Understanding the impact of non-standard customisations in an engineer-to-order context: A case study

Companies operating with an engineer-to-order (ETO) manufacturing strategy produce customised solutions for their customers. While they may be able to build on a base of existing sub-solutions, e.g. standard product structures, modules or parts when engineering a customer-specific solution, they often have to create something completely new to satisfy customers’ requirements. However, it is not always clear to ETO companies what the costs associated with making customer specific solutions are, or which product or project characteristics drive costs and in what business processes. Therefore, it is not clear to companies if it is actually profitable for them to fulfil all of their customers’ requirements. Hence, making it relevant to understand how creating non-standard customisations impact project profitability. This paper presents a framework for how ETO companies can quantify the impact of the complexity associated with non-standard customisations when cost data is only available at the project level. The framework is theoretically founded; it is based on statistical regression and a definition of a complexity index for non-standard customisations. The framework is validated in the context of an ETO case company and empirical data is presented.
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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.67 SJR 1.435 SNIP 1.413
Web of Science (2016): Impact factor 2.325
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.29 SJR 1.306 SNIP 1.317
Web of Science (2015): Impact factor 1.693
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.15 SJR 1.222 SNIP 1.33
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BFI (2013): BFI-level 1
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ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.93 SJR 1.238 SNIP 1.558
Web of Science (2012): Impact factor 1.46
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.69 SJR 1.138 SNIP 1.392
Web of Science (2011): Impact factor 1.115
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.889 SNIP 1.119
Web of Science (2010): Impact factor 1.033
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.771 SNIP 1.097
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.907 SNIP 1.272
Scopus rating (2007): SJR 0.836 SNIP 1.194
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.904 SNIP 1.356
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.681 SNIP 1.263
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.819 SNIP 1.317
Scopus rating (2003): SJR 0.821 SNIP 1.044
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.967 SNIP 1.198
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.717 SNIP 1.064
A Database Administration Tool to Model the Configuration Projects

General information
State: Published
Contributors: Shafiee, S., Friis, S. C., Lis, L., Harlou, U., Wautelet, Y., Hvam, L.
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Challenges of Digital Transformation: The case of the Non-Profit Sector
Nonprofit organizations (NPOs) are critical to the quality of life in many communities not only due to the valuable services and social impact they create, but also because of the positive economic impact within local communities. However, NPOs, just as for-profits, need to innovate in response to changing customer demands and lifestyles and to capitalize on opportunities offered by technology and changing marketplaces, structures and dynamics. Digitalization is essential to fuel NPO's innovation in order to be a differentiator in the highly competitive environment. In this paper, we first develop a review to identify the challenges of digital transformation and then we examine some of the challenges that the nonprofit sector faces in undertaking digital transformation initiatives.

General information
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Contributors: Shafiee Nahrkhalaji, S., Shafiee, S., Shafiee, M., Hvam, L.
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DOI:
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Source-ID: 154549121
Configuration lifecycle management (CLM) encompasses all configuration models across a product's life cycle. CLM covers manufacturers' needs for complex configurable products, which tend to require more seamless integration of all their business units and external stakeholders in terms of process continuity and data exchange. CLM differs from existing life cycle management tools because it focuses on sharing the configuration knowledge and data of a configurable product throughout its entire life cycle across all the involved business units of an organization. Therefore, assessing the maturity level of the organization is important for more effective and efficient implementation of CLM. Based on this, the contribution of this research is the development of a CLM maturity model that serves as a guide for the transition to complete horizontal and vertical integration of CLM knowledge and tools across and beyond an organization. The proposed maturity model is validated against the literature and existing maturity models, in addition to being examined through a workshop with industry representatives and empirical cases.

General information
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Organisations: Operations Management, Management Science, Department of Management Engineering, Configit A/S
Contributors: Myrodia, A., Randrup, T., Hvam, L.
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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
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BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.66 SJR 0.948 SNIP 2.309
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Web of Science (2014): Indexed yes
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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
Scoping a PIM System: A Supporting Framework

This article presents a four-step framework for supporting the scoping phase of a product information management system (PIM) and describes the results from applying the framework in an international company. The framework is based on the literature, developed in collaboration with industrial partners and tested in a multi-division and multimarket company. The framework is intended to: (1) identify the stakeholders of the PIM; (2) collect the stakeholders' requirements; (3) give an understanding of the current working process; (4) suggest a future scenario with the implementation of the software; and (5) framing a centralized product information model. The information on the PIM system are defective in the literature and no studies were found on the scoping process of this software. This study fills that gap by developing and testing a framework to support a PIM project in the scoping phase.

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Organisations: Department of Management Engineering, Management Science, Operations Management
Contributors: Battistello, L., Kristjansdottir, K., Hvam, L.
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The costs and benefits of product configuration projects in engineer-to-order companies

In recent decades, many engineering-oriented companies have gained significant benefits from the use of product configurators, including higher product specification quality, fewer specification errors, faster quote creation and higher quote accuracy. On the other hand, many companies also experience great difficulties in realising such benefits within reasonable costs, which in many cases makes them abandon such projects. Although the literature provides a variety of methods to support the development and implementation of product configurators, it remains unclear how to estimate the costs and benefits for different scenarios — and, from there, how to define a profitable project scope. To address this issue, this paper develops a framework to support the estimation of costs and benefits of configurator projects in connection with their scoping. The framework includes models of the relationships between costs and benefits of product configurators at three different abstraction levels: product family level, product part level, and product detail level. The framework is investigated through studies of five configurator projects, which include descriptions of the total costs and benefits of these projects. The numbers from the projects studied support the hypothesised cost-benefit models. The studies also show that there can be great variety with regard to break-even points, as one of the configurator projects became profitable after only 12 months, while two projects had yet to become so after five years.

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Contributors: Haug, A., Shafiee, S., Hvam, L.
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Scopus rating (2017): CiteScore 3.68 SJR 1.028 SNIP 1.886
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
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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
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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.

General information

State: Accepted/In press
Organisations: Department of Management Engineering, Management Science, Operations Management, Department of Mechanical Engineering, Engineering Design and Product Development
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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 quantify 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 too 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.

General information
State: Published
Organisations: Engineering Design and Product Development, Department of Mechanical Engineering, Operations Management, Management Science, Department of Management Engineering
Contributors: Rasmussen, J. B., Myrodia, A., Hvam, L., Mortensen, N. H.
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Behavior-Driven Development in Product Configuration Systems
Product Configuration Systems (PCS) are increasingly used by companies to automate the performance of the sales and engineering processes. Since the benefits from such projects have huge variations, it is crucial to make the right decisions when scoping and developing PCSs. The development of PCS is influenced by both business interests and technical insights. Developers of PCS face various challenges while working in team including different stakeholders such as business owners, developers, project managers, and product experts. The more diverse the team is, the more significant are the challenges. This paper suggests that Behavior-driven Development (BDD) may provide configuration teams with a specific structure to express scenarios (and thus constraints) on PCS in natural language. BDD may yield benefits such as a better expression of PCS constraints, more efficient communication of requirements and incorporation of the expressed rules in a software transformation process. In other words, applying BDD may eliminate unnecessary tasks when gathering knowledge, developing, and testing PCS projects. In this paper, we present a novel approach from an ongoing project on how to relate BDD to the development process of PCS while using Scrum-based methods.

General information
State: Published
Organisations: Department of Mechanical Engineering, Engineering Design and Product Development, Department of Management Engineering, Management Science, Operations Management, KU Leuven
Contributors: Shafiee, S., Hvam, L., Haug, A., Wautelet, Y.
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Configuration Lifecycle Management – An Assessment of the Benefits Based on Maturity

To handle the increasing product complexity manufacturing companies of configurable products tend to utilize configurators to cover more lifecycle phases of their products. This is described as configuration lifecycle management (CLM) and it is concerned with the management of all configuration models across a product’s lifecycle. However, to connect and align all configurators and IT systems to each other remains a challenging task. Apart from the technical perspective, on an operational level the integration and alignment of the IT systems also requires a structured approach and is highly related to the maturity of the organization. Therefore, this research focuses on studying the relation between the maturity level and the expected benefits from implementing CLM. It is expected that the more advanced an organization is in using product configurators in different lifecycle phases and integrating and aligning them to each other and to other IT systems, the realized benefits would be significantly higher than the sum of benefits from applying standalone configurators to support each life cycle phase. Empirical evidence from seven case studies demonstrate that there is a relation between the maturity and the realized benefits with regards to the utilization of product configurators.

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Contributors: Myrodia, A., Randrup, T., Hvam, L.
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Configuration Lifecycle Management – Future of Product Configurators

The utilization of product configurators (PC) in the sales phase is a well-established solution for manufacturing companies of configurable products and it comes along with several benefits. However, there is a tendency identified currently in the industry that companies use PC to cover more lifecycle phases, such as engineering, manufacturing and service. This is described as configuration lifecycle management (CLM). Digitalization, increasing complexity and competitiveness are the main drivers of this need. This research analyses 59 case studies using PC in several lifecycle phases. The findings from the case studies confirm this tendency and the need towards a complete CLM solution is discussed.

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Contributors: Myrodia, A., Randrup, T., Hvam, L.
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Cost Benefit Analysis in Product Configuration Systems

Companies’ reports indicate a mixture of success and failure in Product Configuration Systems (PCS) projects. Moreover, the attention paid to PCS across different industries is increasing. Therefore, more studies are needed to analyze risks, costs, and benefits of PCS. This paper uses real case projects to demonstrate the cost-benefit analysis of PCSs in real industrial setups. Hence, this article quantifies savings in terms of reduced working hours, and the cost implications with reference to development, implementation, and maintenance. The study fills the gap in previous research by addressing what the influence of other factors on gained cost-benefits from PCSs are likely to be. This study aims to explain why some PCS projects are more cost effective than the others. While there are a number of factors affecting the cost-benefit analysis in PCS, the focus of this study remains mainly on the number of users and complexity of the project.

The comparison in the case studies revealed that both factors have a positive direct correlation with the gained cost benefits from PCSs can be forecasted. Aiming to investigate these effects, the following propositions were developed:

Proposition 1. The higher the number of users in PCSs, the higher Return on Investment (ROI) and cost-benefits.

Proposition 2. The higher the complexity in PCSs, the higher ROI and cost-benefits.

Firstly, we calculate the cost of three different projects during their last four years. Secondly, we calculate the cost-benefits during the last four years. In this research, we focus on the saved man-hours in calculating the ROI on multiple case projects in one case company, while investigating different factors influencing the ROI. Then, the data related to the number of users in the last year and the complexity of PCSs is retrieved. Finally, based on the knowledge in the literature and our research propositions, we demonstrate the results using graphs and discuss the findings.

General information
State: Published
Organisations: Department of Mechanical Engineering, Engineering Design and Product Development, Department of Management Engineering, Management Science, Operations Management, Graz University of Technology
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Research output: Research - peer-review › Article in proceedings – Annual report year: 2018

Design Science Research: A Suitable Approach to Scope and Research IT Service Catalogs

Based on the best-practice framework ITIL, an IT service catalog is a system which displays all live IT services but does not manage service requests. Moreover, an IT service catalog also shows how IT services are technically realized. When implementing an IT service catalog as part of the IT service management, firms often struggle with service catalog implementation projects as it requires portfolio-wide information and knowledge about service design, service operations, the customers’ use of services, service level agreements and service costing. There is a lack of existing literature on how to design an IT service catalog to fit the individual context and service offerings of companies. This concise paper proposes an approach based on design science for defining the initial design requirements for IT service catalogs. Using this approach in practice resulted in the identification and scoping of the design objectives of IT service catalogs to the needs of individual firms. Moreover, the explorative knowledge on how to design an IT service catalog has been validated by following rigorous research guidelines set out by the design science research method.

General information
State: Published
Organisations: Department of Management Engineering, Management Science, Operations Management, DSV A/S
Contributors: Schorr, F., Hvam, L.
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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.

How to scope configuration projects and manage the knowledge they require
Purpose
This paper aims to explore the use of the knowledge management (KM) perspective for configuration projects. Configuration projects implement configurators as information technology systems that help companies manage the specification process of customised products. An effective method of retrieving and formalising knowledge for configurators is essential, because it can reduce the risk of unsuccessful implementation and the time and effort required for development. Unfortunately, no standard KM frameworks are available specifically for configuration projects. This study identifies the knowledge necessary for different phases of a configuration project (which knowledge, for what purpose and from what sources), examines how it is transformed during a configuration project (what KM activities and tools are used) and establishes how the knowledge can be documented for future maintenance and updates.

Design/methodology/approach
This paper proposes a four-step framework for making the KM process more efficient in configuration projects. The framework is based on the literature, developed in collaboration with industrial partners and tested on four configuration projects in two engineering companies. The framework is a structured KM approach designed to save time for both domain experts and the configuration team. The authors have used a qualitative exploratory design based on multiple data sources: documentation, workshops and participant observation.

Findings
The proposed framework comprises four steps: determination of the system's scope, to establish the project’s goal based on stakeholders’ requirements and prioritise the required products and processes; knowledge acquisition, to classify the knowledge according to the desired output and identify different knowledge sources; modelling and knowledge validation; and documentation and maintenance, to ensure that the KM system can be maintained and updated in the future.

Research limitations/implications
Because the framework is tested on a limited number of cases, its generalisability may be limited. However, focusing on a few case applications allows us to assess the effectiveness of the framework in detail and in depth to identify the practical challenges of applying it. The results of the tests support the framework’s validity. Although the framework is designed mainly for engineering companies, other industries could benefit from using it as well.

Practical implications
The individual steps of the framework create a structured approach for the KM process. Thus, the approach can save both time and resources for companies, without the need for additional investment.
Originality/value
A standard framework is lacking in the literature on KM for configuration projects. This study fills that gap by developing a KM framework for configuration projects, based on KM frameworks developed for IT projects, and KM tools.

General information
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Organisations: Department of Management Engineering, Management Science, Operations Management, Universita di Padova
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Scopus rating (2017): CiteScore 3.12 SJR 0.922 SNIP 1.746
Web of Science (2017): Impact factor 2.551
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.185 SNIP 2.217
Web of Science (2016): Impact factor 2.053
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.06 SJR 1.181 SNIP 2.164
Web of Science (2015): Impact factor 1.689
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.87 SJR 1.1 SNIP 2.289
Web of Science (2014): Impact factor 1.586
BFI (2013): BFI-level 1
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BFI (2012): BFI-level 1
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Web of Science (2012): Impact factor 1.474
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BFI (2011): BFI-level 1
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ISI indexed (2011): ISI indexed no
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Scopus rating (2010): SJR 0.652 SNIP 1.351
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.729 SNIP 1.38
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.971 SNIP 1.541
Scopus rating (2007): SJR 0.877 SNIP 1.404
Management Challenges in Product Configuration Projects

Product Configuration Systems (PCS) are considered types of IT systems that enable companies to develop product alternatives to facilitate the sales and production processes automation. Based on literature, there are various challenges reported on managing different phases of PCS projects. Different tools and solutions have been suggested and applied for solving these challenges especially at the level of the project management process. Moreover, various software project management methods are used, in order to get high quality PCS, such as Rational Unified Process (RUP). The changes from Plan-driven methodologies towards a pure agile way of working is a challenge that comes with both benefits and risks. In this paper, first we will investigate about the PCS projects using the RUP method and then we will discuss PCS projects cases managed and launch using Agile principles. We use a comparative qualitative explanatory case study method on multiple data sources: documentation, workshops and participant observation. We find that changing from RUP to Scrum brings both positive effects and challenges to the organization.

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Measuring the complexity of product configuration systems

The complexity of product configuration systems is an important indicator of both development and maintenance effort of the systems. Existing literature proposes a couple of effort estimation approaches for configurator projects. However, these approaches do not address the issues of comprehensibility and modifiability of a configuration model. Therefore, this article proposes a metric to measure the total cognitive complexity of the configuration model corresponding to a product configuration system, expressed in the form of an UML class diagram. This metric takes into account the number and the type of attributes, constraints and the relationships between classes in an UML class diagram. The proposed metric can be used to compare two configuration models, in terms of their cognitive complexity. Moreover, a relation between development time for a PCS project and the total cognitive complexity of the corresponding configuration model is established using linear regression. To validate the proposed approach a case study is conducted where the cognitive complexity is calculated for two configuration models.

General information
State: Published
Merging Commercial and Technical Configurators

Companies are increasingly investing in product configurators in order to automate sales and production processes. The investment in product configurators can also be quite high mainly because of the need for an expert team and software. Companies develop configurators to support the specification of both commercial (sales) and technical parts of their products. The previous research addresses both approaches, including the pros and cons of each solution. However, there are also advantages in developing merged technical and sales configurator for a specific product instead of just developing one of them. The merged approach is tested in three case projects in an ETO company to investigate the pros and cons of the suggested approach. The cost of the project and Return On Investment (ROI) and complexity analysis demonstrates the benefits gained from the proposed approach.

Product Modularization: Case Studies from Construction Industries

Across all industries companies benefit from product standardization and product modularization in order to automate sales and production processes, and construction industry is no exception. Product modularization is normally the prerequisite to the automation in both sales and production. The literature is lacking guidelines and examples to discuss both theory and practice of product modularization in construction industry. In this study, we discuss two main product modularization strategies and investigate how and where they were applied in different construction companies. This research benefits from comparative case studies research. The gathered empirical data and the results from industrial expert interviews can then be used as guidelines for the companies to analyze how, when and where to use different product modularization techniques and what the gained benefits and challenges can be.
Product Modularization in the Architecture, Engineering and Construction (AEC) Industry

All industries benefit from product standardization and modularization in order to automate the sales and production processes. The Architecture, Engineering and Construction (AEC) industry is lagging behind due to the challenges it faces compared to other industries. The literature discusses how to apply modularization in construction industries, however, what seems to still be missing are guidelines and case examples for both researchers and practitioners. In this study, we discuss two main modularization strategies and investigate how and where they were applied in different construction companies. This research benefits from comparative case studies research in order to make deductions from different empirical data to draw a logically plausible conclusion. The gathered empirical data and the results from industrial expert interviews can then be used as guidelines for the companies to analyze how and where to use different modularization techniques and what are the gained benefits and challenges.

General information
State: Published
Organisations: Department of Mechanical Engineering, Engineering Design and Product Development, Department of Management Engineering, Management Science, Operations Management, University of Brighton
Contributors: Shafiee, S., Piroozfar, P., Hvam, L.
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Publisher: IEOM Society International
Keywords: Case study research, Construction industry, Product Architecture, Product modularization, Product standardization
Electronic versions: 98.pdf
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2018

Product Wheels for Scheduling in the Baking Industry: A Case Study

This paper illustrates current challenges and suggests solutions within the area of scheduling in the baking industry. The analysis applies the product wheel heuristic approach of King (2009) and tests the production cycles generated using actual sales and production data from a manufacturer of frozen baked goods. The product wheel method showed to be a suitable method for application at the baked goods manufacturer and generated a 23% reduction in setup and inventory cost at the case company. Despite the benefits, the product wheel method proved difficult to apply in a high variety setting, where an operations research model may have achieved more significant results.

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Organisations: Department of Management Engineering, Management Science, Operations Management
Number of pages: 15
Publication date: 2018
Peer-reviewed: Yes

Publication information
Volume: 6
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ISSN (Print): 2340-4876
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Web of Science (2018): Indexed yes
Web of Science (2017): Indexed yes
Original language: Undefined/Unknown
Electronic versions:
Product_wheels_for_scheduling_in_the_baking_industry_Orbit_.pdf
DOIs: 10.4995/ipjme.2018.8662
Source: FindIt
Source-ID: 2438035010
Research output: Research - peer-review › Journal article – Annual report year: 2018
Return on investment from the use of product configuration systems – A case study

Product configuration systems (PCS) are increasingly being used in industrial companies to enable the efficient design of customized products. The literature describes substantial benefits that companies have achieved from the use of PCS, such as reduced resource consumption, reduced lead-time, improved quality, and increased sales, which should lead to a significant return on investment (ROI). However, there is little detailed quantification of the benefits, costs, and ROI from using PCS in the literature. Thus, the true value of PCS remains unknown. Hence, this study quantifies (1) the benefits in terms of reduced man-hours, improved quality of specifications, reduced lead-time, and increased sales and (2) the costs of development, implementation, and maintenance of PCS. Based on this, the ROI is calculated. The analyses presented in this study are based on a world-leading company in pump manufacturing. This study verifies the benefits of PCS that are described in the literature. Further, it contributes to the field by introducing a method to quantify the related benefits, costs, and ROI. Finally, the article illustrates how PCS can be used in companies having product portfolios consisting of a standard to engineered products.

General information
State: Published
Organisations: Department of Management Engineering, Management Science, Operations Management, Department of Mechanical Engineering, Engineering Design and Product Development
Contributors: Kristjansdottir, K., Shafiee, S., Hvam, L., Bonev, M., Myrodia, A.
Pages: 57-69
Publication date: 2018
Peer-reviewed: Yes

Publication information
Journal: Computers in Industry
Volume: 100
ISSN (Print): 0166-3615
Ratings:
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 1
Scopus rating (2017): CiteScore 3.68 SJR 1.028 SNIP 1.886
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
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.

General information

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Organisations: Department of Management Engineering, Management Science, Operations Management, Department of Mechanical Engineering, Engineering Design and Product Development, University of Padova
Contributors: Kristjansdottir, K., Shafiee, S., Hvam, L., Forza, C., Mortensen, N. H.
Pages: 196-211
Publication date: 2018
Peer-reviewed: Yes

Publication information

Journal: Computers in Industry
Volume: 100
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<td>2</td>
<td>SJR 1.129</td>
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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.

