Oehmen, J., Supervisor, Department of Management Engineering
Mortensen, N. H., Examiner, Department of Mechanical Engineering
Stopczynski, A., Examiner, Department of Applied Mathematics and Computer Science
Wynn, D. C., Examiner
Institut stipendie (DTU)
01/11/2015 → 31/10/2018
Award relations: Analysis and modelling of Engineering Systems using Data Science and Complex Networks
Project: PhD

Investigating New Design Paradigms in Agile Product Development and Rapid Prototyping
Jensen, L. S., PhD Student, Department of Mechanical Engineering
Özkil, A. G., Main Supervisor, Department of Mechanical Engineering
Application of Product Configuration Systems in Engineering Companies
Kristjansdottir, K., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Mortensen, N. H., Supervisor, Department of Mechanical Engineering
Thuesen, C., Examiner, Department of Management Engineering
Anisic, Z., Examiner
Jensen, L. J., Examiner
Anisic, Z., Examiner
Jensen, L. J., Examiner
Samfinansieret - Andet
15/11/2014 → 06/03/2018
Award relations: Application of Product Configuration Systems in Engineering Companies
Project: PhD

Reducing time-to-market by means of modular platforms
Løkkegaard, M., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
Hildre, H. P., Examiner
Bysted, T., Examiner
Malmqvist, J., Examiner
Hildre, H. P., Examiner
Malmqvist, J., Examiner
Forskningsrådsfinansiering
01/08/2014 → 06/03/2018
Award relations: Reducing time-to-market by means of modular platforms
Project: PhD

Conceptual Modelling for Product Configuration Systems
Shafiee, S., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Mortensen, N. H., Supervisor, Department of Mechanical Engineering
Jacobsen, P., Examiner, Department of Management Engineering
Malis, M., Examiner, Department of Management Engineering
Vareilles, É., Examiner
Vareilles, É., Examiner
Industrial PhD
01/05/2014 → 21/09/2017
Award relations: Conceptual Modelling for Product Configuration Systems
Project: PhD

Business Intelligence i Engineeringvirksomheder
Ulrikkeholm, J. B., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Mortensen, N. H., Supervisor, Department of Mechanical Engineering
Jacobsen, P., Examiner, Department of Management Engineering
Jensen, L. J., Examiner
Sunnertjø, S., Examiner
Jensen, L. J., Examiner
Sunnertjø, S., Examiner
ErhvervsPhD-ordningen VTU
15/10/2010 → 26/05/2014
Award relations: Business Intelligence i Engineeringvirksomheder
**Requirement management with multiple product platforms**
Hauksdóttir, D., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
Nielsen, P. E., Examiner
Malmqvist, J., Examiner
Hildre, H. P., Examiner
Krause, D., Examiner
Malmqvist, J., Examiner
Hildre, H. P., Examiner
Krause, D., Examiner
Institut/centerfinansieret
01/12/2011 → 24/09/2015
Award relations: Requirement management with multiple product platforms

**Indlejret produktkonfiguration hos Grundfos Strukturering af produktviden**
Oddsson, G. V., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Mortensen, N. H., Examiner, Department of Mechanical Engineering
Malmqvist, J., Examiner
Forskningsrådsfinansiering
01/06/2005 → 31/10/2008
Award relations: Indlejret produktkonfiguration hos Grundfos Strukturering af produktviden

**Indlejret konfigurering: Modellering af produktfamilier og versionsstyring**
Christensen, T. T., PhD Student, Institute for Product Development
Hvam, L., Main Supervisor, Department of Management Engineering
Mortensen, N. H., Examiner, Department of Mechanical Engineering
Jensen, L. J., Examiner
Forskningsrådsfinansiering
01/03/2005 → 05/05/2010
Award relations: Indlejret konfigurering: Modellering af produktfamilier og versionsstyring

