IMPLEMENTING PRODUCT PLATFORMS: A CASE STUDY

Fiil-Nielsen O., Mortensen N.H. - *Technical University of Denmark (DNK)* 823

The paper describes a case study dealing with the process of creating and implementing a product platform. The paper espessially deals with the fact that to obtain the benefits of platforms a permanent change in behaviour in product development must be ensured. This change in behaviour requires acceptance and approval from the organisation in general and the commitment from management to enforce agreed-upon decisions. The case study itself was performed in the Danish company LEGO Group. The case study had two objectives: To create a technical architecture and align this architecture with the manufacturing setup; And to create procedures for using and maintaining the system and getting the commitment and approval of the platform.

INTEGRATED AND CONFIGURABLE PRODUCT AND MANUFACTURING SYSTEM MODELS

Claesson A., Johannesson H. - *Saab Automobile AB (SWE)* 791

Many automotive companies are developing products using a platform approach. This approach puts new requirements on product and process modeling and the design methods employed. This paper presents an approach to support platform based product development through an integrated and configurable product and manufaturing system model. This modeling approach is also put into the larger context of the company through an outline of an integrated view of the three domains: product, manufacturing, and sales & marketing. The described approach is based on the concept of configurable components as the core element in the model providing for modeling of the required product variety of a platform.

PRODUCT FAMILY DESIGN FROM A MANUFACTURING POINT OF VIEW

Jensen T., Hildre H.P. - *NTNU (NOR)* 863

Highly competitive global markets force companies to change their way of doing business. A major trend designing product families is an increased interest in using product platforms, to increase the reuse in the design processes and of components. Product platform is well established for configurable products, but not in the same degree for nonconfigurable products. To change a product family over to a product platforms design there is a need to visualise and understand the evolution of the existing products. This article present a model to visualise the evolution of a nonconfigurable product family, based upon the industrial processes. It also discusses how the launch of industrial processes affects the organisation resources.

PLATFORM EVALUATION USING EXCPLICIT MODELLING: A CASE STUDY

Munk L., Mortensen N.H. - *Technical University of Denmark (DNK)* 951

Platform evaluation methods are often based on indices rather than modelling of measurable consequences, which inhibits the decision making process. This case study shows benefits from using explicit modelling of critical parameters in the evaluation process in a platform project in the LEGO Group. Parameters of market, product and production and their interdependent relations were identified and modelled, supported by IT-tools. The results showed improved quality of decisions, reduced evaluation time, a higher number of considered solutions, and that the modelling task is a challenge for the project team. This indicates benefits of using this approach, when evaluating platforms and that better tools for such modelling are required.

FROM DESIGN ERRORS TO CHANCES – A COMPUTER-BASED ERROR TRACKING SYSTEM IN PRACTICE

Möhringer S. - *Simon Moehringer Anlagenbau GmbH (DEU)* 943

The number of design errors in practice is increasing. Existing methodologies e.g. change process or quality management do not support the tracking of errors in a broad and continuous way. Every error incorporates as well chances to improve the product and the product development process. This potential needs to be opened up in a systematic way. A computer-based methodology – an error tracking system – has been developed and introduced in the industrial context. It supports to record errors in a structured way, to carry out error correction and the involved actions, to analyse errors and transfer errors into knowledge. This knowledge can be provided in the designers situational context for new design tasks.

ON THE USE OF FUNCTIONS, BEHAVIOUR AND STRUCTURAL RELATIONS AS CUES FOR ENGINEERING CHANGE PREDICTION

Ariyo O.O., Eckert C.M., Clarkson P.J. - *University of Cambridge (GBR)* 773

Unforeseen side effects of engineering changes can affect other parts of a product, which are expected to remain relatively unchanged. As a result, known component relations are used as cues for assessing probable change propagation paths. In this paper, we assess the use of functions, behaviour and structural relations as cues for predicting engineering change propagation. It was observed from the analysis that estimates of possible propagation paths varied according to the type of the query as well as the type of cue used support prediction. The result indicates that in order to have credible estimates of change propagation paths, it is important that all three product-relations are considered when analysing change instances.