General information
State: Accepted/In press
Organisations: Department of Mechanical Engineering, Engineering Design and Product Development, Department of Management Engineering, Management Science, Operations Management
Contributors: Løkkegaard, M., Mortensen, N. H., Hvam, L.
Number of pages: 17
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Peer-reviewed: Yes

Publication information
Journal: International Journal of Production Research
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Ratings:
BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.9 SJR 1.432 SNIP 1.483
Web of Science (2017): Impact factor 2.623
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.67 SJR 1.435 SNIP 1.413
Web of Science (2016): Impact factor 2.325
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.29 SJR 1.306 SNIP 1.317
Web of Science (2015): Impact factor 1.693
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.15 SJR 1.222 SNIP 1.33
Web of Science (2014): Impact factor 1.477
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.09 SJR 1.2 SNIP 1.53
Web of Science (2013): Impact factor 1.323
Improving product configurability in ETO companies

For engineer-to-order (ETO) companies, it is from a strategic perspective crucial to be able to supply highly customized solutions to customers, while at the same time improving re-usability across projects to increase efficiency. To address the challenges this study aims to support ETO companies by improving their product configurability without compromising the flexibility, by focusing on product modularization. For this purpose, a 5 step framework is proposed with the aim of creating a product overview with a post perspective on requirements to improve the modularity of the product platforms. The framework was based on a literature review and tested in a case company, where it proved to be beneficial as it provided a structured approach to identify improvements to the products platforms modularity.

General information
State: Published
Organisations: Management Science, Department of Management Engineering
Contributors: Markworth Johnsen, S. H., Kristjansdottir, K., Hvam, L.
Number of pages: 10
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 modularization, such as, for example, the construction and building industry.

General information

State: Published
Organisations: Department of Management Engineering, Management Science, Operations Management, Department of Mechanical Engineering, Engineering Design and Product Development, NCC, University of Southern Denmark
Pages: 1-14
Publication date: 2017
Peer-reviewed: Yes

Publication information

Journal: Advances in Mechanical Engineering (New York)
Volume: 9
Issue number: 10
ISSN (Print): 1687-8132
Ratings:
Web of Science (2019): Indexed yes
Web of Science (2018): Indexed yes
Scopus rating (2017): CiteScore 0.91 SJR 0.272 SNIP 0.555
Web of Science (2017): Impact factor 0.848
Web of Science (2017): Indexed yes
Scopus rating (2016): CiteScore 0.76 SJR 0.282 SNIP 0.609
Web of Science (2016): Impact factor 0.827
Web of Science (2016): Indexed yes
Scopus rating (2015): CiteScore 0.64 SJR 0.26 SNIP 0.596
Web of Science (2015): Impact factor 0.64
Scopus rating (2014): CiteScore 0.63 SJR 0.249 SNIP 0.576
Web of Science (2014): Impact factor 0.575
Web of Science (2014): Indexed yes
Scopus rating (2013): CiteScore 1.11 SJR 0.366 SNIP 1.048
Web of Science (2013): Impact factor 0.5
ISI indexed (2013): ISI indexed yes
Scopus rating (2012): CiteScore 0.88 SJR 0.402 SNIP 0.857
Web of Science (2012): Impact factor 1.062
Automatic Identification of Similarities Across Products to Improve the Configuration Process in ETO Companies

Engineer-To-Order (ETO) companies making complex products face the challenge of delivering highly customised products with high quality, affordable price and a short delivery time. To respond to these challenges, ETO companies strive to increase the commonality between different projects and to reuse product-related information. Therefore, ETO companies need to retrieve data about previously designed products and identify parts of the design that can be reused to improve the configuration process. This allows companies to reduce complexity in the product portfolio, decrease engineering hours and improve the accuracy of the product specifications. This article proposes a framework to identify and compare products' similarities. The framework (1) identifies the most important product variables available in the Product Configuration System (PCS), (2) retrieves data of previously designed products in an Enterprise Resource Planning (ERP) system, (3) identifies a method to compare products based on the main products variables and (4) sets up an IT system (database) with data of the previously designed products to integrate with the PCS. The proposed approach (the framework and the IT system) is tested in an ETO company to evaluate the application of the framework and the IT system. We retrieved the needed data from the ERP system at the case company and developed the IT system in Microsoft Excel, which is integrated with the PCS.

Complexity of Configurators Relative to Integrations and Field of Application

Configurators are applied widely to automate the specification processes at companies. The literature describes the industrial application of configurators supporting both sales and engineering processes, where configurators supporting the engineering processes are described more challenging. Moreover, configurators are commonly integrated to various IT systems within companies. The complexity of configurators is an important factor when it comes to performance, development and maintenance of the systems. A direct comparison of the complexity based on the different application and IT integrations is not addressed to a great extent in the literature. Thus, this paper aims to analyse the relationship of the complexity of the configurators, which is based on parameters (rules and attributes), in terms of first different applications of configurators (sales and engineering), and second integrations to other IT systems. The research method
adopted in the paper is based on a survey followed with interviews where the unit of analysis is based on operating configurators within a company.

**General information**

State: Published

Organisations: Department of Management Engineering, Management Science, Operations Management, Department of Mechanical Engineering, Engineering Design and Product Development

Contributors: Kristjansdottir, K., Shafiee, S., Battistello, L., Hvam, L., Forza, C.

Number of pages: 5

Publication date: 2017

Peer-reviewed: Yes


Electronic versions:

Bibliographical note

Proceedings of the 19th International Configuration Workshop

Source: PublicationPreSubmission

Source-ID: 139511349

Research output: Research - peer-review › Paper – Annual report year: 2017

**How to Identify Possible Applications of Product Configuration Systems in Engineer-to-Order Companies**

Product configuration systems (PCS) play an essential role when providing customised and engineered products efficiently. Literature in the field describes numerous strategies to develop PCS but neglects to identify different application areas. This topic is particularly important for engineer-to-order (ETO) companies that support gradual implementation of PCS due to large product variety and, several times, higher complexity of products and processes. The overall PCS process can thereby be broken down, and the risk minimised. This paper provides a three-step framework to identify different applications of PCS including the following steps: (1) identifying potential PCS, (2) aligning IT development, and (3) establishing an overview of PCS application. The study is supplemented by results from a case study in which the proposed framework was tested. The results from the testing confirm that the framework is applicable, as it leads to strategic and smart decisions regarding the implementation of PCS.

**General information**

State: Published

Organisations: Department of Management Engineering, Management Science, Operations Management, Department of Mechanical Engineering, Engineering Design and Product Development

Contributors: Kristjansdottir, K., Shafiee, S., Hvam, L.

Pages: 157-165

Publication date: 2017

Peer-reviewed: Yes

**Publication information**

Journal: International Journal of Industrial Engineering and Management

Volume: 8

Issue number: 3

ISSN (Print): 2217-2661

Ratings:

Scopus rating (2017): CiteScore 0.5 SJR 0.199 SNIP 0.572

Scopus rating (2016): CiteScore 0.35 SJR 0.225 SNIP 0.395

Scopus rating (2015): CiteScore 0.47 SJR 0.212 SNIP 0.459

Scopus rating (2014): CiteScore 0.39 SJR 0.198 SNIP 0.268

Scopus rating (2013): CiteScore 0.23 SJR 0.147 SNIP 0.172

Scopus rating (2012): SJR 0.2 SNIP 0.193

Scopus rating (2011): SJR 0.107 SNIP 0.049

Original language: English

Source: PublicationPreSubmission

Source-ID: 139511307

Research output: Research - peer-review › Journal article – Annual report year: 2017

**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.

**General information**

State: Published
Organisations: Department of Mechanical Engineering, Engineering Design and Product Development, Department of Management Engineering, Management Science, Operations Management
Contributors: Ravn, P. M., Mortensen, N. H., Hvam, L.
Pages: 289-302
Publication date: 2017
Peer-reviewed: Yes

**Publication information**

Journal: Concurrent Engineering: Research and Applications
Volume: 25
Issue number: 4
ISSN (Print): 1063-293X
Ratings:
- 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 1
- Scopus rating (2017): CiteScore 1.66 SJR 0.642 SNIP 1.133
- Web of Science (2017): Impact factor 1.456
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 1.45 SJR 0.549 SNIP 1.116
- Web of Science (2016): Impact factor 1
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
- Scopus rating (2015): CiteScore 1.14 SJR 0.574 SNIP 1.023
- Web of Science (2015): Impact factor 1.02
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 1
- Scopus rating (2014): CiteScore 1.08 SJR 0.386 SNIP 0.826
- Web of Science (2014): Impact factor 0.851
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 1
- Scopus rating (2013): CiteScore 0.9 SJR 0.485 SNIP 1.007
- Web of Science (2013): Impact factor 0.531
- ISI indexed (2013): ISI indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): CiteScore 0.65 SJR 0.437 SNIP 0.69
- Web of Science (2012): Impact factor 0.542
- ISI indexed (2012): ISI indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): CiteScore 0.89 SJR 0.364 SNIP 0.922
- Web of Science (2011): Impact factor 0.478
- ISI indexed (2011): ISI indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 0.912 SNIP 1.452
- Web of Science (2010): Impact factor 0.553
Impact of product configuration systems on product profitability and costing accuracy

This article aims at analyzing the impact of implementing a product configuration system (PCS) on the increased accuracy of the cost calculations and the increased profitability of the products. Companies that have implemented PCSs have achieved substantial benefits in terms of being more in control of their product assortment, making the right decisions in the sales phase and increasing sales of optimal products. These benefits should have an impact on the company's ability to make more accurate cost estimations in the sales phase, which can positively affect the products' profitability. However, previous studies have not addressed this relationship to a great extent. For that reason, a configure-to-order (CTO) manufacturing company was analyzed. A longitudinal field study was performed in which the accuracy of the cost calculations and the products' profitability were analyzed before and after a PCS was implemented. The comparison in the case study revealed that increased accuracy of the cost calculations in the sales phase and consequently increased profitability can be achieved by implementing a PCS.

General information
State: Published
Organisations: Department of Management Engineering, Management Science, Operations Management
Contributors: Myrodia, A., Kristjansdottir, K., Hvam, L.
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Publication date: 2017
Peer-reviewed: Yes

Publication information
Journal: Computers in Industry
Volume: 88
ISSN (Print): 0166-3615
Ratings:
BFI (2019): BFI-level 2
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.68 SJR 1.028 SNIP 1.886
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
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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Organisations: Department of Management Engineering, Management Science, Operations Management, Department of
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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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Product portfolio optimization based on substitution
The development of production capabilities has led to proliferation of the product variety offered to the customer. Yet this fact does not directly imply increase of manufacturers’ profitability, nor customers’ satisfaction. Consequently, recent research focuses on portfolio optimization through substitution and standardization techniques. However when re-defining the strategic market decisions are characterized by uncertainty due to several parameters. In this study, by using a GAMS optimization model we present a method for supporting strategic decisions on substitution, by quantifying the impact of
those parameters. Empirical evidence supplements the research, where a case study from an industry company producing construction material demonstrates the results.

Product variety, product complexity and manufacturing operational performance: A systematic literature review
Manufacturing in the twenty-first century has been wrought with the struggle to satisfy the rising demand for greater product variety and more complex products while still maintaining efficient manufacturing operations. However, the literature lacks an overview of which operational performance measures are most affected by increased variety and complexity. This study presents a systematic literature review of the recent scholarly literature on variety, complexity and manufacturing operational performance (MOP). Results show that product variety has a consistently negative relationship with MOP across different time, cost, quality and flexibility measures while product complexity lacks evidence of strong relationships with MOP measures.

The documentation of product configuration systems: A framework and an IT solution
When designing and maintaining a product configuration system (PCS), complete and up-to-date documentation of the system is needed in the form of a product model that outlines the structures, attributes, and constraints of the PCS. Furthermore, up-to-date documentation for the PCS is crucial for maintenance, further development, system quality and communication with domain experts. Product models are the main communication and documentation tools used in PCS projects. Recent studies have shown that up-to-date documentation for the PCS is often lacking due to the significant amount of work required to maintain product models. To address these challenges, this paper proposes an approach for documenting the PCS that is based on the structure, attributes, and constraints modelled within the PCS, in which the product model is generated directly from the PCS. The suggested approach avoids knowledge duplication, as knowledge needs to be maintained within the PCS only. It involves two steps: the first is the building of the initial product model, which is used for the programming of the PCS. In the second step, the product model is generated directly from the PCS and is based on the structure, attributes, and constraints modelled inside the PCS. The product model does not need to be maintained, therefore, outside the PCS. This approach meets the demand for agile documentation and efficient communication with domain experts, and uses the fewest resources possible. Furthermore, to support the framework, an IT documentation system is proposed that is capable of retrieving knowledge from the PCS and thus generating the product model. Our framework and IT documentation system were developed and tested at a case company on five different projects. The
results confirm that benefits can be achieved by using the proposed IT documentation system, as time and resources are saved, while the quality of the PCS is improved.

**General information**

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Organisations: Department of Management Engineering, Management Science, Operations Management, SolutionSpace ApS, University of Southern Denmark
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- BFI (2011): BFI-level 1
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- Web of Science (2011): Impact factor 1.489
- ISI indexed (2011): ISI indexed yes
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- Scopus rating (2010): SJR 0.645 SNIP 1.432
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- BFI (2009): BFI-level 1
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- BFI (2008): BFI-level 1
- Scopus rating (2008): SJR 0.913 SNIP 1.91
- Scopus rating (2007): SJR 0.704 SNIP 2.307
- Scopus rating (2006): SJR 0.411 SNIP 1.84
- Scopus rating (2005): SJR 0.228 SNIP 0.736
Usage Frequency of Product Configuration Systems Relative to Integrations and Fields of Application

Product Configuration Systems (PCS) are automatic solutions that can support and facilitate the sales and engineering processes. PCSs have recently attracted increased attention both from the researchers and practitioners. There are variety of challenges reported in the literature as consequences of using PCS, which reduces the usage frequency of the system. To address those challenges, IT integrations can be an effective solution to reduce the number of manual tasks and complexity inside PCSs and make PCSs more user friendly. However, the influence of integrating PCS to different IT systems on usage frequency has not been addressed in the literature. This paper aims to study the relationship of PCS usage frequency in terms of (1) different application area of the PCSs, and (2) integrations to different IT systems. The research method adopted in the paper is survey-based conducted in one company where the unit of analysis is operating PCS.

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Organisations: Department of Mechanical Engineering, Engineering Design and Product Development, Operations Management, Department of Management Engineering, Management Science, University of Padova
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Which variety is free? Discerning the impact of product variety in the process industry

In the pursuit of mass customization, it is a great challenge for companies to maintain mass production efficiencies while producing a wide range of products. This poses an even greater challenge to process industry manufacturing systems which are built for high volume, low variety operations and which are sensitive to changes in process parameters. Many studies have been performed to quantify the impact of product variety on the efficiency of automotive assembly processes, but little work has been done to address pro cess manufacturing systems. This study aims to determine the effects of individual product features on machine productivity at a process industry manufacturer. A lasso regression model is developed and tested using actual product and process level data from a stone wool manufacturer in central Eu rope. Results show that product features are less correlated to machine efficiency than process parameters, such as planning and crew performance.

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Analysis of visual representation techniques for product configuration systems in industrial companies

In recent years, there has been an increasing demand for customized products. Product configuration systems (PCS) are introduced as one of the most successful systems of artificial intelligence for providing customized products. One of the main challenges in PCSs projects are described in relation with knowledge representations and communications with domain experts. The results presented in the paper are therefore aimed to provide insight into the impact from using visual knowledge representations techniques in PCSs projects. The findings indicate that use of visual knowledge representations techniques in PCSs projects will result in improved quality of maintenance and development support for the knowledge base and improved quality of the communication with domain experts.

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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Scopus rating (2014): CiteScore 1.08 SJR 0.386 SNIP 0.826
Web of Science (2014): Impact factor 0.851
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 0.9 SJR 0.485 SNIP 1.007
Web of Science (2013): Impact factor 0.531
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 0.65 SJR 0.437 SNIP 0.69
Web of Science (2012): Impact factor 0.542
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 0.89 SJR 0.364 SNIP 0.922
Web of Science (2011): Impact factor 0.478
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.912 SNIP 1.452
Web of Science (2010): Impact factor 0.553
BFI (2009): BFI-level 1
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Scopus rating (2008): SJR 0.564 SNIP 1.159
Web of Science (2008): Indexed yes
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Scopus rating (2006): SJR 0.464 SNIP 0.99
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.224 SNIP 0.58
Scopus rating (2004): SJR 0.537 SNIP 1.09
Scopus rating (2003): SJR 0.628 SNIP 0.892
Scopus rating (2002): SJR 0.471 SNIP 0.825
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Business cases for product configuration systems

In the recent years, product configuration systems (PCSs) have received greater attention from industries providing customized products as a response to increased demand to fulfil diverse customers’ needs for customized products. Before developing a PCS, a well-established business case has to be made in order to secure the success and delivery of the project as it will increase the commitment from the business side. This paper presents a framework for supporting the development of business cases for PCSs and discusses the experiences from multiple case studies benefiting from the suggested framework.

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Business process management and IT management: The missing integration

The importance of business processes and the centrality of IT to contemporary organizations' performance calls for a specific focus on business process management and IT management. Despite the wide scope of business process management covering both business and IT domains, and the profound impact of IT on process innovations, the association between business process management and IT management is under-explored. Drawing on a literature analysis of the capabilities of business process and IT governance frameworks and findings from a case study, we propose the need for horizontal integration between the two management functions to enable strategic and operational business - IT alignment. We further argue that the role of IT in an organization influences the direction of integration between the two functions and thus the choice of integration mechanisms. Using case study findings, we propose that IT as a business enabler respectively calls for sequential and reciprocal integrations at strategic and operational planning levels. Drawing on logical reasoning, we suggest that IT as a strategic driver necessitates reciprocal integration at both levels.

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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 represent 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 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. Future 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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Development and implementation strategy for the of product configuration systems in engineer-to-order companies
This paper will address how to develop a strategy when developing and implementing product configuration systems (PCSs) in engineer-to-order (ETO) companies. PCSs are often gradually implemented especially where there are complex products and processes in order to break down the overall project and reduce risk. This highlights the importance of having an overall strategy to guide the long-term development and implementation of PCSs. In this paper, guideline for making the strategy are provided and supplemented with examples based on a case study. The guideline includes the main objectives for the development and implementation process, PCSs to be used to support the sales and/or the engineering processes, more uniform IT support for making product configurations, combining output from different PCSs and finally integrations that includes both internal and external IT systems. Based on this, an overview of how PCSs can support the overall configuration process can be generated.

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Contributors: Kristjansdottir, K., Shafiee, S., Hvam, L.
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Impact of the utilization of a product configuration system on product's life cycle complexity

The purpose of this paper is to identify areas throughout a product's lifecycle processes where complexity can be reduced by implementing a product configuration system (PCS). As discussed in the literature, several benefits are realized by using a PCS in terms of product and process standardization. This also leads to control and reduction of complexity both in products and processes. To this end, this research attempts to quantify and assess these benefits and is supported by empirical evidence. A case study of an engineering company is used and the results indicate significant improvements for the company in several life cycle processes.

Improved Performance and Quality of Configurators by Receiving Real-Time Information from Suppliers

Companies providing customized products are increasingly applying configurators in order to support the sales and design activities. Yet, especially for engineer-to-order (ETO) companies such activities are often divided across different organizations, where throughout the configuration process product specification has to be retrieved across the supply chains. Therefore, it is required that relevant information from suppliers is included in the configuration process, either as sub-models or by integrating configurators across the supply chains. This study investigates the challenges associated with including suppliers' product specifications as sub-models and how these can be addressed by integrating configurators across supply chains to receive real-time information from suppliers. Based on established literature on the illustrated technical integration of configurators across the supply chains, this paper contributes with empirical evidence on the overall impact of its implementation. The results presented are based on a case study in an ETO company where it is supported that the complexity of the configuration models can be significantly reduced as well as the time devoted for the modelling and maintaining the systems. Furthermore, with the ability of receiving accurate and up-to-date information from suppliers, the quality of the specifications can be improved, which leads to reduced cost of the overall design.
Industrial Application of Configurators: From Motivations to Realized Benefits

Manufacturing companies are increasingly seeking to gain the benefits from mass customization strategies as a response to increased customers’ demand for customized products. To automate the process of generating products’ specifications and guide the sales process, configurators are commonly used to support companies applying mass customization strategies. This article analyzes the relationship between the initial motivations manufacturing companies have for implementing configurators and the realized benefits from the application of configurators. The results presented in this paper are based on a survey followed with interviews in 22 industrial companies. The findings show that the main motivations can be grouped into seven categories, where the successfulness of achieving the targeted benefits varies between the individual categories. Furthermore, the results highlights that substantial benefits can be achieved when applying configurators in manufacturing companies.

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Industrial experience from using the cpm-procedure for developing, implementing and maintaining product configuration systems

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Management of business process design in global implementation of enterprise resource planning systems

Investments in global enterprise resource planning (ERP) systems are typically carried out as a part of the globalization process in multinational corporations (MNCs). Global ERP systems support integration and control in MNCs in an important way by establishing a common language across an MNC. As process and data standardization are among the primary drivers of ERP consolidation efforts, business process design is an important concern when implementing global ERP systems. This PhD study addresses three research questions that develop understanding, support, and improvement of the practice of business process design in the course of a global ERP implementation in MNCs. In light of existing theoretical and practical challenges, the research questions focus on three business process management (BPM) capabilities: alignment, governance, and method. Drawing on extensive literature reviews and findings from case studies in nine organizations, the study addresses the three prescriptive research questions through five descriptive studies.