**Systemintegration i teknologiudviklingsprojekter**
Ravn, P. M., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
Hildre, H. P., Examiner
Jensen, L. J., Examiner
Krause, D., Examiner
Hildre, H. P., Examiner
Jensen, L. J., Examiner
Krause, D., Examiner
Institut, samfinansiering
01/07/2012 → 04/07/2016
Award relations: Systemintegration i teknologiudviklingsprojekter

**Requirements management with multiple product platforms**
Bonev, M., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Mortensen, N. H., Supervisor, Department of Mechanical Engineering
Thuesen, C., Examiner, Department of Management Engineering
Elgh, F., Examiner
Jensen, L. J., Examiner
Elgh, F., Examiner
Jensen, L. J., Examiner
**Institut, samfinansiering**
01/10/2011 → 21/05/2015
Award relations: Requirements management with multiple product platforms
Project: PhD

**Udvikling af teknologisk produktarkitektur fra specification til produktion**
Guðlaugsson, T. V., PhD Student, Department of Management Engineering
Mortensen, N. H., Main Supervisor, Department of Management Engineering
Hvam, L., Supervisor, Department of Management Engineering
Lenau, T. A., Examiner, Department of Mechanical Engineering
Hildre, H. P., Examiner
Pulkkinen, A. J., Examiner
Institut, samfinansiering
01/10/2011 → 07/04/2016
Award relations: Udvikling af teknologisk produktarkitektur fra specification til produktion
Project: PhD

**Development of modeling techniques for project management in product development**
Wörösch, M., PhD Student, Department of Management Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
Lenau, T. A., Examiner, Department of Management Engineering
Berard, O. B., Examiner, Department of Civil Engineering
Brockmann, C., Examiner
Institut, samfinansiering
01/03/2011 → 26/05/2014
Award relations: Development of modeling techniques for project management in product development
Project: PhD

**Parallelsynte af marked, produkt og produktion/supply chain**
Munk, L., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Johannesson, H. L., Examiner
Hildre, H. P., Examiner
Riitahuhta, A., Examiner
DTU, Samfinansiering
01/09/2004 → 31/08/2011
Award relations: Parallelsynte af marked, produkt og produktion/supply chain
Project: PhD

**Platforme i produktion**
Nielsen, O. F., PhD Student, Department of Management Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Boelskifte, P., Examiner, Department of Mechanical Engineering
Malmqvist, J., Examiner
Riitahuhta, A., Examiner
DTU, Samfinansiering
15/08/2004 → 14/04/2010
Award relations: Platforme i produktion
Project: PhD

**Referencerarkitektur for produktplatforme og produktionsprocesser**
Pedersen, R., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
McAloone, T. C., Supervisor, Department of Mechanical Engineering
Hildre, H. P., Examiner
Kyvsgaard Hansen, P., Examiner, Department of Management Engineering
Johannesson, H. L., Examiner
Hansen, P. K., Examiner
DTU, Samfinansiering
01/09/2004 → 09/06/2010
Award relations: Referencearkitektur for produktplatforme og produktionsprocesser
Project: PhD

Modeling of product- and process architecture
Jepsen, A. D., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
Skov, L., Supervisor
Hildre, H. P., Examiner
Elgh, F., Examiner
Jensen, L. J., Examiner
Hildre, H. P., Examiner
Elgh, F., Examiner
Jensen, L. J., Examiner
1/3 FUU, 1/3 inst 1/3 Andet
01/09/2009 → 21/05/2015
Award relations: Modeling of product- and process architecture
Project: PhD

Quantitative Architecture Synthesis
Jensen, T. V., PhD Student, Department of Mechanical Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hansen, C. T., Supervisor, Department of Mechanical Engineering
1/3 FUU, 1/3 inst 1/3 Andet
15/11/2013 → 01/04/2018
Award relations: Quantitative Architecture Synthesis
Project: PhD

Syntese af produktarkitekturer
Harlou, U., PhD Student, Institute for Product Development
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Andreasen, M. M., Supervisor, Department of Mechanical Engineering
Riitahuhta, A., Examiner, Department of Control and Engineering Design
Hildre, H. P., Examiner
Kill, H., Examiner
Riitahuhta, A., Examiner
DTU-lønnet stipendie
01/01/2001 → 08/11/2006
Award relations: Syntese af produktarkitekturer
Project: PhD