EXPLORING STRATEGIES IN CHANGE MANAGEMENT – CURRENT STATUS AND ACTIVITY BENCHMARK

Deubzer F., Kreimeyer M., Lindemann U. - *Technical University Munich (DEU)* 815

Product changes result in time and cost consuming processes for the industry; therefore, most companies established a more or less resource-intensive change management. Against this background, a survey was conducted among manufacturers of the branches automotive and electrical equipment, highlighting the current status of change management, the selected strategies and planned activities. The paper gives a brief presentation of the results and the basic concept of a correlation analysis of change management strategies and effects. A framework as outcome allows companies the self-assessment on basis of the statistical distribution and identifies strategies being most promising when intending to improve a company's change management.

CHANGE IMPACT ANALYSIS AT THE INTERFACE OF SYSTEM AND EMBEDDED SOFTWARE DESIGN

Kilpinen M.S., Clarkson P.J., Eckert C.M. - *University of Cambridge (GBR)* 881

Embedded software provides a means for the functionality of a design to adapt to new needs and requirements. Systems engineering has devised processes to incorporate embedded software with the designs from other fields, including mechanical and hardware design, to manage this flexibility attained. This paper investigates the change impact analysis techniques prescribed at the system and embedded software engineering interface and identifies the disparities between these ideal practices with the actual implemented methods through an industrial study. Observations on the barriers to the prescribed change impact analysis derive suggestions for potential improvement of the design change process.

DESIGN CATALOGUES FOR MICROSYSTEMS

López Garibay J.A., Binz H. - *University of Stuttgart (DEU)* 913

MEMS design catalogues are needed. They could help introduce systematic product development into microsystem engineering. The authors propose their implementation in the conceptual phase to fulfil the requirements on quality, time and cost of design. Microsystems are characterised by interdisciplinarity, heterogeneity and complexity, but these qualities and catalogue properties correlate. Foreseen applications of design catalogues are: to assist microsystem engineering in education and self-learning and to support the integration of effective interdisciplinary project teams. Further, microsystems industry could display with them a knowledge-management strategy, promoting so the exploitation of expertise and creativity as production factors.

DESIGN OF MICROSYSTEMS BASED ON COMPLIANT STRUCTURES AND DEVICES

Zelenika S., De Bona F. - *University of Rijeka (HRV)* 1033

In this work a broad overview of the topics related to the mechanical design of compliant micromechanisms is presented. Innovative methodologies to be used in the design of devices based on leaf springs employed in the geometrically non-linear domain are given. In the case of devices with flexural hinges, an approach to the optimisation of their shape based on stiffness minimisation with constraints given by strength and kinematical requirements is presented. Design tools applicable to continuum structures with distributed compliance are also presented. A critical analysis of the peculiarities of these design solutions is provided, allowing designers to profit from the usage of compliant structures in the development of microsystems.

ON THE IMPORTANCE OF A FUNCTIONAL DESCRIPTION FOR THE DEVELOPMENT OF COGNITIVE TECHNICAL SYSTEMS

Paetzold K. - *University Erlangen (DEU)* 967

The development of cognitive technical systems is considered as a further development of mechatronic systems. Rigid sensor-actor chains are broken up while thereby becoming flexible. This is achieved by appropriate data processing, which enables a high degree of learning aptitude. Cognitive abilities have an effect on the product structure, so on the physicalness of the system. It proves to be reasonable to represent the system's functionality by input-output coherences. Behavioral modeling enables reconciliation with the functions required by the user, and can simultaneously be understood as an integrating element for the domains involved. From this derived is the postulation to supplement the digital mock-up by a functional mock-up.

ASPECTS OF HIGH INTEGRATION IN MEMS TECHNOLOGY

Watty R., Binz H. - *University of Stuttgart (DEU)* 1017

MEMS (Micro-Electro-Mechanical-Systems) technology challenges interdisciplinary teams of designers with the integration of diverse micro technologies in complex and highly integrated systems under continuously developing boundary conditions. MEMS development therefore requires an effective design process, guidelines for geometry, manufacturing and materials as well as assistance in the understanding of the entire system. A new developed working structure for MEMS supplies a holistic system view beyond the functional aspects covered by the function structure. It is enriched by a Design Structure Matrix enabling the designer to consider and optimise physical, geometrical and functional influences and dependencies during the design process.