First, by deploying alternative theories, this study explores the strategic, institutional, organizational, and relational factors that influence business process design, and particularly process standardization, in an MNC. Second, the study
investigates implications of process standardization for the choice of ERP architecture in MNCs. The findings indicate the moderating impact of process standardization on a global ERP systems total cost of ownership and its support for control and coordination. Third, having identified the factors that influence process standardization in MNCs, the study investigates the alignment between process standardization and an MNC’s international management strategy and indicates that process standardization as a centralizing coordination mechanism better fits MNCs structured for global integration compared to those seeking local responsiveness. The study develops conditions of fit between structural elements characterizing an MNC’s international management strategy and process standardization. Fourth, seeking governance mechanisms enabling business process design, the study explores collaborations between BPM and IT management functions and suggests the need for horizontal integration between the two functions in support of business–IT alignment. In addition, the study associates the direction of integration with the role of IT. Fifth, in search of a method enabling integrated business process design, the study investigates diverse views on enterprise architecture (EA) and various applications of enterprise architecture management (EAM) in organizations. The findings are classified as a taxonomy of EAM applications in organizations based on EA scope.

Drawing on findings from descriptive studies, the PhD study clarifies the criticality of business process design in the course of a global ERP implementation by explaining the impact of strategic, institutional, organizational, and relational contexts on process standardization on the one hand, and the importance of process standardization for reducing ERP total cost of ownership and its deployment as an integrative mechanism on the other. The study concludes that business process design in the course of a global ERP implementation can be supported by aligning decision making on process standardization with corporate international management strategy and structural characteristics. Furthermore, business process design can be supported by establishing permanent central governance for BPM and horizontally integrating the BPM function with the IT function at the strategic and operational levels. Business process design in the course of a global ERP implementation can be improved by adopting EAM as a methodology that enables integrated design of business processes and IT systems in alignment with business strategy.

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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 underdevelopment. 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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Operational impact of product variety in the process industry

The purpose of this research article is to examine the impact of product variety on production performance in the process industry. As the number of product variants sold by a process company typically impacts the run length, production data from a mineral wool insulation manufacturer is analyzed to quantify the impact of longer runs on productivity. In testing the hypothesis that longer runs lead to higher productivity, the results show that the number of variants in itself is not a sufficient parameter to explain the variation in production performance; rather, the different types of product variants and their production sequence must also be considered. Based on the findings, a method for quantifying the production cost of product variety in the process industry is developed, adding to the literature a rich case howcasing factors which influence production performance and the impact is measured with metrics.

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Product configuration system and its impact on product's life cycle complexity

The purpose of this paper is to identify areas throughout a product's lifecycle processes where complexity can be reduced by implementing a product configuration system (PCS). As discussed in the literature, several benefits are realized by using a PCS in terms of product and process standardization. This also leads to control and reduce of complexity both in products and processes. To this end, this research attempts to quantify and assess these benefits and is supported by empirical evidence. A case study of an engineering company is used and the results indicate significant improvements for the company in several life cycle processes.

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Quantification of Benefits and Cost from Applying a Product Configuration System

This article aims at analyzing the long-term benefits and the cost from developing, implementing and maintaining product configuration systems (PCSs). The results presented indicate that over 5 years period a case company has achieved significant savings as a result to reduced workload of generating the products’ specifications. In addition the lead-time for generating products’ specifications has been reduced and indications of improved quality of the products’ specifications and additional sales are identified. The research verifies the benefits described in the current literature and contributes by linking the benefits to the direct cost savings companies can expect from utilizing PCSs.

Reconfiguring Variety, Profitability, and Postponement for Product Customization with Global Supply Chains

At present, many industrial companies offering high product variety focus on systematically reducing the complexity of their product range and business processes. Related challenges are often named to increase time to market, reduce the effectiveness in product development, and lower process efficiency. For manufacturers with global supply chains additional uncertainties arise in defining the right manufacturing strategy with respect to production location and postponement. To better understand related managerial implications, this paper discusses a case study a global manufacturer providing customized industrial applications. In particular, the study investigates the relationships between product variant profitability and manufacturing strategy relative to postponement and location. The results indicate that an improved configuration of these factors through substitution and supply chain redesign significantly increases the overall product portfolio profitability.

Succeeding in process standardization: Explaining the fit with international management strategy

Purpose: The purpose of this paper is to explore the fit between process standardization and international management strategy of multinational corporations (MNCs) by assessing the compatibility between process standardization and corporate structural characteristics in terms of asset configuration and headquarters-subsidiary relationships.

Design/methodology/approach: First, after a literature review on MNCs’ strategy and process standardization, the study suggests two propositions on the fit between corporate international management strategy and process standardization. Second, to empirically examine the propositions, the study investigates the outcome of process standardization in three cases with different strategic and structural contexts. Third, using the propositions and empirical findings, the study
proposes a framework for aligning process standardization with MNCs’ structural characteristics. Findings: Process standardization has a higher degree of fit in MNCs pursuing global integration where process standardization parallels the need for coordinating interdependencies in the functional structure, and is consistent with the headquarters’ operational control over the subsidiaries. Process standardization has a lower degree of fit in MNCs seeking local responsiveness as process standardization disturbs the financial control relationship between the headquarters and subsidiaries and is less crucial for coordination as the subsidiaries contain the necessary coordination mechanisms. Originality/value: The study provides in-depth understanding of how the international management strategy and consequent structural characteristics of MNCs affects process standardization in the course of a global enterprise resource planning implementation. The study proposes conditions of fit for aligning process standardization with asset configuration and headquarters-subsidiary relationships of an MNC.

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Utilizing product configuration systems for supporting the critical parts of the engineering processes

Engineering-To-Order (ETO) companies have to respond to increasing demands to provide highly customized and complex products with high quality at competitive prices. In order to respond to those challenges ETO companies have started to implement product configuration systems (PCS) to increase efficiency of the specification processes. As a result to complex products and processes in ETO companies, PCS are usually gradually implemented where only subsets of the products are included to support specific processes. However, a systematic way to identify and evaluate the products and the processes to be supported with the PCSs is not described in the current literature. This paper aims to pursue that research opportunity by presenting a framework, which aims to identifying the critical parts of the engineering processes in order to identify where it most beneficial to implement a PCSs and how to prioritize the future PCSs projects.

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Alignment of Configuration and Documentation for Highly Engineered Complex Product Configuration Systems: a Demonstration from a Case Study

Adequate documentation is critical for successful implementation, maintenance and further developments of product configuration system (PCS) specially in companies making complex and highly engineered products. This article is based on experience of modelling and utilizing a PCS from an Engineer-To-Order (ETO), where the main focus is on the challenges concerned with the documentation of the PCS, both in the development and production phase. Aligning the development of the PCS with an automatic documentation system creates value. Using the suggested method for documentation facilitates the following activities: (1) iterative testing of the system during the development, (2) communication with domain experts, (3) documentation and maintenance, and finally (4) updates without spending a lot of time and resources. This article is supplemented with a case study from an ETO company where the method for the
automatic documentation was developed and tested.

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An agile documentation system for highly engineered, complex product configuration systems
When modelling and maintaining a product configuration system (PCS) there is a need for a complete and updated documentation of the system. This research work focuses on a framework for documenting PCSs based on structures, data and constraints already implemented in the PCS. Looking at previously suggested PCS documentation, systems focus on creating the documentation separated from PCS. Documenting the PCS separately request extra time and resources. We suggest building the PCS models and then extracting the structure, data and constraints for documentation from PCS. This makes the task of documentation easier and less time consuming.

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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 fulfilment 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.

**General information**
With product customization companies aim at creating higher customer value and stronger economic benefits. The profitability of the offered variety relies on the quality of the developed product family architectures and their consistent implementation in configuration systems. Yet existing methods are informal, providing limited support for domain experts to communicate, synthesize and document architectures effectively. In single product design explicit visual models such as design structure matrices and node-link diagrams have been used in combination with structural analysis methods to overcome the limitation of the informal approach. Drawing on thereto established best practises, this paper evaluates and extends the relevant methods and modelling techniques, to create a consistent and formal approach for the design and customization of entire product families. To validate it’s applicability, the approach is tested on a case study at a manufacturing company offering bespoke industrial applications. A generic modelling method termed the integrated design model (IDM) is developed and complemented with a computational structural analysis method, to assist domain experts in their daily work. When combined with a configuration system, the presented IDM tool automates the documentation and formalizes the synthesis of architectures, thereby making any decision about a preferred solution explicit and transparent.

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This article proposes a systematic framework for data collection when executing Product Configuration System (PCS) projects. Since the data collection in PCS is one of the most time consuming tasks, a systematic framework to handle and manage the large amount of complex data in the early stages of the PCS project is needed. The framework was developed based on the current literature in the field and revised during testing at a case company. The framework has proven to provide a structural approach for data collection, which saved the company both time and money in the initial phases of the PCS project. The framework consists of five steps, which are: establishing a goal and the methods for stakeholder analysis, categorize and group the data collection, prioritizing of products and functionalities, collection and validation of the data by domain experts and finally analysis, documentation and maintenance in the future.
How to Analyze and Quantify Similarities between Configured Engineer-To-Order Products by Comparing the Highlighted Features Utilizing the Configuration System Abilities

Engineering-To-Order (ETO) companies making complex and highly engineered products, face the challenge of delivering highly customized and engineered products with high quality and short delivery time. In order to respond to those challenges ETO companies strive to increase commonality between different projects and to reuse product related information. For that purpose companies need to be able to retrieve previously designed products and identify which parts of the design can be reused and which parts to redesign. This allows companies to reduce complexity in the product range, to decrease the engineering hours and to improve the accuracy of the product specifications. In this article we suggest a framework where product features from the company’s configuration system are listed up in order to compare with previously made products by retrieving information from internal ERP/PLM systems. The list of features consists of defining features with potential sets of values e.g. capacity, dimensions, quality of material, energy consumptions, etc. When identifying a specific previously designed product, it allows access to all of the specifications of the existing product along with the engineering hours used, materials used, and hours used in the workshop. The aim of this paper is to make a framework for setting up a database before starting the comparison.

Identification of complexity cost factors in manufacturing companies

Complexity tends to be arguably the biggest challenge of manufacturing companies. As the demand from the customers increases in volume and diversity, the number of finished products and components increases as well. This increasing product complexity has a direct effect on the production processes. This research focuses on the relation between product and process complexity. Complexity cost factors are identified and categorized under the industrial standard APQC for process classification. Then, this categorization is used as a tool for identification of complexity cost factors in seven companies. The results from this research are evaluated and future work is discussed.
Identification of profitable areas to apply product configuration systems in Engineering-To-Order companies

This article suggests a systematic framework for identifying potential areas, where Engineering-To-Order (ETO) companies may increase their profitability by implementing a Product Configuration System (PCS). In order to do so a three-step framework is proposed based on literature. The starting point is to conduct a profitability analysis to determine the accuracy of the cost estimates, and based on that the reason for the deviations across different projects is found. The next step is to generate the scope for different scenarios that aim to improve the current situation. Finally, it is suggested to make a cost-benefit analysis for different scenarios to determine where a PCS can provide the most benefits. This article is supplemented with a case study from an ETO company where potential areas for using PCS were found by applying the suggested framework.

Impact on cost accuracy and profitability from implementing product configuration system – A case-study

This article aims at analyzing the impacts from implementing a product configuration system (PCS) on company profitability and improved cost estimations in the sales phase. Companies that have implemented PCSs have achieved substantial benefits in terms of being more in control of their product assortment, making the right decisions in the sales phase and increased sales of optimal products. Those benefits should have direct impact on improved profitability in terms of increased contribution ratios and more accurate cost estimations used to determine the price in the budgetary quotations. As the literature describes, there are various benefits from implementing a PCS, however the effects on the company’s profitability have not been discussed in details. This study analyzes the impact from implementing a PCS on the accuracy of calculations in the quotations and the impact on the relative contribution ratios. For that reason, a configure-to-order (CTO) manufacturing company has been investigated. A longitudinal study is performed where both the accuracy of the cost calculations and the profitability is analyzed before and after implementation of a PCS. The comparison reveals increased profitability and accuracy of the cost estimation in the sales phase can be achieved from implementing a PCS.
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 are yet to be developed as the foundation for their development will be developed during the technology development. Furthermore, the production of a new technology is not defined as both 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 fulfill 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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Two-way substitution effects on inventory in configure-to-order production systems
In designing configure-to-order production systems for a growing product variety, companies are challenged with an increased complexity for obtaining high productivity levels and cost-effectiveness. In academia, several optimization methods and conceptual frameworks for substituting components, or increasing storage capacity, have been proposed. Our study presents a practical framework for quantifying the impact of a two-way substitution at different production stages and its impact on inventory utilization. In a case study, we quantify the relation between component substitution and inventory capacity utilization, while maintaining the production capacity as well as the external product variety.

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Utilizing platforms in industrialized construction: A case study of a precast manufacturer
Purpose – The purpose of this paper is to explore the development of a platform-based project execution in the industrialised construction sector, with a focus on systematically balancing cost and value. Offering custom-tailored buildings at reasonable costs has been a growing concern for many construction companies. A promising approach adapted by operations management and design theory regards individual building projects as the adjustment and recombination of components and processes from a set of predefined platforms, while configuration systems assure feasible building solutions. Design/methodology/approach – After adapting some of the underlying assertions of platform design to the engineer-to-order (ETO) situation in construction, the practical implications are evaluated on a case study of a precast manufacturer using high performance concrete. Findings – Based on empirical findings from three distinct platform strategies, this research highlights key aspects of adapting platform-based developed theory to industrialised construction. Building projects use different layers of product, process and logistics platforms to form the right cost–value ratio for the target market application, while modelling methods map structural platform characteristics so as to balance commonality and distinctiveness. Originality/value – This paper proposes a general theory of platform-based development and execution in the industrialised construction sector, which goes beyond concurrent approaches of standardising and systemising buildings projects. It adapts and extends established frameworks for platform development to the ETO situation in construction and empirically validates their cost and value effects.
Alignment between business process governance and IT governance
The importance of business processes and the increasing centrality of IT to an organization's performance have called for a specific focus on business process governance and IT governance in contemporary enterprises. Despite the wide scope of business process management, which covers both business and IT domains, and the profound impact of IT on process innovations, the association between business process governance and IT governance remains under-explored. Analyzing the constituting elements of the two governance concepts, we propose the necessity of alignment between business process and IT governance frameworks to enable business-IT strategic alignment, efficient process and IT requirements specification, and IT-enabled business value realization. We examine the actuality of this alignment in practice through a case study conducted in a relatively mature multinational corporation. The findings indicate the presence of mutual adjustment between business process and IT management functions to support strategic and operational process and IT decision making.

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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 the production system life cycle. 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 counters 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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Framework for developing product strategy for Configure-To-Order products
Companies producing customized products tend to increase the variety of their product portfolio, in order to fulfill the demand of their customers and align with the competitors. Nevertheless the profitability of the product families may vary greatly. The purpose of this paper is to analyze profitability of Configure-To-Order (CTO) products. The framework consists of a 4-step model: Analysis of product assortment, Profitability analysis on configured products, Market and Competitors analysis, Scenarios for future product assortment. The suggested framework is tested on a company. The results in terms of product delimitation and experiences gained from the case study are further discussed.

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How to Scope a Product Configuration Project in an Engineering Company
When implementing a product configuration system in a company making complex and highly engineered products, many decisions need to be made in the early phases of the project. This article presents a framework for supporting the initial scoping process and discusses experiences from applying the framework in an engineering company. The framework covers a number of topics, such as identifying the users of the configuration system, prioritizing the user requirements, defining the input and output, and the overall functionality of the configuration system. Furthermore, the scoping process considers the availability of the product knowledge to model into the configuration system, the level of detail and which particular product parts and aspects to include in the system.

Managing complexity of product mix and production flow in configure-to-order production systems
In designing configure-to-order production systems for a growing product variety, companies are challenged with an increased complexity for obtaining high productivity levels and cost-effectiveness. In academia several optimization methods and conceptual frameworks for substituting components, or increasing lot sizes and storage capacity have been proposed. Our study presents a practical framework for quantifying the impact of a two-way substitution at different production stages and its impact on storage and machinery utilization. In a case study we quantify the relation between substitution, lot sizing and capacity utilization, while maintaining the production capacity as well as the external product variety.

Managing Variety in Configure-to-Order Products - An Operational Method
Companies producing customized products tend to increase the variety of their product portfolio, in order to fulfill the demand of their customers and align their strategies with those of competitors. However, the profitability of product families may vary greatly. The purpose of this paper is to develop an operational method to analyze profitability of Configure-To-Order (CTO) products. The operational method consists of a four-step: analysis of product assortment, profitability analysis on configured products, market and competitor analysis and, product assortment scenarios analysis. The proposed operational method is firstly developed based on both available literature and practitioners experience and
subsequently tested on a company that produces CTO products. The results from this application are further discussed and opportunities for further research identified.

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**New Product Introduction in the Pharmaceutical Industry**
Due to the limited time of the monopoly provided by patent protection that is used for recouping the R&D investment, pharmaceutical companies focus on keeping time-to-market for new products as short as possible. This process is however getting more uncertain, as the outcome of clinical trials is unknown and negotiations with authorities have become harder, making market introduction more difficult. This dissertation treats the new product introduction process in the pharmaceutical industry from an operations perspective. The overarching aim of this dissertation is to improve the planning methodology in this critical process. In an empirical study, the process is first analyzed in detail, leading to the identification of several gaps in the industry’s current planning approaches. To support a set of key operational decisions towards market launch, a model is subsequently developed, considering uncertainty and several important industry characteristics. The model is used to gain several insights on the use of risk packaging and on keeping time-to-market short. As capacity in secondary pharmaceutical production is critical for product availability, a capacity planning model for a new drug delivery system is also developed. It captures the ramp-up phase in a better way, while considering inventory build up, plant validation and limited shelf life. The performance of several ramp-up functions is tested and insights into ramp-up management are presented. The dissertation is concluded with showing the new proposed planning structure, concluding in the preceding chapters and outlining future research possibilities.
Scoping a Product Configuration Project for Engineer-to-Order Companies
When implementing a product configuration system in a company making complex and highly engineered products, many decisions need to be made in the early phases of the project. This article presents a framework for supporting the initial scoping process and discusses experiences from applying the framework in an engineering company. The framework covers a number of topics, such as identifying the users of the configuration system, prioritizing the user requirements, defining the input and output and considering the overall functionality of the configuration system. Furthermore, the scoping process considers the availability of product knowledge to model into the configuration system, the level of detail and which particular product parts and aspects to include in the system.

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The cost of customising: assessing the performance of a modular product programme
Introducing modularity in product development as a mean for dealing with increasing levels of variance within product portfolios has been widely and successfully applied by many companies. It is however important to acknowledge that challenges related to product portfolio variance will not disappear after introducing modularity. A new type of variance on modular level is likely to develop over time. Empirical work carried out in a large international engineering company designing customer specific products confirms that increasing levels of variance within module portfolios can lead to reduced performance according to crucial key performance indicators. The findings illustrate the importance of recognising the potential trade-off when continually complying with unique customer requests. The paper contributes with a detailed insight into a company's competitive performance trade-off on a modular level after introducing mass customisation. The paper also adds a dimension to existing survey-based findings on the potential trade-offs.

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The Use of Modelling Methods for Product Configuration in Industrial Applications

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.
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.

Extending product modeling methods for integrated product development
Despite great efforts within the modeling domain, the majority of methods often address the uncommon design situation of an original product development. However, studies illustrate that development tasks are predominantly related to redesigning, improving, and extending already existing products. Updated design requirements have then to be made explicit and mapped against the existing product architecture. In this paper, existing methods are adapted and extended through linking updated requirements to suitable product models. By combining several established modeling techniques, such as the DSM and PVM methods, in a presented Product Requirement Development model some of the individual drawbacks of each method could be overcome. Based on the UML standard, the model enables the representation of complex hierarchical relationships in a generic product model. At the same time it uses matrix-based models to link and evaluate updated requirements to several levels of the product architecture and to illustrate how these requirements have an upstream (towards stakeholders) and downstream (towards production) effect on the product architecture.
Modularization in the construction industry using a top-down approach

Throughout the last centuries, the manufacturing industry has experienced great improvements in efficiency and cost reductions, but the same improvements have not taken place in the construction industry. Based on the principles of mass customization that are known from the manufacturing industry, a case study of one of the largest construction companies in Northern Europe was carried out according to the principles of action research. This approach was used to clarify whether potential exists for using the principles of mass customization to improve efficiency and minimize costs connected with the construction of buildings; and if so, what they are. The main technical solutions used for residential and office buildings were analyzed using a top-down approach. These solutions were identified and their relations mapped using a Product Variant Master (PVM). When a satisfactory overview was achieved of the major technical solutions, a configuration system was made. Such a system is often used to communicate findings from the PVM to the user. Through the work of constructing the PVM and the configuration system, it was found that a great potential exists for implementation. Based on the findings and experiences gathered throughout the process, the conclusion is that the principles of mass customization are best used in the construction industry if used with a top-down perspective. © Kudsk et al.; Licensee Bentham Open.

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New complex product introduction by means of product configuration

Configuration systems have widely been applied to efficiently address the customization responsive-ness squeeze of companies dealing with Mass Customization. Over time, several frameworks have been introduced to enable their systematic plan-ning, analyses, development and implementation. Traditional research has thereby either focused on defining modelling techniques for the configuration model of stable products, on improved configura-tion algorithms, or on the impact of configurators on companies’ operations. However, little attention has yet been paid how the growing need for prod-uct innovation can effectively been supported. Es-pecially for engineering companies moving to-wards Mass Customization, compared to mass pro-ducers the challenges caused by the complexity of their products and by the highly uncertain markets are much higher. This study develops and validates a framework which enables the use of configura-tion systems along the introduction of complex products. It in particular examines (1) what are suitable development strategies for configuration systems during product innovation, (2) how prod-uct development and configuration development can be aligned and managed, and (3) how supplier integration can be achieved.