Complexity Management
Myrodia, A., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Mortensen, N. H., Supervisor, Department of Mechanical Engineering
Jacobsen, P., Examiner, Department of Management Engineering
Malis, M., Examiner, Department of Management Engineering
Olhager, J. E., Examiner
Olhager, J. E., Examiner
Samfinansierede - Virksomhed
01/11/2013 → 18/05/2017
Award relations: Complexity Management
Project: PhD

Udvikling af mekatroniske platforme
Bruun, H. P. L., PhD Student, Department of Management Engineering
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering
Hvam, L., Supervisor, Department of Management Engineering
Malmqvist, J., Examiner
Bysted, T., Examiner
**Design for micro manufacturing**

Omidvarnia, F., PhD Student, Department of Mechanical Engineering  
Hansen, H. N., Main Supervisor, Department of Mechanical Engineering  
Lenau, T. A., Supervisor, Department of Mechanical Engineering  
Mortensen, N. H., Supervisor, Department of Mechanical Engineering  
Tosello, G., Examiner, Department of Mechanical Engineering  
Bilberg, A., Examiner, Department of Manufacturing Engineering  
Shu, L., Examiner  
Shu, L., Examiner  
Institut, samfinansiering  
15/06/2012 → 30/10/2015  
Award relations: Design for micro manufacturing  
Project: PhD

**Koordineret udvikling af produktarkitekturog forretningsprocesser**

Hansen, C. L., PhD Student, Department of Management Engineering  
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering  
Hvam, L., Supervisor, Department of Management Engineering  
Welo, T., Examiner  
Johannesson, H., Examiner  
Krause, D., Examiner  
Institut stipendie (DTU) Samf.  
01/08/2009 → 26/01/2015  
Award relations: Koordineret udvikling af produktarkitekturog forretningsprocesser  
Project: PhD

**Metodisk konstruktion af produkter**

Torry-Smith, J., PhD Student, Department of Management Engineering  
Mortensen, N. H., Main Supervisor, Department of Mechanical Engineering  
Johannesson, H. L., Examiner  
McAlloone, T. C., Examiner, Department of Mechanical Engineering  
Ritahuhta, A., Examiner  
Institut stipendie (DTU) Samf.  
01/01/2009 → 27/08/2013  
Award relations: Metodisk konstruktion af produkter  
Project: PhD

**Connovate - optimized building system using High Performance Concrete**

Vision The parties will develop a new sustainable building system using High Performance Concrete (HPC) for sandwich elements. The system meets the visions of low energy use, low material consumption, material recycling and low CO2 emission throughout the entire life cycle, contributing to Denmark fulfilling its international obligations as well as expanding Denmark's international position through export of an innovative building technology. The system will represent the next step in the construction industry's increasing use of prefabricated elements, making it possible to offer the end user better solutions for insulation, increased living space and better indoor air quality at a competitive price. As a result of the superior performance compared to current refurbishment methods, the system is expected to play a central role in the foreseen energy refurbishment of the existing building stock. Focused on global warming, this allows for legislation on the issue to be further tightened. Objective The aims are to develop and certify the basic elements for a new HPC building system and launch it on the Danish market prior to introducing the system to further markets. We will establish Connovate as a joint IPR holder and a company to develop business models for future development of products, markets and systems globally. IPR will be shared between Connovate, DTU and IPU and continuously strengthened throughout the development period supporting the core business. Success criterion The overall success criterion is to develop the basic HPC building elements and to create an effective production layout. A further criterion is the establishment of a company (Connovate) that on the basis of innovation and strong IPR’s will secure the continuity of developing the HPC system. A third criterion is to create jobs in a broad range of companies in Denmark and gain increased market share in export markets. Finally, we expect a measurable positive impact on the environmental challenges.
Bro, K., Project Manager, Arkitema K/S
Hvam, L., Project Participant, Department of Management Engineering
Mortensen, N. H., Project Participant, Department of Management Engineering
Serwin, B., Project Participant, Contec ApS
Nieport, C., Project Participant, Smith Innovation
Svendsen, S., Project Participant, Department of Civil Engineering
Stang, H., Project Participant, Department of Civil Engineering
Olesen, H., Project Participant, DELTA - a Part of FORCE Technology
Bertelsen, I., Project Participant, DBI - Dansk Brand- og Sikringsteknisk Institut
Gregersen, J., Project Participant, Institute for Product Development