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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 imple-menting product configuration systems: lead time in the specification processes, on-time delivery of the specifica-tions, 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 comp-a-panies 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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Performance measures for mass customization strategies in an ETO environment

When following mass customization (MC) principles, manufacturing companies have to consider several aspects. Complexity is thereby seen as a major challenge to be handled. Especially for ETO companies the movement towards MC is much more complex, as products are not standardized, processes are seldom automated and little control over the customer portfolio is obtained. Based on case studies, this research proposes a new way of effectively and efficiently
implementing MC strategies. It closely investigates deviations between contribution margins and between pre- and post-calculations of operational measures. The results show the negative impact of high deviations on the corresponding performance.

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.
Rethinking the Business Model in Construction by the Use of Off-Site System Deliverance: Case of the Shaft Project

This paper presents a set of insights to be used in the development of business models for off-site system deliveries contributing to the development of Off-Site Manufacturing practices (OSM). The theoretical offset for discussing the development of business models is the blue ocean strategy literature combined with theories on mass-customization and platform development identifying the optimization of cost and value through the handling of complexity as the central process. This framework is developed in order to analyze a specific case on system deliverances – the prefabrication of installation shafts. Findings from the development and production of the installation shaft show that system deliveries represent a promising strategy for moving from red ocean competitive environment with the predominant cost+ business model, to a blue ocean situation in which the competition emerges in the constant pursuit of value creation and cost reduction. On the basis of that system deliverances represent a promising strategy in the future development and application of off-site manufacturing practices. The application of system deliveries is however demanding as it represents a fundamental shift in the existing design and production practices. More specifically the development of system deliveries requires: (1) an explicit market focus, enabling the achievement of economy of scale, (2) a coordinated and coherent development around the system deliverance focusing on its internal and external modularity. (3) development of processes and configuration practices which make it possible to put together (configure) the product matching the needs of the individual building project. (4) development of alliances between companies in enabling value chain integration.

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Stepwise modularization in the construction industry using a bottom-up approach

The manufacturing industry has experienced a great deal of improvement in efficiency and cost reductions throughout the last centuries. But although there have been improvements in the manufacturing industry, the principles and work methods in the construction industry have stood still for more than a hundred years. Based on principles of mass customization applied in the manufacturing industry, two cases of successful implementation of mass customization and modularization have been investigated as a means of showcasing the possibility to incorporate standardization in parts of the construction industry. The investigation examined two different companies that have standardized parts of a construction. One, Altan.dk, standardized the method for constructing balconies; and NCC Skakt standardized the construction of shafts. Altan.dk standardized their balconies by studying the balconies they previously built and constructing solution spaces in which a configured balcony can be constructed. The information gathered from studying these balconies was then put into a Product Variant Master, so that an overview of the product was achieved. All the information gathered was put into a configurator in order to guide the entire construction process. NCC Skakt standardized their shafts by studying apartments already constructed and extracting different archetypes of toilets and kitchens. Much information was gathered, which was
fed into a Product Variant Master, so that an overview could be achieved. This led to a standardization of the shafts. Three types of shafts that make up 95 percent of the investigated market were defined. Based on the findings and experiences gathered through the standardization, it is concluded that the principles of mass customization of a sub-part can be successful when implemented stepwise. The case shows that substantial benefits can be gained through implementing modularized construction. It is especially interesting to note that these benefits are achieved through the development of a module with focus on the internal interfaces. © Kudsk et al.; Licensee Bentham Open.
aims to enable a design that can be coordinated with a prefabricated installation shaft sold by the firm, and also to create customer leads. Four scenarios are developed for how design can be supported by four different types of configuration technologies. The four scenarios are evaluated in relation to a number of functional and technical requirements. The scenarios indicate that a good and varied range of opportunities exist for using configuration systems in the construction industry. They also show that it can be done without fundamentally changing the present process. © Kudsk et al.; Licensee Bentham Open.

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**Analyzing the Accuracy of Calculations When Scoping Product Configuration Projects**
Product configurators have increasingly been applied in industrial environments. With their help, companies providing customized products have managed to redesign their specification processes and to better handle the growing product variety. But despite the promising benefits, conducting configuration projects is still challenging. Assuming that configurators would naturally solve the existing flaws, both, researchers and professionals typically neglect the need for a making a precise scope for their implementation. Based on this theoretical and practical concern, the present study provides a detailed framework on how the highest potential and eventually the most benefits from using configuration
systems can be identified. In particular, this paper investigates how the less explored domain of varying gross margins and calculations reveal a considerable potential for improvement by means of configuration.

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Scopus rating (2017): CiteScore 0.9 SJR 0.295 SNIP 0.655
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.67 SJR 0.339 SNIP 0.642
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 0.37 SJR 0.369 SNIP 0.684
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 0.42 SJR 0.354 SNIP 0.743
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 0.49 SJR 0.36 SNIP 0.761
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 0.49 SJR 0.346 SNIP 0.762
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 0.49 SJR 0.338 SNIP 0.765
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.322 SNIP 0.663
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.302 SNIP 0.576
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.277 SNIP 0.465
Scopus rating (2007): SJR 0.293 SNIP 0.513
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.317 SNIP 0.661
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.334 SNIP 0.766
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.347 SNIP 0.821
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 of 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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ISBN (Print): 978-87-91831-51-5
Keywords: Complexity costs, Product program, Rationalization, Product architecture
Electronic versions:
Calculation of Complexity Costs - An Approach for Rationalizing a Product Program 008.pdf
Source: dtu
Source-ID: u::5025
Research output: Research - peer-review > Article in proceedings – Annual report year: 2012

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.

General information
State: Published
Organisations: Department of Management Engineering, Production and Service Management, Department of Mechanical Engineering, Engineering Design and Product Development, University of Southern Denmark
Contributors: Haug, A., Hvam, L., Mortensen, N. H.
Pages: 471-481
Publication date: 2012
Peer-reviewed: Yes
Developing engineering processes through integrated modelling of product and process

This article aims at developing an operational tool for integrated modelling of product assortments and engineering processes in companies making customer specific products. Integrating a product model in the design of engineering processes will provide a deeper understanding of the engineering activities as well as insight into how product features affect the engineering processes. The article suggests possible ways of integrating models of products with models of engineering processes. The models have been tested and further developed in an action research study carried out in collaboration with a major international engineering company.

Knowledge-based geometric modeling in construction

A wider application of IT-based solutions, such as configuration systems and the implementation of modeling standards, has facilitated the trend to produce mass customized products to support inter alia the specification process of the increasing product variety. However, not all industries have realized the full potential of using product and process modelling tools as well as the implementation of configuration systems to support their business processes. Especially in the building industry, where Engineer-to-Order (ETO) manufacturers provide complex custom tailored products, up to now, often a considerably high amount of their resources is required for designing and specifying the majority of their product assortment. As design decisions are hereby based on knowledge and experience about behaviour and applicability of construction techniques and materials for a predefined design situation, smart tools need to be developed, to support these activities. In order to achieve a higher degree of design automation, this study proposes a framework for using configuration systems within the CAD environment together with suitable geometric modeling techniques on the example of a Danish manufacturer for precast concrete elements.
Modularisation i byggeriet: Fra en systemleverance og Mass Customization tilgang

The use of configurable system deliveries, based on the principles of Mass Customization, is described by many as a solution to the challenges of construction, which is characterized by low earnings, lack of development in productivity and poor quality. Technical University of Denmark (DTU), School of Architecture Aarhus (aarch) and Centre for Industrial Architecture CINARK at the Royal Danish Art Academy’s School of Architecture. Design and Conservation (hereafter referred to as School of Architecture) are playing a central role in establishing a vision regarding the use of system deliveries in construction. These institutions have produced a series of publications describing the possibilities presented by the transfer to construction of Mass Customization, product platforms and the use of configuration systems, theories and methods developed in the production industry.

With this point of departure, this project has carried out work that, with an engineering focus and research approach, investigates the possibilities for realizing this vision. The work focuses on some selected areas within the following overall research question:

How, in a Danish context, can Mass Customization and the theories on which it is based realize the vision of industrialized architecture through the use of system deliveries?

An important element in Mass Customization, the establishment and use of product families, is modularization. Modules in construction lead most of us to think about the period with module and montage construction, when much construction was industrialized, but in order to build many large units of very standardized construction, a type of building for which a market no longer exists in Denmark. To expand understanding of modules in construction, a study was conducted of historical construction built according to the “Building Law for the Capital City of Copenhagen and Its Suburbs”. The study found that historical buildings, when studied using modern methods, could be described as comprising modules with standardized interfaces.

Buildings are very large products sold in a limited number of units as small as a single unit. At the same time, building construction is carried out by enterprises of limited size and capacity for development. This means that most enterprises, by far, must work with step-wise implementation of modules. Possibilities for implementing modules step-wise are described in several studies that work with a top-down approach that is based on the whole building, and a bottom-up approach that focuses on specific parts.

Step-wise implementation also leads to partial modularization, something that Mass Customization, on which it is based, and modularization theory only focus on to a limited extent. In order to create a framework for understanding partial modularization, this work presents The Module Application Matrix, which makes it possible to map completely or partially modularized products with completely or partially detailed modules.

Another central element in Mass Customization theory and in the vision is the use of configuration systems. Here, three different prototype configuration systems are presented to illuminate the possibilities for using configuration systems in construction – also including the possibilities and challenges that lie in configuring partially modularized and partially described products and products with infinite potential solutions.

General information

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ISBN (Print): 978-87-92706-92-8
Original language: English
Electronic versions:
Afhandling_afeleveretsamtresumeDK_.PDF
Research output: Research › Ph.D. thesis – Annual report year: 2012
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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Contributors: Hansen, C. L., Mortensen, N. H., Hvam, L.
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Volume: 1
Publisher: Design Society
ISBN (Electronic): 9789537738174
Keywords: Market architecture, Product architecture, Product program design, Product family, Platform

**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 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.

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Organisations: Department of Mechanical Engineering, Engineering Design and Product Development, Department of Management Engineering, Production and Service Management
Contributors: Hansen, C. L., Mortensen, N. H., Hvam, L.
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Title of host publication: Proceedings of NordDesign Conference 2012
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ISBN (Print): 978-87-91831-51-5
Keywords: Product architecture, Product platform, Systems theory, Contingenct factors

**Efficient on-site construction: - learning points from a German platform for housing**
Purpose – This research aims to analyse the implementation of a German platform for housing projects through a successful case on modern methods of construction featuring efficient on-site construction. Through continuous development, the platform has been carefully designed to suit a carefully selected market – optimising cost and value. Based on the platform, the company has managed to create a high-quality product at low cost. In fact, they have managed to reduce costs by more than 30 per cent, enabling the company to sell houses to people that normally would not be able to afford a house of their own. Design/methodology/approach – The paper adopts a case study approach combining a qualitative collection of empirical material with an analytical framework drawing upon classical modelling techniques for
development of product platforms. Findings – The paper identifies some central learning points from the German platform such as: platform does not imply that “off-site manufacturing” is the most optimal production method, rather it is a matter of handling complexity; strong commitment and loyalty from the whole organization is needed; importance of having a specific customer focus (target costing); and incremental rather than radical innovation. Originality/value – The findings challenge the predominant understanding of industrialisation of the construction processes, illustrating how substantial improvements can be achieved through platform thinking, on-site production and traditional construction practices.

**General information**

State: Published
Organisations: Planning and Management of the Built Environment, Department of Management Engineering, Operations Management
Contributors: Thuesen, C. L., Hvam, L.
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Journal: Construction Innovation
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ISSN (Print): 1471-4175
Ratings:
- BFI (2019): BFI-level 2
- Web of Science (2019): Indexed yes
- BFI (2018): BFI-level 2
- BFI (2017): BFI-level 2
- Scopus rating (2017): CiteScore 2.12 SJR 0.731 SNIP 0.987
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 2
- Scopus rating (2016): CiteScore 1.56 SJR 0.513 SNIP 0.965
- BFI (2015): BFI-level 2
- Scopus rating (2015): CiteScore 0.97 SJR 0.443 SNIP 0.72
- BFI (2014): BFI-level 2
- Scopus rating (2014): CiteScore 1.13 SJR 0.544 SNIP 0.963
- BFI (2013): BFI-level 2
- Scopus rating (2013): CiteScore 0.85 SJR 0.498 SNIP 0.864
- ISI indexed (2013): ISI indexed no
- BFI (2012): BFI-level 2
- Scopus rating (2012): CiteScore 0.39 SJR 0.317 SNIP 0.994
- ISI indexed (2012): ISI indexed no
- BFI (2011): BFI-level 2
- Scopus rating (2011): SJR 0.271 SNIP 0.448
- ISI indexed (2011): ISI indexed no
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 0.282 SNIP 0.63
- BFI (2009): BFI-level 2
- Scopus rating (2009): SJR 0.293 SNIP 0.547
- BFI (2008): BFI-level 1
- Scopus rating (2008): SJR 0.297 SNIP 0.252
- Scopus rating (2007): SJR 0.323 SNIP 0.365
- Scopus rating (2006): SJR 0.348 SNIP 0.532
- Scopus rating (2005): SJR 0.319 SNIP 0.258
- Scopus rating (2004): SJR 0.251 SNIP 0.74
- Scopus rating (2003): SJR 0.443 SNIP 1.11
- Scopus rating (2002): SJR 0.124 SNIP 0.583
Original language: English
DOIs:
10.1108/14714171111149043
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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Organisations: Engineering Design and Product Development, Department of Management Engineering, Operations Management, Department of Mechanical Engineering
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Journal: International Journal of Industrial Engineering-Theory Applications and Practice
Volume: 18
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Scopus rating (2017): CiteScore 0.63
Scopus rating (2016): CiteScore 0.51 SJR 0.289 SNIP 0.543
Scopus rating (2015): CiteScore 0.5 SJR 0.247 SNIP 0.341
Scopus rating (2014): CiteScore 0.25 SJR 0.292 SNIP 0.633
Scopus rating (2013): CiteScore 0.24 SJR 0.209 SNIP 0.384
Scopus rating (2012): CiteScore 0.26 SJR 0.224 SNIP 0.347
Scopus rating (2011): CiteScore 0.3 SJR 0.173 SNIP 0.442
Scopus rating (2010): SJR 0.222 SNIP 0.173
Scopus rating (2009): SJR 0.276 SNIP 0.228
Scopus rating (2008): SJR 0.252 SNIP 0.36
Scopus rating (2007): SJR 0.147 SNIP 0.441
Scopus rating (2006): SJR 0.246 SNIP 0.403
Scopus rating (2005): SJR 0.172 SNIP 0.25
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.162 SNIP 0.28
Scopus rating (2003): SJR 0.195 SNIP 0.257
Scopus rating (2002): SJR 0.186 SNIP 0.117
Scopus rating (2001): SJR 0.239 SNIP 0.335
Scopus rating (2000): SJR 0.186 SNIP 0.306
Scopus rating (1999): SJR 0.281 SNIP 0.312
Original language: English
Keywords: Master plan, Sales, Data mining, Product configuration, Product assortment, Conceptual modeling, Visualization, Flow visualization, Product development, Models, Configuration system, Sea global, Formal Description, Early phases, Product variety, Product families, Modeling, Functional areas

Source: orbit
Source-ID: 316285
Research output: Research - peer-review › Journal article – Annual report year: 2011

Modules in historic building construction according to the Copenhagen Building Code

This paper describes an analysis of building works from Copenhagen, Denmark in the period 1850 to 1950. In the study we investigate, based on the theory of product architecture and product modularization, if examples of the use of well-
defined interfaces can be found. Furthermore, the aim is to study how the use of such interfaces has influenced former building processes and how they were implemented and kept stable over decades. The result of the study is that at that time a number of standardized interfaces between the individual parts of the building work existed, and that these interfaces have remained unchanged for many years. The interfaces have been identified and modeled seen from a product, process and organizational perspective. The standardized interfaces have been implemented and kept primarily because of the existing legislation, training of project supervisors and craftsmen, and arrangements / agreements between the individual professional groups.

General information
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Contributors: Kudsk, A., Thuesen, C. L., Hvam, L.
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Publisher: Lulu, Inc.
Source: orbit
Source-ID: 280652
Research output: Research - peer-review › Article in proceedings – Annual report year: 2011

Optimizing the order processing of customized products using product configuration
For the better part of the 20th century many large companies have been focussed on optimizing their mass production process as a way of maximizing their profits. Nowadays, in the existing environment of global competitiveness, enhancing the production process remains a significant issue as well. Product configuration based on integrated modular product structure and product family architecture has been recognized as an effective means for implementing mass customization. In order to evaluate the effects of product configuration on order processing, a study has been conducted by the Department of Management Engineering and Operations Management of the Technical University of Denmark in cooperation with the Institute of Production Engineering and Machine Tools of the Leibniz Universität Hannover. Thereby, a product configuration system has been modelled for a manufacturer of mass customized products and its benefits for the order processing have been evaluated.

General information
State: Published
Organisations: Operations Management, Department of Management Engineering, Leibniz Universität Hannover
Contributors: Hvam, L., Bonev, M., Denkena, B., Schürmeyer, J., Dengler, B.
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Peer-reviewed: Yes

Publication information
Journal: Production Engineering
Volume: 5
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ISSN (Print): 0944-6524
Ratings:
Web of Science (2019): Indexed yes
Web of Science (2018): Indexed yes
Scopus rating (2017): CiteScore 1.23 SJR 0.602 SNIP 1.04
Scopus rating (2016): CiteScore 0.92 SJR 0.536 SNIP 1.118
Scopus rating (2015): CiteScore 0.74 SJR 0.618 SNIP 0.968
Scopus rating (2014): CiteScore 1.09 SJR 0.868 SNIP 1.391
Scopus rating (2013): CiteScore 1 SJR 0.744 SNIP 1.255
ISI indexed (2013): ISI indexed no
Scopus rating (2012): CiteScore 1.07 SJR 0.982 SNIP 1.706
ISI indexed (2012): ISI indexed no
Scopus rating (2011): CiteScore 1.1 SJR 1.067 SNIP 1.751
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.666 SNIP 1.374
Scopus rating (2009): SJR 0.43 SNIP 1.234
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

Product Complexity Impact on Quality and Delivery Performance

Existing literature on product portfolio complexity is mainly focused on cost related aspects. It is widely acknowledged that an increase in a company's product portfolio will lead to an increase in complexity related costs such as order management, procurement and inventory. The objective of this article is to examine which other factors that might be affected when a company is expanding its product portfolio, if initiatives are not taken to accommodate this increase. Empirical work carried out in a large international engineering company having a market leader position confirms that cost is increased, but it is not the only factor affected. We can document that there is a tendency towards increasing lead times as well as a drop in on time delivery and quality for newly introduced product variants. This means that the company experiences a reduced ability to deliver on time while also receiving more quality related complaints for the product variants, seldom engineered and produced.

General information
State: Published
Organisations: Operations Management, Department of Management Engineering
Contributors: Nielsen, J. B., Hvam, L.
Publication date: 2011

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Title of host publication: World Conference on Mass Customization, Personalization, and Co-Creation
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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State: Published
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Contributors: Haug, A., Hvam, L., Mortensen, N. H.
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Peer-reviewed: Yes

Publication information
Journal: Artificial Intelligence for Engineering Design, Analysis and Manufacturing
Volume: 25
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Ratings:
BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.19 SJR 0.375 SNIP 0.956
Web of Science (2017): Impact factor 1.045
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.09 SJR 0.486 SNIP 0.901
Web of Science (2016): Impact factor 0.885
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
Understanding Socio Technical Modularity: reinterpreting modularity from Actor Network Theory

Modularity has gained an increasing popularity as a central concept for exploring product structure, process structure, organization structure and supply chain structure. With the offset in system theory the predominant understanding of modularity however faces difficulties in explaining the social dimension of modularity like irrational behaviors, cultural differences, learning processes, social organization and institutional influences on modularity. The paper addresses this gap offering a reinterpretation of the modularity concept from a socio-technical perspective in general and Actor Network Theory in particular. By formulating modularity from an ANT perspective covering social, material and process aspects, the modularity of a socio-technical system can be understood as an entanglement of product, process, organizational and institutional modularity. The theoretical framework is illustrated in a small case of construction products and practices in Copenhagen between 1850 and 1900. Based on this exemplary case central questions for the development of the concept of modularity is put forward.

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.

**General information**

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**Organisations:** Operations Management, Department of Management Engineering, Engineering Design and Product Development, University of Southern Denmark

**Contributors:** Haug, A., Hvam, L., Mortensen, N. H.

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**Publication information**

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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 1
- Scopus rating (2017): CiteScore 3.68 SJR 1.028 SNIP 1.886
- 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
Assessment of Benefits from Product Configuration Systems

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Organisations: Operations Management, Department of Management Engineering, Engineering Design and Product Development, University of Southern Denmark
Contributors: Hvam, L., Haug, A., Mortensen, N. H.
Publication date: 2010

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Electronic versions:
AssessmentofBenefitsfromProductConfiguration.pdf
Source: orbit
Source-ID: 251935
Research output: Research - peer-review » Journal article – Annual report year: 2010

Examining the Possibilities of Identifying and Modeling Correlations between Product Families and Business Processes
In order for companies to make well founded decisions on the product family makeup, an understanding of the correlation between the complexity of the product family and business processes is required, though it is often not available. This paper investigates the potential of using the Product Variant Master (PVM) modeling technique and Process Flow Charts in combination, to analyze the correlation between complexity in product families and business processes. The approach is based on a visual modeling of the product assortment and the business processes. It is hypothesized that the combined use of the modeling techniques can allow for analysis and communication of the product family and business processes; as well as the connections between the two, with the potential of creating a single combined model. A case from a Danish industrial company is used for the purpose of the investigation. The case shows that it is possible to identify correlations between product complexity and the induced effects in the business processes through the use of product Variant Master and Flow Chart models. Examples are given, and conclusions are drawn concerning the possible usefulness of combining PVM and process flow charts for the purpose of identification and visualization of correlations.

General information
State: Published
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%.

General information

State: Published

Organisations: Engineering Design and Product Development, Department of Management Engineering, Operations Management, University of Southern Denmark

Contributors: Mortensen, N. H., Hvam, L., Haug, A., Boelskifte, P., Hansen, C. L.

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Publication information

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Web of Science (2019): Indexed yes

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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
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.

General information
State: Published
Organisations: Engineering Design and Product Development, Department of Management Engineering, Operations Management, University of Southern Denmark
Contributors: Mortensen, N. H., Hvam, L., Haug, A.
PUBLICATION DATE: 2010
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.
CRC-cards to support development and maintenance of product configuration systems
This article presents a new definition of special Class, Responsibility and Collaboration (CRC) cards to be used for the development and maintenance of Product Configuration Systems (PCSs). CRC cards were introduced as an informal and user-friendly technique for teaching object-oriented modelling. These CRC cards are often applied in the early phases of a software development project to come up with design alternatives. In 1994, extended CRC cards, with the purpose of holding detailed descriptions of classes in structural diagrams, were incorporated into a procedure for the development and maintenance of PCSs. This procedure has since been applied in several configuration projects and further developed at the Centre for Product Modelling (CPM) at the Technical University of Denmark. However, the investigations of two companies that applies CRC cards to document the knowledge base of their PCSs showed that their CRC card layouts differ from the definitions by CPM in many respects. Therefore, this article proposes a new CRC card definition that incorporates the experiences from the studied cases together with other kinds of extensions. The proposed CRC-card definition improves the basis for the companies that take up the technique.

General information
State: Published
Organisations: Operations Management, Department of Management Engineering
Contributors: Haug, A., Hvam, L.
Pages: 38-57
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Peer-reviewed: Yes

Publication information
Journal: International Journal of Mass Customisation
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BFI (2017): BFI-level 1
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BFI (2015): BFI-level 1
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
BFI (2011): BFI-level 1
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
BFI (2009): BFI-level 1
BFI (2008): BFI-level 1
Original language: English
DOIs:
10.1504/IJM ASSC.2009.021660
Source: orbit
Source-ID: 236885
Research output: Research - peer-review › Journal article – Annual report year: 2009

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.

**Platforms as vehicles for systemic innovation in construction - Learning points from a successful implementation of platform for house building in Germany**

**General information**
State: Published
Organisations: Planning and Management of the Built Environment, Department of Management Engineering, Operations Management
Contributors: Thuesen, C. L., Hvam, L.
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Source-ID: 251876
Research output: Research - peer-review › Article in proceedings – Annual report year: 2009

**Representation of Industrial Knowledge - as a Basis for Developing and Maintaining Product Configurators**

Abstract A product configurator is a software-based expert system that supports the user in the creation of product specifications by restricting how different components and properties may be combined. The use of product configurators has for several years provided many engineering-oriented companies such benefits as: shorter lead times, improved quality of product specifications, preservation of knowledge, use of fewer resources for specifying products, optimized products, less routine work, improved certainty of delivery, and less time needed for training new employees. Unfortunately, not all configuration projects are successful, but in fact many fail or experience great problems during the course of the project. An important factor for the success of a configuration project is the quality of the methods, techniques and tools applied when extracting, representing and documenting relevant domain knowledge. Despite this fact, research in the knowledge acquisition process of configuration projects is an area that has been much neglected till now. Therefore, this thesis deals with some of the most important aspects of the knowledge acquisition process in configuration projects by answering seven research questions in nine papers, produced during the course of the PhD project. The questions are grouped under three topics: domain expert knowledge; knowledge representation techniques; and documentation of configuration knowledge. The thesis takes its point of departure in analysing existing literature, after which research questions are defined, a frame of reference established and the scientific approach outlined. Next, the main contribution of the PhD project is described, namely the papers that are part of the thesis, starting with analysis of the process in which domain experts provide relevant information to knowledge engineers. The process is investigated by analysing the role of tacit knowledge in configuration projects and by proposing a classification of the kinds of information involved in this process. The thesis then investigates how the information retrieved from domain experts can be represented in analysis and design models. To solve inadequacies of an existing graphic knowledge representation technique, the thesis proposes a representation technique that combines the existing technique with tables and other modelling constructs. Next, the two most commonly applied graphic knowledge representation techniques in configuration projects are investigated by analysing their mutual strengths and weaknesses. Having clarified the nature of these strengths and weaknesses, a new layout principle is proposed that combines the advantages of both notation techniques. To deal with cases where graphic models with overlapping content are to be maintained, the thesis proposes and tests a moulding principle that allows maintenance of models with overlapping content in a common model. Finally, the thesis investigates how knowledge in configuration projects can be documented, from a software perspective. To test the definitions, a software prototype is developed. In conclusion, this thesis provides new insights into the knowledge acquisition process of configuration projects and several new modelling techniques and principles. The contributions provide an improved basis for future research in product configuration and for the companies that engage in configuration projects.
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.

General information
State: Published
Organisations: Engineering Design and Product Development, Department of Management Engineering, Department of Mechanical Engineering, Operations Management, Grundfos DK AS
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Peer-reviewed: Yes

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Journal: International Journal of Mass Customisation
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Ratings:
BFI (2019): BFI-level 1
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Mass Customization Services

Topics of the IMCM’08 & PETO’08 and this book are: Mass customization in service, mass customizing financial services, mass customization in supply networks, implementation issues in logistics, product life cycle and mass customization. The research field of mass customization is more than 15 years old but as the topics illustrate, quite a diverse field. This is expected to continue as long as all fields continue to evolve in their own direction. From a research point of view this provides an opportunity as practitioners from diverse fields have an interest in meeting and sharing ideas. The IMCM’08 & PETO’08 is one such opportunity.

General information

State: Published
Organisations: Work, Technology and Organisation, Department of Management Engineering, Operations Management, Hamburg University of Technology, IE Business School, University of Klagenfurt
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Publication information

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Source: orbit
Source-ID: 232126
Research output: Research - peer-review : Book – 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.
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.
A classification of the information that domain experts do and do not provide in configuration projects

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Haug, A., Hvam, L.
Publication date: 2007

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Title of host publication: Proceedings of the 12th annual international conference on Industrial Engineering Theory, Applications & Practice
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Research output: Research - peer-review : Article in proceedings – Annual report year: 2007

A comparative study of two graphical notations for the development of product configuration systems

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Haug, A., Hvam, L.
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: International Journal of Industrial Engineering (Online)
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Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
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
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
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
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.

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Organisations: Operations Management, Department of Management Engineering, Engineering Design and Product Development
Contributors: Hvam, L., Mortensen, N. H.
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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
An approach for the development of visual configuration systems

How can a visual configuration system be developed to support the specification process’ in companies that manufacture customer tailored products? This article focuses on how visual configuration systems can be developed. The approach for developing visual configuration systems has been developed by Centre for Product Modelling (CPM) at The Technical University of Denmark. The approach is based on experiences from a visualization project in co-operation between CPM and the global provider of power protection American Power Conversion (APC). The visual configuration system was developed in 2001-2002 and has during its operation since the beginning of 2003 delivered promising results. The lead-time for approval of quotations has been reduced and the percentages of first-time-completed and correct configuration sessions are increased thanks to an increased user-interaction, caused by the visualization of the product in the visual configuration system.

General information

State: Published
Organisations: Department of Management Engineering, Work, Technology and Organisation
Contributors: Hvam, L., Ladeby, K. R.
Pages: 401-419
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Peer-reviewed: Yes

Publication information

Journal: Computers & Industrial Engineering
Volume: 53
Issue number: 3
ISSN (Print): 0360-8352
Ratings:
BFI (2019): BFI-level 1
A prototype of a documentation system that supports the development and maintenance of product configuration systems

Product configuration systems (PCSs) can be defined as product-oriented expert systems that allow users to specify products while restricting how different elements and properties may be combined. For several companies the use of PCSs has led to improvements of product specification processes, such as shorter lead times, reductions of resources needed and fewer errors. A procedure for the development and maintenance of PCSs, which has been applied in configuration projects for more than ten years, includes three main modelling techniques to support the development and maintenance of PCSs. Unfortunately, no software exists which supports all three techniques in an integrated fashion. This means that when developing PCSs based on this procedure there is no automatic integration between the created models. Therefore, for some years, researchers have worked on creating a basis for developing a documentation system that supports the development and maintenance of PCSs. This article describes how some of this research has been converted into a prototype of a documentation system and what has been learned from the evaluation of the prototype.
An external knowledge system keeps track of how each subsystem has to be configured, but the actual configuration is often done manually. Installing and maintaining those kinds of systems can be a tedious task and often requires repetitive labour. The idea is to "split-up" the product knowledge and encapsulate it into each subsystem. Then, when the subsystems are assembled, the configuration of each subsystem can either be done automatically or with minimum input. The concept could be called: embedded configuration. This article will try to connect three aspects of making distributed knowledge system, the encapsulation of product knowledge, its subsequent encoding into product models, and finally, the communication of knowledge between the subsystems. There are two main reasons for focusing on communication, namely the encapsulation of knowledge and the communication between machines. One has to identify the information needed from outside for each subsystem to work. That information should also aid in finding the "services" that the subsystem can offer the overall system. Communication between subsystems has to be made explicit. A protocol has to be in place to tell the subsystem how to share its inner workings and how to be able to participate in the overall system.

**General information**

State: Published
Organisations: Department of Management Engineering
Contributors: Oddsson, G. V., Hvam, L.
Publication date: 2007

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Creating a documentation system to support the development and maintenance of product configuration systems

**General information**

State: Published
Organisations: Department of Management Engineering, Computer Science and Engineering, Department of Informatics and Mathematical Modeling
Contributors: Haug, A., Degn, A., Poulsen, B., Hvam, L.
Publication date: 2007

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Electronic versions:

imm5133.pdf
URLs:
http://www2.imm.dtu.dk/pubdb/p.php?5133
Source: orbit
Source-ID: 199915
Research output: Research › Article in proceedings – Annual report year: 2007

Innovative Processes and Products for Mass Customization

This paper describes the solution developed in the KoViP project and presents the results of introducing this solution in the scope of a pilot project. The idea of the KoViP project targets SMEs of the German machine and plant manufacturing, which are forced to produce customized products whilst simultaneously keeping costs and delivery times low following the approach of mass customization. But the majority of the SMEs with product platforms cannot afford to develop an individual product configurator. Therefore they have a large demand for a more cost-effective and flexible product configuration solution. The first part of the paper describes the product configuration software and service platform KoViP, developed by the CAD software provider ISD, Dortmund, in cooperation with the ITM chair of the University of Bochum and funded by the EU and the federal state of North Rhine-Westphalia. The main goal of KoViP was to create a modular, easy configurable, standard software platform and a suite of standard services for the knowledge acquisition and maintenance as well as for the implementation of product configurators in SMEs producing mass customized products. The second part of the contribution summarizes the validation of the KoViP platform in a pilot project within the company VHV Anlagenbau, Hörstel.

**General information**

State: Published
Organisations: Department of Management Engineering, Hamburg University of Technology, University of Klagenfurt, IE Business School
Contributors: Blecker, T., Edwards, K., Hvam, L., Gerhard, F., Fabrizio, S.
Number of pages: 489
Mass Customization’s implication on after-sales services
In many years’ service operations management literature has been focusing on advocating for customized service products for customers. The problem is that every customized product should be supported by a unique service operation. To increase the problem these services are often characterised by lack of structure and manual processes that run them. All this leads to lack of operational efficiency and lesser quality than can be achieved. Although mass customisation techniques suggest solution for the trade off between customisation and efficiency for the manufacturing industry, no widely known concept has been introduced when it comes to after sales services. As mass customisation also generates customized products, the implications on after sale services like installation, training, routine maintenance, emergency repair, parts supply and software services are comparable to customised service products. This research points out that service operations management should consider a new approach to services. It is suggested to include embedded configuration systems in product design and to modularise the service product assortment. The article points out that the solution basically incorporates finding the relevant decision variables, operationalization of these same and their internal mapping. At the end of the article two case studies are supplied to support the argumentation.

Product configuration for making quotations for complex and highly engineered products
This presentation will describe a practical implementation of a configuration system at F.L. Smith, which is a Danish cement plant manufacturer. The prototype of this system was developed from 1998-1999 and it was based on a procedure for building product models developed by the Centre for Product Modeling at the Technical University of Denmark. The first version of the configuration system was implemented in 2000 and has now been in operation for more than seven years.

Product configuration of infrastructure systems for data centres
This article describes how American Power Conversion (APC), a company in the electronics industry, has used product configuration systems as a central part of the company’s mass customisation strategy. APC sells, designs, produce, delivers, and installs large complex infrastructure systems for data centres, and components and systems for these systems. At the heart of its mass customisation strategy are a module-based product range and the use of product configuration systems for sales and order processing. In addition, the company has implemented a manufacturing
concept, which involves the mass production of standard components in the Far East, and customer order-based final assembly at various production sites around the world within close customer proximity. The results of applying mass customisation principles include a reduction of the overall delivery time for a complete system from around 400 to 16 days. Also, production costs were significantly reduced. The use of product configuration systems also supports a widely distributed process of selling APC’s products via more than 10,000 sales associates and dealers worldwide. At the same time, the company’s capability for introducing new products has increased. Each year, APC introduces more than 1,000 new products to the market.
Tacit knowledge in configuration projects

The modelling techniques of a documentation system that supports the development and maintenance of product configuration systems
A Configuration System for Supportive Purposes in the Middle of a Product Lifecycle

This paper presents a new way of using configuration systems. Traditionally, these systems have been used for decision support for sales. The aim is now to support “Middle-Of-Lifecycle” (MOL) processes, which means that the decision support system is targeted for the customer and the manufacturer (field services, technical support and after sales). This is especially interesting, as manufacturing companies are increasingly focusing their operations on service operations. The background for this idea is that companies often experience a lack of information between the initial sale and the following service operations. For instance, the sales info regarding a product is often obsolete due to changes in the product setup since installation/implementation, and considerable amounts of time are wasted on inefficient updates. To support the daily business we suggest using configuration systems for supportive purposes in the middle of a product lifecycle. By doing so a product in operation (including maintenance) could be administrated more effectively. At the same time it is a good opportunity to hand over important runtime information and thereby create a basis for general improvements of the manufacturer’s service operations. A company case is shortly described in the second half of this article.

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Christensen, T. T., Hvam, L.
Number of pages: 489
Pages: 85-92
Publication date: 2006

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Publisher: GITo-Verlag
ISBN (Print): 3-936771-73-1
Source: orbit
Source-ID: 191787
Research output: Research › Article in proceedings – Annual report year: 2006

Conceptualizing Embedded Configuration
Installing and servicing complex electromechanical systems is more tedious than is necessary. By putting the product knowledge into the product itself, which then would allow automation in constructing the product from modules, could solve that. It would support personnel in aftersales installation and services. The general idea can be named embedded configuration. In this article we intend to conceptualize embedded configuration, what it is and is not. The difference between embedded configuration, sales configuration and embedded software is explained. We will look at what is needed to make embedded configuration systems. That will include requirements to product modelling techniques. An example with consumer electronics will illuminate the elements of embedded configuration in settings that most can relate to. The question of where embedded configuration would be relevant is discussed, and the current work being done at Grundfos is highlighted.

General information
State: Published
Organisations: Department of Management Engineering, Grundfos DK AS
Contributors: Oddsson, G. V., Hvam, L., Lysgaard, O.
Number of pages: 489
Pages: 369-381
Publication date: 2006

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Volume: 2
Place of publication: Berlin
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Source: orbit
Source-ID: 191779
Research output: Research - peer-review › Article in proceedings – Annual report year: 2006

CRC-cards for the development and maintenance of product configuration systems

General information
State: Published
Organisations: Department of Management Engineering
Improving the quotation process with product configuration

How can product configuration support the process of engineering highly complex industrial products? This article describes how an IT-based product configuration system was developed to support the process of making budget quotations. The article is based on a research project carried out as collaboration between the Centre for Product Modelling at the Technical University of Denmark and a Danish cement plant manufacturer. A procedure for building product models developed by the Centre for Product Modelling was tested empirically at the company during the project. The system was developed from 1998 – 1999, and the configuration system has now been in operation for more than three years during which period significant results have been achieved. The lead time for making budget quotations has been reduced from 2-5 weeks to 1-3 days. The quotations are more consistent and easy to read with focus on the big issues of the cement plant. The configuration system makes it possible to optimise the cement factories with respect to performance, an increased use of the company’s components, and with respect to the use of previously manufactured components. Finally, the engineering resources used for making a budget quotation have been significantly reduced.

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., Christensen, S. P.
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Peer-reviewed: Yes
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Issue number: 7
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Web of Science (2019): Indexed yes
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.68 SJR 1.028 SNIP 1.886
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
Kundetilpassede systemprodukter: - en vej til ny konkurrencekraft i Byggematerialeindustrien

American Power Conversion (APC), a company in the electronics industry, has used the principles of mass customisation to achieve major improvements in its efficiency and performance. APC sells, designs, produces, delivers, and installs large complex infrastructure systems for data centres, and components for these systems. At the heart of its mass customisation strategy are a module-based product range and the use of product configuration systems for sales and order processing. In addition, the company has implemented a manufacturing concept, which involves the mass production of standard components in the Far East, and customer order-based final assembly based on customer orders at various production sites around the world within close customer proximity. The results of applying mass customisation principles include a reduction of the overall delivery time for a complete system from around 400 to 16 days. Also, production costs were significantly reduced. At the same time, the company's capability for introducing new products has increased.
Mass Customization in the Electronics Industry: Based on Modular Products and Product Configuration
This article describes how American Power Conversion (APC), a company in the electronics industry, has used the principles of mass customization to achieve major improvements of its efficiency and performance. APC sells, designs, produces, delivers, and installs large complex infrastructure systems for data centers, and components and systems for these systems. At the heart of its mass customization strategy are a module based product range and the use of product configuration systems for sales and order processing. In addition, the company has implemented a manufacturing concept which involves mass production of standard components in the Far East, and order-based final assembly based on customer orders in various production sites around the world in close customer proximity. The results of applying mass customization principles include a reduction of the overall delivery time for a complete system from about 400 days to 16 days. Also, production costs were reduced significantly. The use of product configuration systems also supports a widely distributed process of selling APC's products via more than 10,000 sales associates and dealers worldwide. At the same time, the company's capability for introducing new products has increased. Each year, APC introduces more than 1,000 new products onto the market.

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Publication date: 2006

Host publication information
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Place of publication: Berlin
Publisher: GITO-Verlag
ISBN (Print): 3-936771-73-1
Source: orbit
Source-ID: 191789
Research output: Research › Article in proceedings – Annual report year: 2006

Mass Customization of process plants
This case study describes how F.L.Smidth A/S, a manufacturer of large processing plants for cement production, has applied the principles of mass customisation in the area of highly complex, custom engineered products. The company has based its sales process on a configuration system to achieve a more efficient sales and engineering process. The implementation of the configuration system was accompanied by a radical redefinition of the modular structure of the company's product architectures. The project was carried out in cooperation with the Centre for Product Modelling (CPM) at the Technical University of Denmark and illustrates the methods developed at the CPM for the construction of configuration systems. The case analyses the implementation process of the configuration system and documents the results attained after implementation.

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Organisations: Department of Management Engineering
Contributors: Hvam, L.
Pages: 18
Publication date: 2006
Peer-reviewed: Yes
Merging models with different perspectives on product configuration knowledge

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Haug, A., Hvam, L.
Publication date: 2006

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Title of host publication: Research in Interactive Design
Volume: Volume 2
Publisher: Springer-Verlag France
ISBN (Print): 2287483632
Source: orbit
Source-ID: 194932
Research output: Research - peer-review › Article in proceedings – Annual report year: 2006

Produktkonfigurering: Effektiv konfigurering af kundetilpassede produkter

General information
State: Published
Organisations: Department of Management Engineering, Engineering Design and Product Development, Department of Mechanical Engineering, Niro A/S
Contributors: Hvam, L., Mortensen, N. H., Riis, J.
Number of pages: 301
Publication date: 2006

Publication information
Place of publication: København
Publisher: Nyt Teknisk Forlag
Edition: 1
ISBN (Print): 87-571-2428-0
Original language: English
Source: orbit
Source-ID: 191279
Produktmodellering i virksomhedsnetværk - en fremgangsmåde for udvikling af produktkonfigureringsystemer til understøttelse af produktrelateret informationsudveksling mellem virksomheder i netværk

General information
State: Published
Organisations: Department of Management Engineering, Operations Management
Contributors: Malis, M., Hvam, L.
Number of pages: 355
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Publication information
ISBN (Print): 87-91035-38-4
Original language: Danish
Source: orbit
Source-ID: 187703
Research output: Research › Ph.D. thesis – Annual report year: 2006

The modelling techniques of a documentation system that supports the development and maintenance of product configuration systems

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Haug, A., Hvam, L.
Publication date: 2006

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Source: orbit
Source-ID: 194930
Research output: Research › Article in proceedings – Annual report year: 2006

A documentation tool for product configuration systems - improving the documentation task
Configuration systems are increasingly applied to automate the configuration of complex products. A configuration system is an expert system designed to combine specified modules according to constraints. The constraints are stored as product data and rules in a product model, and one of the most essential tasks is thus to develop a complete and consistent product model which can reflect the actual product. A procedure for building product models has been developed at the Centre for Product Modelling (CPM), and the procedure has been successfully applied in several industrial companies. CPM's experience with the procedure and the hitherto empirical experience from companies having applied the procedure have revealed that there is a need for an IT-based documentation tool to support the process of constructing product configuration systems. Time can be saved by letting a documentation tool handle trivial time consuming tasks (notification on change, consistency check etc.), as a computer often handles these tasks in a better way. Thus, a serious bottleneck can be eliminated by applying Information System (IS) technology to the process tasks. This paper deals with the specifications of a documentation tool for product configuration, based on CPM's procedure and experience from four Danish industrial companies which have applied the procedure. The requirements have been gathered and structured by using object-oriented system development techniques based on an analysis of the existing product configuration processes of the companies. The analysis was based on the procedure for building product models as developed at CPM, and revealed several common requirements within the different companies.