Project ID: 81148
Forsk. Andre statslige danske i øvrigt
01/09/2010 → 31/08/2013
Award relations: Connovate - optimized building system using High Performance Concrete

Project: Research

**Systemleverancer i byggeriet : - et forskningsnetværk**


Hvam, L., Project Manager, Department of Management Engineering
Mortensen, N. H., Project Manager, Department of Management Engineering
27/02/2007 → 31/05/2007
Collaborators: Aarhus School of Architecture, Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation

Project: Research

**Design for Manufacture**

DFM belongs to one of the DFX-areas, which are treated as a totality and long range research area at the Department. In 1996 especially IKS’s sister organisation Institute for Product Development has been active in this area, with Eureka FAMOS and Nordic DFM research projects, and several industries projects. For IKS this has lead to strengthening the research activities on the design/production interaction, treated in the IPS (Integrated Production System) research project. A teaching model for DFM was introduced in 1996 for polytechnic midway projects at IKS. In 1997 IKS has established DFM as a permanent part of the midway projects and part of the course Product life engineering at IKS. In 1998 our teaching focussed on "lessons learned" relation between supplier and product development team. In 1999 the Lucas' methodology was brought in by new staff member Tone Robotham. Substantial research are forund in the modularisation area (see Synthesis of product families) and in the area of multiple DFX. Project members: Mortensen, Niels Henrik; Robotham Anthony John.

Andreasen, M. M., Project Manager, Department of Control and Engineering Design
Mortensen, N. H., Project Participant, Department of Control and Engineering Design
Robotham, A. J., Project Participant, Department of Control and Engineering Design
01/01/1980 → 31/12/1999
Project: Research

**Integrated Production System**

IKS is participating in a research program with the same name, together with four DTU institutes and AAU. IKS is active in the sub projects "Product Design and Process Planning in Concurrent Development" and "Methods for Engineering Management", see project Design Coordination. The purpose of the programme is strenghtening of the competing edge of Danish industry through integration and by IT. In the sub projects is established models for Design for Manufacture and Models for a design support system, i.e. a Designer's Workbench (see project). A Ph.D.-student is working on product modelling, Niels Henrik Mortensen, see project. Søren B. Terkelsen is working on Design Coordination (DC). Sandra Duffy has been appointed as guest researcher for Design Coordination, see publications. Cooperation with the University of C., Delft and Strathclyde is established and workshop established as DC.

Andreasen, M. M., Project Manager, Department of Control and Engineering Design
Mortensen, N. H., Project Participant, Department of Control and Engineering Design
Dawids, S., Project Participant, Department of Control and Engineering Design
Development of a designer's workbench

It is the long term goal of IKS to contribute to the creation of a design support system, which can support the total design sequence. This area is treated in Ph.D.-projects related to two research programs, and by efforts of staff members. The Ph.D.-projects are allocated to Thomas Jensen and Niels Henrik Mortensen, see their projects. Control functionalities are decomposing/ composing, specification, organ oriented design synthesis, product modelling and structuring. These topics are treated in the mentioned projects and publications from the department, see publications related to the staff below. The results have been presented by workshops in Erlangen and Delft 1996-99 and by conferences in Budapest and Helsinki in 1996, and at the ICE'D97 and ICE'D99. Substantial results are obtained concerning design language, produkt modelling and product life modelling, synthesis operations, organ and part synthesis and modelling of design intent!