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., Jensen, K. L.
Publication date: 2005
Peer-reviewed: Yes

Publication information
Journal: International Journal of Engineering
Volume: 1
Original language: English
Developing 3D configuration systems for manufacturers of complex building components

**General information**
State: Published
Organisations: Department of Management Engineering
Contributors: Haug, A., Hvam, L.
Publication date: 2005

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Title of host publication: Mass Customization - Concepts - Tools - Realization
Publisher: GITO-Verlag, Berlin
ISBN (Print): 3-936771-46-4
Source: orbit
Source-ID: 194927
Research output: Research - peer-review › Article in proceedings – Annual report year: 2005

Development and maintenance of product configuration systems: Requirements for a documentation tool
Product configuration systems are increasingly applied to automate the configuration of complex products. A configuration system is an expert system designed to combine specified modules according to constraints. The constraints are stored as product data and rules in a product model, and one of the most essential tasks is thus to develop a complete and consistent product model which can reflect the actual product. A procedure for building configuration systems has been developed at the Centre for Product Modelling (CPM), and the procedure has been successfully applied in several industrial companies. CPM's experience with the procedure and the hitherto empirical experience from companies having applied the procedure have revealed that there is a need for an IT-based documentation tool to support the process of constructing and maintaining product configuration systems. Time can be saved by letting a documentation tool handle trivial time consuming tasks (notification on change, consistency check etc.), as a computer often handles these tasks in a better way. Thus, a serious bottleneck in the maintenance of configuration systems can be eliminated by applying Information System (IS) technology to support the documentation process. This paper deals with the requirement specification of a documentation tool for product configuration systems, based on CPM's procedure and experience from four Danish industrial companies which have applied the procedure. The requirements have been gathered and structured by using object-oriented system development techniques based on an analysis of the existing product configuration processes of the companies. The analysis was based on the procedure for building configuration systems as developed at CPM, and revealed several common requirements within the different companies. Significance: There is an actual need for a documentation tool for product configuration systems. The objective of the study is to identify and capture requirements of such a documentation tool, and serve as a basis for future design and implementation.

**General information**
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., Christensen, S. P., Jensen, K. L., Riis, J.
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Scopus rating (2017): CiteScore 0.63
Scopus rating (2016): CiteScore 0.51 SJR 0.289 SNIP 0.543
Scopus rating (2015): CiteScore 0.5 SJR 0.247 SNIP 0.341
Scopus rating (2014): CiteScore 0.25 SJR 0.292 SNIP 0.633
Scopus rating (2013): CiteScore 0.24 SJR 0.209 SNIP 0.384
Scopus rating (2012): CiteScore 0.26 SJR 0.224 SNIP 0.347
Scopus rating (2011): CiteScore 0.3 SJR 0.173 SNIP 0.442
A multi perspective approach for the design of product configuration systems
This article presents a procedure for building product configuration systems. The procedure includes, as 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 in several companies. This article includes the experiences from the most recent project, which has been carried out at Demex Electric – a Danish company making electronic switchboards. The research has been carried out at the Centre for Product Modelling, Department of Manufacturing Engineering and Management at the Technical University of Denmark.

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State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L.
Publication date: 2004

Host publication information
Title of host publication: A multi perspective approach for the design of product configuration systems
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Source: orbit
Source-ID: 177998
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004
A multi-perspective approach for the design of Product Configuration Systems - an evaluation of industry applications

This article presents a suggested procedure for modelling and implementation of product configuration systems. The procedure has been applied in several industrial companies. The procedure comprises: •Analysis of the business processes to be supported by a product configuration system. Furthermore, a de-markation and definition of the configuration system to be designed. •Analysis and modelling of the part of the company’s product assortment which is to be included in the con-figuration system. •Selection of configuration software and programming of the configuration system. •Operations, maintenance and further development of the configuration system. The procedure has been developed on the basis of the general methods for modelling IT-systems (UML) as well as on the theory for modelling technical systems and theory for the development of business processes. The procedure or certain parts of the procedure have currently been tested and further developed in cooperation with a number of industrial companies including F.L.Smidth, American Power Conversion (APC), Aalborg industries, NEG-Micon, GEA-Niro and IBM-SMS. This paper presents the experiences gained from 4 of these industrial companies which have applied the procedure. Based upon this experience the utility of the method is evaluated, and sugges-tions/ideas as to a further development of the method, e.g. as regards the integration of organisational and economical problems are collected.

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L.
Publication date: 2004

Host publication information
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Publisher: IPL
URLs:
http://www.ipl.dtu.dk/publikation/8441/dk/
Source: orbit
Source-ID: 178005
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004

A multi-perspective approach for the design of Product Configuration Systems - Configuration of electronic switch boards

Configuration of electronic switch boards.

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L.
Publication date: 2004

Host publication information
Title of host publication: INFORMS Annual meeting 2004
URLs:
http://www.ipl.dtu.dk/publikation/8442/dk/
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Source-ID: 178006
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004

Analyse af software til visuel produktkonfigurering i byggebranchen

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hansen, B. L., Hvam, L.
Number of pages: 50
Publication date: 2004

Publication information
Publisher: Institut for Produktion og Ledelse, DTU
Original language: Danish
URLs:
http://www.ipl.dtu.dk/publikation/8445/dk/
**Fundamental Characteristics of industrial variant specification systems**

An article outlining the Order Specification Decoupling Line.

**General information**

State: Published
Organisations: Department of Management Engineering
Contributors: Hansen, B. L., Hvam, L.
Publication date: 2004

**Host publication information**

Title of host publication: International Conference on Economic, Technical and Organisational aspects of Product Configuration
URLs:
http://www.ipl.dtu.dk/publikation/8439/dk/
Source: orbit
Source-ID: 178003
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004

This paper focuses on the operational task of creating customised variants of industrial specifications (e.g. drawings, routings and bill-of-materials). Rooted in a lack of existing literature on the subject the paper describes the nature of variant specification systems. It introduces some fundamental concepts related to this task, which are relevant to academia and practitioners working with the subject. This is done through a description of variant specification tasks and typical aspects of system solutions. To support the description of variant specification tasks and systems a set of situational variables (e.g. frequency of orders [low ¡ê high]), a set of functionality variables (e.g. lead time [low ¡ê high]) and a set of structure variables (e.g. level of IT-automation [manual ¡ê IT-automated]) are proposed. Finally, the presented concepts are illustrated through two examples. In general the paper discusses an important focus area within mass customization and build-to-order production: the nature of industrial variant specification systems.

**General information**

State: Published
Organisations: Department of Management Engineering
Contributors: Hansen, B. L., Hvam, L.
Publication date: 2004

**Host publication information**

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Publisher: Department of Manufacturing Engineering and Management, DTU
Editor: L. M.
URLs:
http://www.ipl.dtu.dk/publikation/8518/dk/
Source: orbit
Source-ID: 178075
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004

**Proceedings from the International Conference on Economic, Technical and Organisational aspects of Product Configuration Systems**

**General information**

State: Published
Organisations: Work, Technology and Organisation, Department of Management Engineering, Operations Management
Number of pages: 250
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**Publication information**

Place of publication: Kgs. Lyngby
Publisher: 87-91035-13-9
Edition: 1
Reengineering of the quotation process - Application of knowledge-based systems

Is it possible to support the engineering processes with intelligent product models when the knowledge and information work is very complex? This article describes how IT-supported product configuration can support the complex engineering activities carried out in the quotation processes. The research has been carried out at the Centre for Product Modelling at the Technical University of Denmark in co-operation with F.L. Smidth, a Danish cement plant manufacturer with a worldwide leading position. The redesign of the quotation process lasted 3 years, but as the paper illustrates, remarkable results have been accomplished. The lead-time for making quotations was reduced from weeks to days. A better quality of quotes was obtained, and the direct consumption of resources for making quotations were reduced to 4%.
This paper discusses the important issue in build-to-order production of separating innovative long term engineering processes from day-to-day variant specification processes, i.e. the processes creating specifications such as bill-of-materials, drawings, text descriptions, routings etc. The paper proposes and discusses the term Order Specification Decoupling Line (OSDL), which is to be used to explain the separation of industrial specifications into some information created prior to order acquisition and some information created during order acquisition and order fulfillment. For instance one may find some welding specifications or product descriptions which are standard for every order, while there may be other specifications, such as bill-of-materials and drawings, which are customized. Through a use of this concept it becomes possible to discuss different levels of OSDL and different variant specification tasks, such as engineer-to-order, modify-to-order, configure-to-order and select to order. It must be emphasized that the paper is more of a research proposal for discussion, than actual conclusive findings.

**The Order Specification Decoupling Line**

This paper discusses the important issue in build-to-order production of separating innovative long term engineering processes from day-to-day variant specification processes, i.e. the processes creating specifications such as bill-of-materials, drawings, text descriptions, routings etc. The paper proposes and discusses the term Order Specification Decoupling Line (OSDL), which is to be used to explain the separation of industrial specifications into some information created prior to order acquisition and some information created during order acquisition and order fulfillment. For instance one may find some welding specifications or product descriptions which are standard for every order, while there may be other specifications, such as bill-of-materials and drawings, which are customized. Through a use of this concept it becomes possible to discuss different levels of OSDL and different variant specification tasks, such as engineer-to-order, modify-to-order, configure-to-order and select to order. It must be emphasized that the paper is more of a research proposal for discussion, than actual conclusive findings.

**General information**

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Publication date: 2004

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Place of publication: Kgs. Lyngby
Publisher: Department of Manufacturing Engineering and Management, DTU
Editor: K. E.
Source: orbit
Source-ID: 178074
CRC-cards for Product Modelling

This paper describes the CRC (class, responsibility, collaboration) modelling process for building product models. A product model is normally represented in an IT system which contains data, information and knowledge on industrial products and their life cycle properties e.g. manufacturing, transportation, service and decommissioning. A main challenge when building product models is to collect and document the product related data, information and knowledge in a structured way. CRC cards are index cards (or computerized versions of these) which are used to record proposed classes, the behavior of the classes, their responsibilities, and their relationship to other classes (collaboration). CRC modelling gives an effective, low-tech method for domain-experts, programmers and users to work closely together to identify, structure, understand and document a product model. CRC cards were originally introduced back in 1989 for software developers in general as a tool for defining an object oriented analysis model. In this paper CRC cards and the associated object oriented modelling techniques are adapted to product modelling. CRC modelling includes for instance: Organizing the CRC modelling team, educating relevant personnel (domain experts, programmers and users), and iteratively performing the steps of CRC modelling (find classes, find responsibilities, define collaborators etc.). CRC modelling covers some of the basic work before implementation of the product model in standard configuration software or programming the system. The CRC cards can be used to document the system through the entire life cycle (analysis, design, programming and maintenance). This article focuses on the application of CRC-cards in the analysis phase. The concepts and methods for modelling product knowledge have been tested in Danish industrial companies. The article presents a case study from Alfa Laval Separation.

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Organisations: Department of Management Engineering
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Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.68 SJR 1.028 SNIP 1.886
Web of Science (2017): Impact factor 2.85
Application of Configurators in Networks

Shorter lead-time, improved quality of product specifications and better communication with customers and suppliers are benefits derived from the application of configurators. Configurators are knowledge-based IT-systems that can be applied to deal with product knowledge and to support different processes in a company. Traditionally, configurators have been used as an internal tool. In this paper focus will be on the application of configurators in a network of companies, and a procedure for developing product configurators in a network of companies will be presented. The aim is to present a structured guideline, tools and methods on how to successfully develop configurators in a network perspective. Findings presented in this paper are supported by research in a case company. The results from the empirical work show a huge potential for the application of configurators in networks of companies.

A Procedure for Building Product Models in Intelligent Agent-based Operations Management

This article presents a procedure for building product models to support the specification processes dealing with sales, design of product variants and production preparation. The procedure includes, as the first phase, an analysis and redesign of the business processes that are to be supported by product models. The next phase includes an analysis of the product assortment, and the set up of a so-called product master. Finally the product model is designed and implemented by using object oriented modelling. The procedure is developed in order to ensure that the product models constructed are fit for the business processes they support, and properly structured and documented in order to facilitate the maintenance and further development of the systems. The research has been carried out at the Centre for Industrialisation of Engineering, Department of Manufacturing Engineering, Technical University of Denmark.

Framework for product knowledge and product related knowledge which supports product modelling for mass customization

The article presents a framework for product knowledge and product related knowledge which can be used to support the product modelling process which is needed for developing IT systems. These IT systems are important tools for many companies when they aim at achieving mass customization and personalization. The framework for product knowledge and product related knowledge is based on the following theories: axiomatic design, technical systems, theory of domains, theory of structuring, theory of properties and the framework for the content of product and product related models. The framework is built on experience from product modelling projects in several companies. Among them for example companies manufacturing electronic switchboards, spray dryer systems and air conditioning equipment. The framework is divided into three views: the product knowledge view, the life phase system view and the transformation process view ("the meeting"). The persons (rolls) involved in the product modelling process are for example: domain experts, change managers, model managers, project leaders, technical facilitators, process managers and software programmers. They
need a framework during the product modelling process. The framework supports the product modelling process in the
following areas: • It defines which concepts (terms) to use. • It supports the understanding of the different knowledge types. 
• It supports the understanding of the specification processes. • It facilitates the demarcation of the product knowledge and 
product related knowledge which should be or should not be included in the model. This demarcation will have a large
influence on the structure of the IT systems (for example the configurator system, the CAD system or the PDM system).
• The use of the framework can help achieve more structured models. • It can be used as a checklist during the modelling
work.

Knowledge Based Product Configuration - a documentation tool for configuration projects
How can complex product models be documented in a formalised way that consider both development and maintenance?
The need for an effective documentation tool has emerged in order to document the development of product models. The
product models have become more and more complex and comprehensive. A lot of knowledge is put into these systems
and many domain experts are involved. This calls for an effective documentation system in order to structure this
knowledge in a way that fits to the systems. Standard configuration systems do not support this kind of documentation.
The chapter deals with the development of a Lotus Notes application that serves as a knowledge based documentation
tool for configuration projects. A prototype has been developed and tested empirically in an industrial case-company. It
has proved to be a succes.

Konfigurering – specifikation af produkter i et netværk af virksomheder

Konfigurering – specifikation af produkter i et netværk af virksomheder
Mass customization and build to order production - in manufacturing networks
Mass Customization and Build to Order Production – In Manufacturing Networks
Mass customization and globalization have radically changed the environment for manufacturers. A new context is emerging with intensified competition and accelerated technology development. In this environment evolution is not an option, but a necessity for survival. This leads to the question “what can manufacturing enterprises do to turn the development into their own advantage?” As competition intensifies customer are increasingly demanding sophisticated and adapted solutions. Conventional manufacturer are challenged. Maintaining leading edge competencies within product development, sales and manufacturing simultaneous is difficult for SME’s with sparse means. The evolution sets new standards for the manufacturer and the people employed with the company. Competitive advantages shall not necessarily be found in the manufacturing as information processing is accountable for an increasing portion of the value creation. In order to improve the information processing some manufacturers have applied product models, thereby giving the customer access to the manufactures knowledge base. This project will introduce solution elements, which can support an improved utilization of product models in relation to new and existing manufacturing systems. The scientific novelty of this project is the exposure of the potential that lies in an improved application and integration of information technology in the supply chain and the manufacturing within the framework of “build to order” production. The main objective of this project is to develop understanding and support tools for the improvement of the information processing in the “build to order” manufacturers through the application of product models. A holistic approach is applied to the specification task thereby enabling the coordination of orders through the supply chain. Furthermore the strategic importance of a well structured supply chain is discussed and the potential value of the application of product models in the supply chain is emphasised. In this project the interface between product models and the manufacturing system will be illuminated and the possibilities for a coherent specification system will be examined through literature studies combined with empirical studies at Nilpeter and other medium sized enterprises.

General information
State: Published
Organisations: Department of Management Engineering, Operations Management
Contributors: Svensson, C., Barfod, A., Hvam, L.
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Research output: Research - peer-review › Article in proceedings – Annual report year: 2003

PØTO Rapport Nr. 1 - Teoretisk Foranalyse

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Edwards, K., Riis, J., Møldrup, M., Hvam, L., Pedersen, J. L., Møller, N.
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Publication date: 2003

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Original language: Danish
Source: orbit
Source-ID: 63605
Research output: Research - peer-review › Book – Annual report year: 2003

Specification process reengineering: concepts and experiences from Danish industry
This paper presents terminologies and concepts related to the IT automation of specification processes in companies manufacturing custom made products. Based on 11 cases from the Danish industry the most significant development trends are discussed.

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State: Published
Organisations: Department of Management Engineering
Contributors: Hansen, B. L., Riis, J., Hvam, L.
Publication date: 2003
Application of Knowledge Based Systems in a B-to-B environment

As a result of globalisation, supply networks are getting increasingly complex and extended, the exchange of knowledge becomes a critical parameter for the improvement of efficiency. This article describes the architecture of a web-based expert system that enables knowledge based product information to reach several companies within a network. The day-to-day interaction for design and purchase of products in a B-to-B environment will be in focus. It is illustrated how the use of web-based expert systems can improve the efficiency in the sales process significantly. The use of configurators has changed the daily interaction between a company and its suppliers. Large multinational companies (e.g. Dell and Cisco) have demonstrated how the use of web-based expert systems can revolutionize the sale of customized products and change market paradigms. The companies have reached new levels of competitiveness. Web-based expert systems are not only feasible for these giants. Solar A/S, Denmark’s largest electrical wholesaler, is running a portal for the purchase of electrical components. Recently an expert system has been introduced by one of the suppliers in order to improve communication within a network of companies. In this paper it is described how configurators are build and the new opportunities they bring are discussed.

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State: Published
Organisations: Department of Management Engineering
Contributors: Malis, M., Svensson, C., Hvam, L.
Publication date: 2002

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Title of host publication: 6th IASTED International Conference - Internet and Multimedia Systems and Applications, 2002
ISBN (Print): 0889863504
Experiences with a procedure for modeling product knowledge
This paper presents experiences with a procedure for building configurators. The procedure has been used in an American company producing custom-made precision air conditioning equipment. The paper describes experiences with the use of the procedure and experiences with the project in general.

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State: Published
Organisations: Department of Management Engineering
Contributors: Hansen, B. L., Hvam, L.
Publication date: 2002

Host publication information
Title of host publication: 15th European Conference on Artificial Intelligence, July 21-26 2002
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http://www.ipl.dtu.dk/publikation/6939/dk/
Source: orbit
Source-ID: 63065
Research output: Research - peer-review › Article in proceedings – Annual report year: 2002

Product Configurators as a means to support the Exchange of Knowledge in Company Networks
Modern enterprises have to face the challenge of how to adapt to changing operating procedures within both their supplier and their customer environment. The desire to satisfy these new demands has lead to the development of new business processes that focus on a higher level of expectations as regards customer service orientation and customization. There are several ways in which this can be obtained. In this paper one of the essential means to reach these demands will be described. Research has been carried out at the Centre for Product Modelling at the Technical University of Denmark in order to develop and implement a structured procedure for building product models. In the following focus will be on the adaption of product modelling techniques when dealing with companies in a network. Four different network types will be introduced. They will be used to describe different product model scenarios.

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., Malis, M.
Publication date: 2002

Host publication information
Title of host publication: The 7th Annual International Conference on Industrial Engineering
Source: orbit
Source-ID: 63069
Research output: Research - peer-review › Article in proceedings – Annual report year: 2002

Produktmodellering - procesanalyse, produktanalyse, objektorienteret analyse - Center for Produktmodellering

General information
State: Published
Organisations: Department of Management Engineering, Department of Mechanical Engineering
Contributors: Hvam, L., Mortensen, N. H.
Number of pages: 233
Publication date: 2002

Publication information
Publisher: IPL
Original language: Danish
URLs:
http://www.ipl.dtu.dk/publikation/6957/dk/
Source: orbit
Source-ID: 63076
Research output: Education › Book – Annual report year: 2002
A Knowledge-based Documentation Tool for Configuration Projects

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., Malis, M.
Publication date: 2001

Host publication information
Title of host publication: World Congress on Mass Customization and Personalization
URLs:
http://www.ipl.dtu.dk/publikation/6937/dk/
Source: orbit
Source-ID: 63063
Research output: Research - peer-review › Article in proceedings – Annual report year: 2001

A procedure for building product models
This article presents a procedure for building product models to support the specification processes dealing with sales, design of product variants and production preparation. The procedure includes, as the first phase, an analysis and redesign of the business processes, which are to be supported with product models. The next phase includes an analysis of the product assortment, and the set up of a so-called product master. Finally the product model is designed and implemented using object oriented modelling. The procedure is developed in order to ensure that the product models constructed are fit for the business processes they support, and properly structured and documented, in order to facilitate that the systems can be maintained continually and further developed. The research has been carried out at the Centre for Industrialisation of Engineering, Department of Manufacturing Engineering, Technical University of Denmark.

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., Riis, J., Malis, M., Hansen, B. L.
Pages: 19-39
Publication date: 2001

Host publication information
Title of host publication: Moving into Mass Customization : Information Systems and Management Principles
Publisher: Springer Verlag
Editor: C. R. R. S. K. T.
ISBN (Print): 3-540-43611-1
Source: orbit
Source-ID: 63039
Research output: Research - peer-review › Article in proceedings – Annual report year: 2001

A Procedure for the Application of Product Modelling

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L.
Pages: 873-885
Publication date: 2001
Peer-reviewed: Yes

Publication information
Journal: International Journal of Production Research
Volume: 39, no. 5
ISSN (Print): 0020-7543
Ratings:
BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
Construction of Product Models for the Development of Product Variants Specifications

General information
State: Published
Organisations: Department of Management Engineering, Technical University of Denmark
Contributors: Hvam, L., Mortensen, N. H., Malis, M.
Publication date: 2001

Host publication information
Title of host publication: Product Data Technology Europe 2002, 11th Symposium May 7-9 2002
URLs:
http://www.ipl.dtu.dk/publikation/6941/dk/
Source: orbit
Source-ID: 63067
Research output: Research - peer-review › Article in proceedings – Annual report year: 2001

Re-engineering of the quotation process - Application of knowledge-based systems

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., Riis, J., Malis, M., Hansen, B. L.
Publication date: 2001

Host publication information
Title of host publication: International Conference on Industrial Engineering and Production Management
URLs:
http://www.ipl.dtu.dk/publikation/6936/dk/
Source: orbit
Source-ID: 63062
Research output: Research - peer-review › Article in proceedings – Annual report year: 2001

Udvikling af tilbudsprocessen hos F.L.Smith

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., Malis, M., Hansen, B. L., Riis, J.
Publication date: 2001

Host publication information
Title of host publication: BPR i praksis
Place of publication: København
Publisher: Børsens Forlag A/S
Editor: B. L.
URLs:
http://www.ipl.dtu.dk/publikation/6890/dk/
Source: orbit
Source-ID: 63036
Research output: Research - peer-review › Book chapter – Annual report year: 2001

A Procedure for Building Product Models

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., Riis, J., Malis, M., Hansen, B. L.
Construction of Product Models for the Development of Specification Processes

**General information**
- State: Published
- Organisations: Department of Management Engineering
- Contributors: Hvam, L., Riis, J., Malis, M., Mertz, J., Hansen, B. L.
- Publication date: 2000

**Host publication information**
- Title of host publication: International ICSC Congress on Intelligent Systems and Applications, 11 - 15 December 2000
- URL: [http://www.ipl.dtu.dk/publikation/6935/dk/](http://www.ipl.dtu.dk/publikation/6935/dk/)
- Source: orbit
- Source-ID: 186877
- Research output: Research - peer-review › Article in proceedings – Annual report year: 2000

Industrialisering af Ingeniørarbejdet; Produktionsnyt

**General information**
- State: Published
- Organisations: Department of Management Engineering
- Contributors: Hvam, L.
- Pages: [0 pp.]
- Publication date: 2000
- Peer-reviewed: Unknown

**Publication information**
- Journal: Unknown title
- Original language: Danish
- URL: [http://www.ipl.dtu.dk/publikation/6962/dk/](http://www.ipl.dtu.dk/publikation/6962/dk/)
- Source: orbit
- Source-ID: 186885
- Research output: Communication › Journal article – Annual report year: 2000

Informations- og kommunikationsteknologi og produktionsledelse. Note vedr. ICT-støttet specifikation af produkter og produktionsgrundlag samt IT og produktion - udfordringer

**General information**
- State: Published
- Organisations: Department of Management Engineering
- Contributors: Vesterager, J., Hvam, L.
- Number of pages: 20
- Publication date: 2000

**Publication information**
- Publisher: IPL
- Original language: Danish
- URL: [http://www.ipl.dtu.dk/publikation/6956/dk/](http://www.ipl.dtu.dk/publikation/6956/dk/)
- Source: orbit
- Source-ID: 186882
- Research output: Education › Compendium/lecture notes – Annual report year: 2000
A procedure for Building Product Models
The application of product modeling in manufacturing companies raises the important question of how to model product knowledge in a comprehensible and efficient way. An important challenge is to qualify engineers to model and specify IT-systems (product models) to support their specification activities. A basic assumption is that engineers have to take the responsibility for building product models to be used in their domain. To do that they must be able to carry out the modeling task on their own without any need for support from computer science experts. This paper presents a set of simple, easily adaptable concepts and methods from data modeling (object oriented analysis) and domain modeling.
(product modeling). The concepts are general and can be used for modeling all types of specifications in the different phases in the product life cycle. The modeling techniques presented have been tested in different companies and have proved to work.

**General information**

State: Published  
Organisations: Department of Management Engineering  
Contributors: Hvam, L.  
Pages: 77-87  
Publication date: Feb 1999  
Peer-reviewed: Yes

**Publication information**

Journal: Robotics and Computer-Integrated Manufacturing  
Volume: 15  
Issue number: 1  
ISSN (Print): 0736-5845  
Ratings:

- BFI (2019): BFI-level 1  
- Web of Science (2019): Indexed yes  
- BFI (2018): BFI-level 1  
- Web of Science (2018): Indexed yes  
- BFI (2017): BFI-level 1  
- Scopus rating (2017): CiteScore 4.11 SJR 1.041 SNIP 2.681  
- Web of Science (2017): Impact factor 3.464  
- Web of Science (2017): Indexed yes  
- BFI (2016): BFI-level 1  
- Scopus rating (2016): CiteScore 4.13 SJR 1.275 SNIP 2.73  
- Web of Science (2016): Impact factor 2.846  
- BFI (2015): BFI-level 1  
- Scopus rating (2015): CiteScore 3.86 SJR 1.435 SNIP 3.027  
- Web of Science (2015): Impact factor 2.077  
- BFI (2014): BFI-level 1  
- Scopus rating (2014): CiteScore 3.66 SJR 1.689 SNIP 3.424  
- Web of Science (2014): Impact factor 2.305  
- BFI (2013): BFI-level 1  
- Scopus rating (2013): CiteScore 3.04 SJR 1.118 SNIP 3.01  
- Web of Science (2013): Impact factor 1.839  
- ISI indexed (2013): ISI indexed yes  
- BFI (2012): BFI-level 1  
- Scopus rating (2012): CiteScore 2.36 SJR 1.154 SNIP 2.921  
- Web of Science (2012): Impact factor 1.23  
- ISI indexed (2012): ISI indexed yes  
- BFI (2011): BFI-level 1  
- Scopus rating (2011): CiteScore 2.28 SJR 0.948 SNIP 2.377  
- Web of Science (2011): Impact factor 1.173  
- ISI indexed (2011): ISI indexed yes  
- BFI (2010): BFI-level 1  
- Scopus rating (2010): SJR 0.928 SNIP 2.246  
- Web of Science (2010): Impact factor 1.254  
- BFI (2009): BFI-level 1  
- Scopus rating (2009): SJR 1.099 SNIP 2.388  
- BFI (2008): BFI-level 1  
- Scopus rating (2008): SJR 0.767 SNIP 1.316  
- Scopus rating (2007): SJR 0.828 SNIP 1.762  
- Scopus rating (2006): SJR 0.957 SNIP 2.139  
- Scopus rating (2005): SJR 0.553 SNIP 1.675
Scopus rating (2004): SJR 0.603 SNIP 1.382
Scopus rating (2003): SJR 0.854 SNIP 1.091
Scopus rating (2002): SJR 0.544 SNIP 0.999
Scopus rating (2001): SJR 0.732 SNIP 0.851
Scopus rating (2000): SJR 0.268 SNIP 0.954
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.285 SNIP 0.87
Original language: English
Keywords: product modeling, object oriented modeling, feature modeling
DOIs:
10.1016/S0736-5845(98)00030-1
Source: orbit
Source-ID: 186864
Research output: Research - peer-review › Journal article – Annual report year: 1999

Agile Manufacturing

General information
State: Published
Organisations: Department of Industrial Management and Engineering
Contributors: Hvam, L.
Publication date: 1999

Host publication information
Title of host publication: The Industrial Engineering Encyclopedia
Place of publication: Cincinatti
Source: orbit
Source-ID: 314744
Research output: Research - peer-review › Book chapter – Annual report year: 1999

CRC-card for product modelling

General information
State: Published
Organisations: Department of Manufacturing Engineering
Contributors: Hvam, L., Riis, J.
Publication date: 1999

Host publication information
Title of host publication: CRC-card for product modelling
Source: orbit
Source-ID: 174269
Research output: Research - peer-review › Article in proceedings – Annual report year: 1999

CRC-cards for product modelling

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., Riis, J.
Publication date: 1999

Host publication information
Title of host publication: The 4th Annual International Conference on Industrial Engineering Theory, Applications and Practice
Publisher: Udefineret
URLs:
http://www.ipl.dtu.dk/publikation/6933/dk/
Source: orbit
Source-ID: 186875
Research output: Research - peer-review › Article in proceedings – Annual report year: 1999

General information
State: Published
Organisations: Department of Manufacturing Engineering
Contributors: Hvam, L.
Publication date: 1999

Publication information
Original language: Danish
Source: orbit
Source-ID: 174286
Research output: Research - peer-review ▶ Book – Annual report year: 1999

Produktmodellering I + II - Dokumentation til eksternt kursus Produktmodellering

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., al, E.
Number of pages: 300
Publication date: 1999

Publication information
Publisher: IPL
Original language: Danish
URLs:
http://www.ipl.dtu.dk/publikation/6954/dk/
Source: orbit
Source-ID: 186880
Research output: Education ▶ Compendium/lecture notes – Annual report year: 1999

Strategic Guidelines for Application of Product Models

General information
State: Published
Organisations: Department of Manufacturing Engineering
Contributors: Hvam, L., Hansen, B. L., Riis, J.
Publication date: 1999

Host publication information
Title of host publication: The 4th Annual International Conference on Industrial Engineering Theory, Applications and Practice
Source: orbit
Source-ID: 186874
Research output: Research - peer-review ▶ Article in proceedings – Annual report year: 1999

Agile Manufacturing: En rejserapport fra USA

General information
State: Published
Organisations: Department of Industrial Management and Engineering
Contributors: Hvam, L.
Pages: 55-70
Publication date: 1998

Host publication information
Title of host publication: Driftsteknikerbogen
Place of publication: Lyngby
Publisher: IPV
Source: orbit
A Line of Procedure for Application of Product Modelling

General information
State: Published
Organisations: Department of Industrial Management and Engineering
Contributors: Hvam, L.
Publication date: 1998
Peer-reviewed: Yes

Publication information
Journal: Computers & Industrial Engineering
ISSN (Print): 0360-8352
Ratings:
BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.8 SJR 1.463 SNIP 1.781
Web of Science (2017): Impact factor 3.195
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.41 SJR 1.484 SNIP 1.793
Web of Science (2016): Impact factor 2.623
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 3.13 SJR 1.458 SNIP 1.921
Web of Science (2015): Impact factor 2.086
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.8 SJR 1.38 SNIP 1.956
Web of Science (2014): Impact factor 1.783
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.81 SJR 1.51 SNIP 2.044
Web of Science (2013): Impact factor 1.69
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.78 SJR 1.503 SNIP 2.066
Web of Science (2012): Impact factor 1.516
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.92 SJR 1.596 SNIP 2.002
Web of Science (2011): Impact factor 1.589
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.21 SNIP 1.473
Web of Science (2010): Impact factor 1.543
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.055 SNIP 1.714
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.061 SNIP 1.457
Scopus rating (2007): SJR 0.85 SNIP 1.353
Web of Science (2007): Indexed yes
An Introduction to Agile Manufacturing

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L.
Publication date: 1998

Host publication information
Title of host publication: The Industrial Engineering Encyclopaedia, University of Cincinnati
Editor: U. O. C.
URLs:
http://www.ipl.dtu.dk/publikation/6889/dk/
Source: orbit
Source-ID: 186861
Research output: Research - peer-review › Book chapter – Annual report year: 1998

Concepts and Methods for Identifying Features and Building Product Models

General information
State: Published
Organisations: Department of Manufacturing Engineering
Contributors: Hvam, L.
Publication date: 1998
Peer-reviewed: No

Publication information
Journal: Computers & Industrial Engineering
Original language: English
Source: orbit
Source-ID: 176161
Research output: Research › Journal article – Annual report year: 1998

Re-engineering the Specification Process

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., Have, U.
Pages: 25-43
Publication date: 1998
Peer-reviewed: Yes

Publication information
Journal: Business Process Management Journal
Volume: 4, No 1
ISSN (Print): 1463-7154
Ratings:
The Rulers Factory: a Tool for Learning Product Modeling Techniques

General information
State: Published
Organisations: Department of Industrial Management and Engineering
Contributors: Hvam, L.
Pages: 29-32
Publication date: 1998

Host publication information
The Rulers Factory - A Tool for Learning Product Modelling Techniques

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L.
Publication date: 1998

Host publication information
Title of host publication: 23rd International Conference on Computers & Industrial Engineering
URLs:
http://www.ipl.dtu.dk/publikation/6925/dk/
Source: orbit
Source-ID: 186869
Research output: Research - peer-review › Article in proceedings – Annual report year: 1998

Agile Manufacturing - En rejserapport fra USA

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L.
Publication date: 1997

Host publication information
Title of host publication: Driftsteknikerdagen 11. marts 1998
URLs:
http://www.ipl.dtu.dk/publikation/6924/dk/
Source: orbit
Source-ID: 186868
Research output: Research - peer-review › Article in proceedings – Annual report year: 1997

Developing the specification process - lecture note for the course Manufacturing and Methods Engineering 83284

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., Have, U.
Number of pages: 23
Publication date: 1997

Publication information
Original language: English
URLs:
http://www.ipl.dtu.dk/publikation/6953/dk/
Source: orbit
Source-ID: 186879
Research output: Education › Compendium/lecture notes – Annual report year: 1997

Modeling Agility in the Supply Chain: Beskrivelse af model for analyse af forsyningskæder

General information
State: Published
Organisations: Department of Industrial Management and Engineering
Contributors: Hvam, L.
Number of pages: 48
Modelling Agility in the Supply Chain - An analysis tool for analysing agility in the supply chains

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., Knies, D. B.
Number of pages: 48
Publication date: 1997

Opgavebegrebet - Note til kurset Produktions- og materialestyring 8388

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L.
Number of pages: 13
Publication date: 1997

Re-engineering af specifikationsaktiviteter hos IBM-SMS

General information
State: Published
Organisations: Department of Management Engineering
Contributors: Hvam, L., Have, U.
Publication date: 1997

Host publication information
Title of host publication: Driftsteknikerdagen 12. marts 1997
URLs:
http://www.ipl.dtu.dk/publikation/6923/dk/
Source: orbit
Source-ID: 186867
Research output: Research - peer-review › Article in proceedings – Annual report year: 1997

Reengineering af specifikationsaktiviteter hos IBM-SMS

General information
State: Published
Organisations: Department of Industrial Management and Engineering
Contributors: Hvam, L., Have, U.
Re-engineering caused by ISO-9000 certification

Based on a project performed at a medium-sized producer of medical utensils, reviews some of the problems which the company experienced in connection with the system built up during ISO 9001 certification, and the re-engineering efforts which were performed in order to relieve these problems. Focuses in particular on a re-structuring of the company’s system for production documentation and its relation to the traceability of their products. This system was radically altered during the project without the traceability requirements being violated or reduced. These changes resulted in a marked increase in productivity.
Application of product modelling - seen from a work preparation viewpoint

Manufacturing companies spend an increasing amount of the total work resources in the manufacturing planning system with the activities of e.g. specifying products and methods, scheduling, procurement etc. By this the potential for obtaining increased productivity moves from the direct costs in the production to the indirect costs in the manufacturing planning system.

This Ph.D.-project consider information technology (IT) to be an important means for obtaining increased productivity and efficiency in these functions. The project focuses on the use of IT to support the activities of specifying products and methods, as only a minor part of the engineering work in these functions in the planning system until now has been supported with IT. The aim is to develop methods for analysing which activities to support with IT, and in relation to this, define context and structure of the IT-systems to support the specification work.

The theoretical fundament of the project include four elements. The first element (work preparation) consider methods for analysing and preparing the direct work in the production, pointing to an analogy between analysing the direct work in the production and the work in the planning systems. The other element covers general techniques for analysing and
modeling knowledge and information, with special focus on object oriented modeling. The third element covers four different examples of product models. The product models are viewed as reference models for modeling knowledge and information used for specifying products and methods. The last element attach to the use of the task concept viewed as a means for expressing the demands to a given system in the company. In this case, systems for specifying products and methods. Based on the referred theory, the project provides a line of procedure for developing systems to support the specification activities in the company using product models. The first phase in the procedure contain an analysis of the task of the system (called the product and methods specification task) leading to a definition of the context and structure of the system in the specific company. The following phases are based on the use of object oriented mode-ling and follow in outline the object oriented project life cycle. The empirical work in the project, carried out at Alfa Laval Separation A/S, covers all the phases in the line of procedure from analysing the task of the system, over building a model, and to the final programming of an application. It has been stressed out to carry out all the phases in the outline of procedure in the empirical work, one of the reasons being to prove that it is possible, with a reasonable consumption of resources, to build an application to support a part of the specification work in the company.

General information
State: Published
Organisations: Department of Industrial Management and Engineering
Contributors: Hvam, L., Vesterager, J.
Number of pages: 219
Publication date: 1996

Publication information
Publisher: Technical University of Denmark (DTU)
ISBN (Print): 87-985169-1-4
Original language: English
(IPV Publication; No. 96.13-A).
Electronic versions:
PhD_Lars_Hvam.pdf
Source: PublicationPreSubmission
Source-ID: 92112489
Research output: Research › Ph.D. thesis – Annual report year: 1996

Produktdatastyring: Note til kurset 8390 Styring af produktinnovation

General information
State: Published
Organisations: Department of Industrial Management and Engineering
Contributors: Hvam, L.
Number of pages: 13
Publication date: 1996

Publication information
Original language: Danish
Source: orbit
Source-ID: 164856
Research output: Research - peer-review › Book – Annual report year: 1996

Re-engineering affødt af ISO-9000 certificering

General information
State: Published
Organisations: Department of Industrial Management and Engineering
Contributors: Munk, B., Nielsen, A. P., Hvam, L., Bjarnø, O.
Pages: 83-98
Publication date: 1996

Host publication information
Title of host publication: Re-engineering affødt af ISO-9000 certificering
Place of publication: Lyngby
Publisher: Institut for Produktions- og Virksomhedsledelse, DTU
Source: orbit
Source-ID: 164855
Research output: Research - peer-review › Book chapter – Annual report year: 1996
**Anvendelse af produktmodellering - set ud fra arbejdsforberedelsessynsvinkel**

Manufacturing companies spend an increasing amount of the total work resources in the manufacturing planning system with the activities of e.g. specifying products and methods, scheduling, procurement etc. By this the potential for obtaining increased productivity moves from the direct costs in the production to the indirect costs in the manufacturing planning system. This Ph.D.-project considers information technology (IT) to be an important means for obtaining increased productivity and efficiency in these functions. The project focuses on the use of IT to support the activities of specifying products and methods, as only a minor part of the engineering work in these functions in the planning system until now has been supported with IT. The aim is to develop methods for analysing which activities to support with IT, and in relation to this, design context and structure of the IT-systems to support the specification work. The theoretical fundament of the project includes four elements. The first element (work preparation) considers methods for analysing and preparing the direct work in the production, pointing to an analogy between analysing the direct work in the production and the work in the planning systems. The other elements cover general techniques for analysing and modelling knowledge and information, with special focus on object-oriented modelling. The third element covers four different examples of product models. The product models are viewed as reference models for modelling knowledge and information used for specifying products and methods. The last element attaches to the use of the task concept viewed as a means for expressing the demands to a given system in the company. In this case, systems for specifying products and methods.

Based on the referred theory, the project provides a line of procedure for developing systems to support the specification activities in the company using product models. The first phase in the procedure contain an analysis of the task of the system (called the product and methods specification task) leading to a definition of the context and structure of the system in the specific company. The following phases are based on the use of object-oriented modelling and follow in outline the object-oriented project life cycle. The empirical work in the project, carried out at Alfa Laval Separation A/S, covers all the phases in the line of procedure from analysing the task of the system, over building a model, and to the final programming of an application. It has been stressed out to carry out all the phases in the outline of procedure in the empirical work, one of the reasons being to prove that it is possible, with a reasonable consumption of resources, to build an application to support a part of the specification work in the company.
**Conceptual modeling of transportation and IT services for configuration systems**

Bayer, M., PhD Student, Department of Management Engineering  
Hvam, L., Main Supervisor, Department of Management Engineering  
Herbert-Hansen, Z. N. L., Supervisor, Department of Management Engineering  
Hove, C., Supervisor  
Industrial PhD  
01/03/2018 → 28/02/2021  
Award relations: Conceptual modeling of transportation and IT services for configuration systems  
Project: PhD

**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 Architects 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 Architects 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

**How to improve the utilization of a Configuration Lifecycle Management (CLM) system**

The aim of the post-doc project is to add to the theory on scoping and setting up Configuration Lifecycle Management (CLM) systems and to study the potential benefits of applying them. A CLM-system supports the management of multi-model configurations, as it covers the application of product configuration in all the different life cycle phases of a complex and highly engineered product.