Andreasen, M. M., Project Manager, Department of Control and Engineering Design
Hansen, C. T., Project Participant, Department of Control and Engineering Design
Jensen, T. A., Project Participant, Department of Control and Engineering Design
Mortensen, N. H., Project Participant, Department of Control and Engineering Design

01/01/1991 → 31/12/1999
Project: Research

Design Languages

Today engineering design may be characterised as being on a craftsmanship like level. It is difficult to separate single activities, only the final result is documented (not the reasoning and verifications), standard "machines", "processes" and "materials" are not utilised and a design process can not be reproduced with known quality of the results. The change of engineering design these years could be characterised as a shift from craftsmanship towards industrialisation. Application of information technology plays a crucial role in achieving industrialisation of engineering design. The goal of this project is to contribute to the next generation CAD systems focusing on the improvement of syntheseis and documentation. To be able to synthesise in an interplay seems to require the existence of design languages which allow a designer to "spell" a design solution formally in such a way that properties can be derived from a design model. This project takes a a starting point that four languages are necessary to design: process, function, organ and part languages. Until now a generic structure of a design languages has been identified for parts, that consist of wirksurfaces, wirkmaterial, wirkskeletons and syntactical rules.

Mortensen, N. H., Project Manager, Department of Control and Engineering Design
Andreasen, M. M., Project Participant, Department of Control and Engineering Design

01/01/1998 → 01/12/1999
Project: Research

Product Variant Master Design

Many manufacturing companies are expanding their product assortment, they make variants which fit different customers. As a result of this sales are increasing but not necessarily the profit. The reason is that many variants cause higher overhead costs. Such market orientation can be very costly unless reuse of engineering effort, modules, parts and production equipment can be achieved. The goal of this project is to identify a variant master or a template which can serve as the basis for designing customer specific variants in a modern feature based CAD system. The variant master consist of four elements: core models, variator models, rules and property models. The core model contains the part of the product which does not change, the variators are the subsystem or modules that have variation, rules can be production rules, structure rules etc., properties describe the behaviour of a product. In a design project a product variant is designed by superimposing variants on the core model. The variant master has been implemented in an industrial company, Kværner Ships Equipment in Gothenburg by means of the feature based CAD system, Ideas. The effects from application are positive. The design time to design a customer specific variant is reduced by a factor 10 and the number of errors are decreasing due to improved documentation which suits relevant stakeholders, e.g. purchase, production and calculation.

Mortensen, N. H., Project Manager, Department of Control and Engineering Design

01/01/1997 → 01/10/1999
Project: Research

Development and integration of tools for a Designer's Workbench

The use of computers in mechanical engineering design is increasing, but so far traditional CAD systems can only capture geometrical reasoning, whereas functional reasoning is not supported. The research project aims at developing a Designer's Workbench (DWB), that support the designer in capturing and reuse of functional reasoning during the synthesis activities.

Jensen, T. A., Project Manager, Department of Control and Engineering Design
Andreasen, M. M., Project Participant, Department of Control and Engineering Design
Hansen, C. T., Project Participant, Department of Control and Engineering Design
Mortensen, N. H., Project Participant, Department of Control and Engineering Design
Automatic design system saves millions
Lars Hvam & Niels Henrik Mortensen
18/08/2018

Description
Three years ago, it used to take Haldor Topsøe one week to design a customized solution for a customer. It can now be done in ten minutes.
Department of Mechanical Engineering, Department of Management Engineering, Engineering Design and Product Development, Management Science, Centre for oil and gas – DTU, Operations Management

Media contribution (1)

Automatic design system saves millions
18/08/2018
DTU, Denmark
http://www.man.dtu.dk/nyheder/nyhed?id=375366C4-032B-46C0-A129-7AEE8BF7EF0A&utm_campaign=Corporate%20News&utm_content=75718991&utm_medium=social&utm_source=linkedIn
Three years ago, it used to take Haldor Topsøe one week to design a customized solution for a customer. It can now be done in ten minutes.
Lars Hvam & Niels Henrik Mortensen
Department of Management Engineering, Management Science, Operations Management, Centre for oil and gas – DTU, Department of Mechanical Engineering, Engineering Design and Product Development

Press/Media: Press / Media