Myrodia, A., Project Participant, Department of Management Engineering, Management Science, Engineering Design and Product Development, Operations Management  
Hvam, L., Supervisor, Department of Management Engineering, Management Science, Operations Management  
Randrup, T., Supervisor, Configit A/S  
14/08/2017 → 14/02/2020  
Collaborators: Configit A/S
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
Project: PhD

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
Forskningsrådssamarbejdssatser 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

Udvikling af systemleverancer hos entreprenører
Kudsk, A., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Thuesen, C., Supervisor, Department of Management Engineering
Jespersen, S. C., Examiner
Vibek, K. S., Examiner
ErhvervsPhD-ordningen VTU
01/01/2010 → 22/11/2013
Award relations: Udvikling af systemleverancer hos entreprenører
Project: PhD

Produktmodellering i virksomhedsnetværk
Malis, M., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Jacobson, L. J., Examiner
Olsen, R. F., Examiner
Samarbejdsforskningsfond
01/01/2001 → 09/01/2006
Award relations: Produktmodellering i virksomhedsnetværk
Project: PhD

Anvendelse af produktmodeller set udfra et styringsmæssigt synspunkt
Svensson, C., PhD Student, Department of Management Engineering
Barfod, A., Main Supervisor, Department of Management Engineering
Hvam, L., Supervisor, Department of Management Engineering
Hvolby, H. H., Examiner
Gulledge, Jr., T. R., Examiner
Michelsen, A. U., Examiner, Department of Management Engineering
Friplads
15/03/2000 → 27/06/2003
Award relations: Anvendelse af produktmodeller set udfra et styringsmæssigt synspunkt
Project: PhD

Modellering af ingeniørviden
Riis, J., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Barfod, A., Examiner, Department of Management Engineering
Hildre, H. P., Examiner
Jensen, L. J., Examiner
Offentlig finansiering
01/02/1999 → 27/06/2003
Award relations: Modellering af ingeniørviden
Project: PhD

Bæredygtig produktion og logistik baseret på Cradle to Cradle princippet
Larsen, S. B., PhD Student, Center for Bachelor of Engineering Studies
Jacobsen, P., Main Supervisor, Department of Management Engineering
Akkerman, R., Supervisor, Department of Management Engineering
Hvam, L., Examiner, Department of Management Engineering
Bilberg, A., Examiner, Department of Manufacturing Engineering
Olhager, J. E., Examiner
Olhager, J. E., Examiner
Institut stipendie (DTU)
01/02/2013 → 04/12/2017
Award relations: Bæredygtig produktion og logistik baseret på Cradle to Cradle princippet
Project: PhD

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
Wörôsch, M., Examiner, Department of Management Engineering
Malmqvist, J., Examiner
Weber, C., Examiner
ErhvervsPhD-ordningen VTU
01/01/2013 → 04/07/2016
Award relations: Håndtering af interfaces i højkomplekse og multidisciplinære produkter
Project: PhD

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

Complexity Management at Rockwool
Trattner, A. L., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Andersen, B. R., Supervisor
Herbert-Hansen, Z. N. L., Supervisor, Department of Management Engineering
Industrial PhD
01/10/2015 → 30/03/2019
Award relations: Complexity Management at Rockwool
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 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, E., Examiner
Vareilles, E., Examiner
Industrial PhD
01/05/2014 → 21/09/2017
Award relations: Conceptual Modelling for Product Configuration Systems
Project: PhD

Management of business processes for global ERP implementations
Rahimi, F., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Haug, A., Supervisor, Department of Management Engineering
Møller, C., Supervisor
Jacobsen, P., Examiner, Department of Management Engineering
Drews, P., Examiner
Tambo, T., Examiner
ErhvervsPhD-ordningen VTU
01/05/2012 → 01/09/2016
Award relations: Management of business processes for global ERP implementations
Project: PhD

Business Intelligence i Engineeringvirksomheder
Ulicht Copenhagen, 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
Sunnersjö, S., Examiner
Jensen, L. J., Examiner
Sunnersjö, S., Examiner
**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., Supervisor
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
Project: PhD

**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
Project: PhD

**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
Project: PhD

**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
Project: PhD

**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
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 Mechanical 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

Informationsteknologi i den tekniske styring
Hvam, L., PhD Student, Department of Management Engineering
Vesterager, J., Main Supervisor, Department of Management Engineering
Forskningsrådene via projektbe
01/11/1991 → 23/01/1995
Award relations: Informationsteknologi i den tekniske styring
Project: PhD

Brug af ny teknologi af logistik og servicesystemer i sundhedssektoren
Jørgensen, P. M. T., PhD Student, Department of Management Engineering
Jacobsen, P., Main Supervisor, Department of Management Engineering
Hvam, L., Examiner, Department of Management Engineering
Bilberg, A., Examiner
Ceglarek, D. J., Examiner
Institut, samfinansiering
01/06/2010 → 20/09/2013
Award relations: Brug af ny teknologi af logistik og servicesystemer i sundhedssektoren
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
Indlejret produktkonfigurering (Embedded product configuration)
Haug, A., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Jensen, L. J., Examiner
Hildre, H. P., Examiner
DTU-lønnet stipendie
01/01/2005 → 04/07/2008
Award relations: Indlejret produktkonfigurering (Embedded product configuration)
Project: PhD

Udvikling af specifikationssystemer
Hansen, B. L., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Barfod, A., Examiner, Department of Management Engineering
Hvolby, H. H., Examiner
Mikkelsen, H., Examiner
DTU-lønnet stipendie
01/01/1999 → 12/02/2004
Award relations: Udvikling af specifikationssystemer
Project: PhD

Technology and Logistics in Health Care
Feibert, D. C., PhD Student, Department of Management Engineering
Jacobsen, P., Main Supervisor, Department of Management Engineering
Hvam, L., Examiner, Department of Management Engineering
Hald, K. S., Examiner
Åhlström, P., Examiner
Samfinansierede - Virksomhed
01/01/2014 → 30/09/2017
Award relations: Technology and Logistics in Health Care
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
Welo, T., Examiner
Malmqvist, J., Examiner
Welo, T., Examiner
Institut stipendie (DTU) Samf.
01/01/2011 → 23/02/2015
Award relations: Udvikling af mekatroniske platforme
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

**Advanced planning approaches for small- and medium-sized enterprises**

Herczeg, G., PhD Student, Department of Management Engineering
Hauschild, M. Z., Main Supervisor, Department of Management Engineering
Akkerman, R., Supervisor, Department of Management Engineering
Jacobsen, P., Supervisor, Department of Management Engineering
Jensen, P. L., Supervisor, Department of Management Engineering
Hvam, L., Examiner, Department of Management Engineering
Govindan, K., Examiner
Olhager, J. E., Examiner
Institut stipendie (DTU)
01/12/2011 → 04/07/2016
Award relations: Advanced planning approaches for small- and medium-sized enterprises
Project: PhD

**New Product Start Up in Pharmaceutical Production**

Hansen, K. R. N., PhD Student, Department of Management Engineering
Hvam, L., Main Supervisor, Department of Management Engineering
Akkerman, R., Supervisor, Department of Management Engineering
Gani, R., Supervisor
Grunow, M., Supervisor, Department of Management Engineering
Jacobsen, P., Examiner, Department of Management Engineering
Jósef, V., Examiner
Olhager, J. E., Examiner
Institut stipendie (DTU)
01/09/2009 → 21/02/2014
Award relations: New Product Start Up in Pharmaceutical Production
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

Product specification systems: Economics, Technology and Organisation
Product specification systems: Economics, Technology and Organisation (ProSSETO) The project was started the 1st of February 2003 and is funded by the Danish Technical Research Council (http://www.forsk.dk/eng/stvf/index.htm), the project ends the 31st December 2004. The Danish Technical Research Council has generously donated 2 million DKK covering four man-years plus expenses. It is the purpose of the project to develop knowledge about the use of product specification systems perceived as a combination of technical, economic, and organisational factors. The project has put forth the hypothesis that interplay between these three factors is crucial for realizing benefits from implementing product specification systems with regard to technical functionality, competitiveness and work environment. The project will further shed light on the radical organisational changes resulting from implementing a product specification system. The research is conducted by a team of 6 researchers with experience and competence in the areas of economics, organisation and the technical aspects of product specification systems. The project is headed by Associate Professor Lars Hvam email: lhv@ipl.dtu.dk whom together with Assistant Professor Jesper Riis, email jri@ipl.dtu.dk represents the technical perspective. The Economic perspective is contributed by Associate Professor Jørgen Lindgaard Pedersen, email: jlp@ipl.dtu.dk and Assistant Professor Kasper Edwards, email: ke@ipl.dtu.dk. The organisational perspective is provided by Associate Professor Niels Møller, email nm@ipl.dtu.dk and Research Assistant Morten Møldrup, email: mmd@ipl.dtu.dk.
Hvam, L., Project Manager, Department of Management Engineering
Pedersen, J. L., Project Participant, Department of Management Engineering
Møller, N., Project Participant, Department of Management Engineering
Edwards, K., Project Participant, Department of Management Engineering
Riis, J., Project Participant, Department of Management Engineering
Møldrup, M., Project Participant, Department of Management Engineering
Forskningsrådene - STVF: DKK2,000,000.00
01/01/2003 → 01/12/2004
Award relations: Product specification systems: Economics, Technology and Organisation
Project: Research

Research in System Deliveries within Construction
Formålet med projektet er at afdække de væsentligste forskningsopgaver i forhold til at muliggøre og afklare hensigtsmæssigheden af brugen af systemleverancer indenfor byggeriet. Projektet er således et forprojekt til en eventuel igangsættelse af forskning indenfor systemleverancer i byggeriet. Det langsigtede mål med denne forskning er at sikre det nødvendige vidensgrundlag for en udvikling af byggeriet gennem brug af systemleverancer.
Hvam, L., Project Manager, Department of Mechanical Engineering, Manufacturing Engineering
Tølle, M., Project Participant, Department of Mechanical Engineering, Manufacturing Engineering
Thomassen, M., Project Participant, Department of Mechanical Engineering, Manufacturing Engineering
Møller, N., Project Participant, Department of Management Engineering
Riis, J., Project Participant, Department of Management Engineering
Møldrup, M., Project Participant, Department of Management Engineering
Forsk. Private danske - Fonde: DKK800,000.00
01/09/2005 → 01/03/2006
Collaborators: Byggeriets Innovation
Award relations: Research in System Deliveries within Construction
Project: Research

Systemleveraner i byggeriet - et forskningsnetværk
Projektformål. Projektets formål er, at udvikle og formidle ny viden indenfor nyindustri produceret arkitektur og byggeri i Danmark via fokus på udvikling af systemleverancer. Den nyeste teknologi vil blive inddraget og udnyttet, og der vil blive fokuseret på design, bæredygtighed, samt nye produktionsmåder og organisationsformer - både på det arkitektoniske, det produktionsmæssige og det forretningsmæssige felt. Systemleverancer skal i denne sammenhæng forstås bredt: der skal arbejdes med udvikling af teori, metoder og konkrete projekter fra "delsystemer", over "rumlige systemer" til
Application of product models in extended enterprises

The research area of the project is the creation and implementation of product models in two different companies, comprising the use of product models to an enhanced co-operation between the company and its suppliers/customers. In order to give a broad perspective of this research area two companies are included in the project. Product models will be studied from two different angles; from the sales force point of view (Niro) and from the developer (Danfoss) point of view. The project aims at using the existing, on-going research at IPT and IP, through additional funding from CIP, as a foundation for a fast development and implementation in Danish Industry. The purpose is to set up methods and guidelines for building advanced product models that can be utilised between companies within a network. The project aims at the content of product models as the foundation for integration of critical engineering tasks. Further, the project aims at a fast implementation of product models in the participating companies. This is done partly in order to ensure a rapid progress in the companies and partly in order to make it possible to study the impacts on the business processes within the companies as well as the organisational changes. Also the strategic opportunities and limitations will be studied. The project contributes to the uncovering of the contingency factors that determine the efficiency and effectiveness of the companies in different phases of a product realization process when working in distributed networks.

Procedure for building product models, Ph.d. student Jesper Riis

The research purpose of this Ph.d. project is to develop a procedure for the construction of product models. The procedure consists of the analysis and formalisation of domain expert knowledge for construction, object oriented modelling, software for the construction/implementation of product models, how product models are completed and implemented in the existing IT systems of a company, and the maintenance and continued development of product models.

Development of specification systems, Ph.d. student Benjamin Loer Hansen

The purpose of this Ph.D.project is to develop procedures for the development of the specification process, to develop methods for the analysis and description of the functional demands on the specification process, to develop structural characteristics of description and examples of structural elements of solution.

Centre for Industrialisation of Engineering

In Center for Industrialisation of Engineering (IaIa) we work with the modelling of engineering product knowledge. By incorporating knowledge of e.g. product construction, function, production, transport, installation, use etc. in a product model, this knowledge becomes accessible to others, and can more easily be shared with other actors, in-house as well as with customers and suppliers.

Engineering of engineering systems

Characteristic key words and challenges for this field are: from marketing of products to sale of customer-specific solutions (agile production); variant explosion; mass-produced one-of-a-kind units; the engineer as model manager; IT supported Concurrent Engineering; BPR of the product specification system or of technical order handling system. In recent years a number of production companies are facing the fact that an increasing part of the company’s manpower resources are being used for specification of the product and its manufacturing process (engineering of the product). At the same time
many companies realise that a considerable amount of rationalisation potential is to be found in the restructuring of specification work, in this connection in supporting parts of the specification work with IT. At an international level extensive research goes on as regards development of IT-supported product life-cycle engineering (e.g. product and facility models, STEP, CALS). Research at IPV (Department of Industrial Management and Engineering) is performed on the basis of - and aims at combining - various theoretical fields, including the task concept (Skinner), Business Process Reengineering, work analysis, the feature concept, product modelling and object-oriented analysis. In this project one issue is the formulation of procedures for reengineering of specification work, including possible IT implementation of product and production models. This through development of concepts and methods for analysis of the specification work in the individual company, and development of matching methods for identification of activities to support by product model based IT applications. Recent research: 4 Ph.D. projects and participation in various international research activities, including GLOBEMAN 21 (Global Manufacturing in the 21st Century, the IMS project), PDTAG (Product Data Technology Advisory Group, ESPRIT 9049) and ESoCE (European Society of Concurrent Engineering).

Vesterager, J., Project Manager, Department of Industrial Management and Engineering
Hvam, L., Project Participant, Department of Industrial Management and Engineering
Claussen, J., Project Participant, Department of Industrial Management and Engineering
Christiansen, K., Project Participant, Department of Industrial Management and Engineering
Jonsdottir, S., Project Participant, Department of Industrial Management and Engineering
Kirkby, L. P., Project Participant, Department of Industrial Management and Engineering

01/01/1997 → …

Project: Research

**Business Process Reengineering at F.L. Smith & Co. - reengineering the sales process**

To an engineering to order (ETO)/make to order (MTO) company the sales process is of major importance to the company's competitiveness. The project has used the management paradigm "Business Process Reengineering" (BPR). Based on BPR a procedure for reengineering the sales process has been developed. The procedure Sales Process Reengineering (SPR) prescribes a way to perform a complete reengineering of the sales process based on the use of a new methodology "Product modelling" and the new technology "Product configurators". The project has been carried out in cooperation with the company F.L. Smith & Co. In the project an integrated product model and a sales configurator prototype have been developed in order to achieve an efficient and correct bid on a cement factory. The development of the prototype was based on the sales configurator SalesPLUS from the company Beologic.

Hvam, L., Project Manager, Department of Industrial Management and Engineering
Vesterager, J., Project Participant, Department of Industrial Management and Engineering

01/02/1997 → 31/01/1998

Project: Research

**Modeling Agility in the Supply Chain**

In this project a tool has been developed for use in analyzing supply chains and establishing overall pictures of the supply chain. The supply chain models are constructed primarily from the viewpoint of agile manufacturing by means of a robust set of characteristics and metrics which together reflect agility. The tool and model deal with customer - supplier characteristics such as: · The Agility -- along four strategic dimensions -- of the companies in the supply chain. · The economic importance -- value adding -- for each individual company in the supply chain. · The use of Information Technology (IT), in terms of breadth of information exchanged, sophistication and interoperability. · The strength and durability of relationships among companies in the supply chain. · Material flow in the supply chain. · Cash flow in the supply chain. · Lead times and on time delivery in the supply chain. The front end of the modeling process employs a simple, and easy to implement, template for characterizing a supply chain. The initial application of the modeling tool focuses on companies that deal with engineered products. This has enabled us to include the multidirectional flow of engineering knowledge, information, and data between companies in a supply chain. The tool enables the production of three complementary "pictures" of the supply chain as described below: 1. An overall view of the supply chain including indices on the client, customer and vendor companies regarding relative value added to the supply chain, relationship, Agility and IT-level. The links are described and indexed with respect to the IT-capability level of the link. 2. A view describing detailed information flow within the supply chain. 3. A view defining the flow of material and money in the supply chain. In addition to the diagrams, detailed reports are generated regarding business characteristics of the individual companies, as well as the total supply chain.

Hvam, L., Project Manager, Department of Industrial Management and Engineering

10/06/1997 → 12/12/1997

Project: Research

**System products in the Building Industry**

The project aims at defining the concept systems products in the building industry by use of examples from the business industry and related industries

Hvam, L., Project Manager, Department of Management Engineering
Telle, M., Project Participant, Department of Management Engineering

Ukendt: DKK200,000.00

01/11/2004 → 01/04/2005
**User Supportive Embedded Configuration**

Configuration is the technical term for the problem of selecting values for a set of parameters. The purpose of configuration is typically to setup digital equipment to behave according to user requirements or to specify needs in a software system. Common examples of configuration situations from everyday life is setting up the video-recorder at home or setting up the alarm system at work. In commerce, configuration arises for instance in tailoring a product to a customer's needs such as a PC, or in tailoring a service such as a travel. In industry, the configuration problems are even more complex than what most consumers’ experience. Modern industrial equipment is facing configuration tasks with hundreds of parameters. Today's business software has thousands of parameters that influence its behaviour. The situation is that configuration is an omnipresent problem in many disguises. The goal of this project is to look beneath the disguises and contribute in three areas: to develop user interfaces suited for solving configuration tasks, to develop methods for describing product models, and to develop the basic algorithms needed for constructing configuration software that supports users in performing intuitive and error-free configurations. The three areas will be addressed by research in user-centred design, product modelling, and configuration technology. The project will focus on embedded configuration, where knowledge and rules about how a product may be configured is embedded in the product itself. Traditionally the specification of valid product configurations has been separated from the products themselves and the process of transferring knowledge about valid setup and installation from product specialists to other functions in a company, partners and end-users has been costly, error prone and time consuming. Embedded configuration eliminates the information gap between product specialists and other users of the product. Embedded configuration is to be based on a product model that captures the relevant knowledge about the product. The product model is made operational in the product as a guidance tool using a generic configuration engine and thereby turning the complex problem of configuration into an integral part of the product and the value obtained by it. In order to ensure that the guidance of the user interface is supportive in the configuration process, an approach based on analyzing the user's work processes must be taken.

Hvam, L., Project Manager, Department of Management Engineering Forskningsrådene - STVF: DKK4,600,000.00 01/09/2004 - 01/09/2008 Award relations: User Supportive Embedded Configuration Project: Research

**Product configuration in the construction sector**

The primary objective of this project is to increase the productivity and quality of the Danish building industry by the application of product configuration to support a number of different processes in the building industry. In collaboration with a number of manufacturers of products for the building industry electronic models of their respective building components will be constructed. Based on the product programme of the companies involved the models will be constructed with a view to achieving two objectives: The first objective is directed towards the outside, towards projecting architects and performing contractors. Thus, architects are to be able to apply the electronic models directly during the execution of their architecture projects, both for sketching, visualization, and projecting. The contractors are to be able to use the models in connection with pricing and different kinds of simulation: construction and logistics, etc. The second objective is directed towards the inside, towards the internal procedures of the manufacturing firms. Here, the purpose is to enhance the efficiency of and rationalize the procedures in connection with the elaboration of the production basis, list of parts, pricing and quotations. In order to achieve the above objectives the electronic models will be made parametric and configurable, meaning that the models are constructed as “intelligent” electronic building components in which are encoded the engineer expert knowledge of the manufacturing firms. If, for example, a parametric and configurable model of a concrete staircase is elaborated, the computer will, after the encoding/entering of various parameters (width of staircase, floor-to-ceiling height, materials character, banister type, etc.), automatically create a 3-D model of the staircase. The engineer expert knowledge about minimum materials thickness, quantity of steel reinforcement, appropriateness between the foundation of the staircase, its rise, etc., information that is entered in advance, ensures that the staircase can be produced and used. When the model has been configured it thus returns direct information about volume, number of incoming units, weight, etc., which facilitates the act of pricing. The way in which the project has been planned ensures that the manufacturing firms participating in the research collaboration cover all areas are representative of various areas of the building industry, so that models of all the building components included in a building project as a whole are constructed. Through the construction of models of this whole the process is being stimulated towards an application of the sophisticated electronic tools that we posses today, but which have difficulties in penetrating the market of the Danish building industry in general. The reason for establishing this research project and the collaboration with the building industry parties are the important changes that the building industry is going through at present. The trend within the building industry is towards new-industrialisation, which means that from being a trade based on craftsmanship where relatively much time was spent on the adaptation of many different building materials on the building site, with subsequent risks of errors and logistics difficulties, the trend is now towards geometrically precise, finished building components that are brought to the building site and assembled without craftsmanship adaptation. The application of product configuration offers a considerable optimisation of the building process, quality assurance, time frame, and thereby the financial management. The research project is primarily based on the know-how of the Technical University of Denmark within the area of configuration of product models (contact person: Associate Professor Lars Hvam) and of the Aarhus School of Architecture within the area of parametric building components.
Hvam, L., Project Manager, Department of Management Engineering
Forskningsprojekter - Erhvervsministeriet: DKK1,385,000.00
01/11/2003 → 01/05/2005
Award relations: Product configuration in the construction sector
Project: Research

Press clippings:

Automatic design system saves millions
Lars Hvam & Niels Henrik Mortensen
18/08/2018

Description
Three years ago, it used to take Haldor Topsee 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
Three years ago, it used to take Haldor Topsee one week to design a customized solution for a customer. It can now be done in ten minutes.
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Press/Media: Press / Media