OPPORTUNITY PARAMETERS IN THE DEVELOPMENT OF PRODUCT/SERVICE-SYSTEMS

Matzen D., Andreasen M.M. - *Technical University of Denmark (DNK)* 929

With the current focus on innovative business development throughout industry and society, the concept of product/service-systems (PSS) is a promising approach to product development, which may yield product offers that benefit company, customer and society alike. This paper presents a number of opportunity parameters that can be utilised when a company shifts from a product to a product/service based business model. The presented parameters where identified by analysis of both industrial PSS-cases and PSS-concepts developed by students of DTU in Denmark. The paper suggests that companies should coordinate their PD-efforts both internally and externally. Also, product development must be based on a life cycle understanding of the product.

SERVICE ENGINEERING: A NOVEL ENGINEERING DISCIPLINE FOR HIGH ADDED VALUE CREATION

Shimomura Y., Sakao T., Sundin E., Lindahl M. - *Tokyo Metropolitan University (JPN)* 999

Service is attracting more and more attention as manufacturing industries are shifting from a “product seller” toward a “service provider.” To design and develop services effectively and efficiently, a methodology of service design and a support by the computer system based on the methodology are needed. However, very few researchers have so far dealt with services from the viewpoint of engineering design. The authors are carrying out fundamental research in “service engineering,” which deals with services in an engineering manner. Based on this, this paper aims at proposing a “service CAD,” a computerized tool to support service design, which provides designers with a design environment equipped with knowledge about existing services.

AN OUTLINE OF AN INTERACTIVE DESIGN MODEL FOR SERVICE ENGINEERING OF FUNCTIONAL SALES OFFERS

Lindahl M., Sundin E., Shimomura Y., Sakao T. - *Linköping University (SWE)* 897

The aim of this paper is to present an outline of an interactive design model that can be used for Service Engineering of functional sales concepts. This paper also aims to show how the previous service engineering research relates to this new model. A further aim is also to verify the overall outline of the interactive design model. The proposed model’s overall outline has been confirmed by and discussed with eight companies and further supported by the output from the literature review, and seems to be relevant for different types of functional sales offers. Therefore, the conclusion is that the proposed model gives a relevant image of important lifecycle activities for Service Engineering of functional sales offers.

A GENERIC SYNTHETIC FRAMEWORK FOR CONCEPTUAL SERVICE DESIGN

Coatanéa E., Makkonen P.E., Saarelainen T., Castillón-Solano M.O. - *Helsinki University of Technology (FIN)* 799

The paper proposes an approach aimed at formalizing and quantifying a service design methodology. First, it is shown that the concepts of service channel and service content are extensions of the concepts of product and function developed in the PhD thesis. Second, the paper presents a group of fundamental metrics originally dedicated to cover conceptual life cycle design and shows that they can also cover the quantitative requirements related services design elements. Future work will improve the classification and categorization of existing services and will allow developing a computer-based implementation covering simultaneously traditional conceptual life cycle design and service design.

USING PRODUCT & PROCESS DESIGN TOOLS TO IMPROVE SERVICES

Hollins W.J. - *Regent's Business School (GBR)* 839

As employment in the service sector in industrialised countries now exceeds that in manufacturing, engineering designers must turn to the service sector and by doing so, will find many of their existing skills can be adapted to this wider market. This paper looks at existing product and process design tools currently used by practitioners in manufacturing that can also be used in the design of services. Also, a different way of approaching the concept stage when designing services will be included. Introducing ‘Life Style Study’ as a trigger for service design to be used in conjunction with blueprinting. By considering a service blueprint as the service process design, this allows it to be analysed using production tools.

INFLUENCE OF THERMAL DILLATATION UPON DESIGN OF SCREW MACHINES

Kovacevic A., Stosic N., Mujic E., Smith I.K. - *City University London (GBR)* 889

Close control of the clearances between the rotors and the casing is essential for efficient and quiet oil free compression or expansion in twin screw machines. Differential thermal expansion between these components can therefore have adverse effects, especially when both functions are performed by the use of only one pair of rotors in a single casing. A plain compressor and a combined compressor-expander are analysed and it is shown how good results can be obtained by the use of different materials for each component. The analytical results show good agreement with experimentally derived data.

TESTING CONNECTIONS AND FASTENERS TO DETERMINE STRENGTH CHARACTERISTICS

Wünsche T., Meyer-Eschenbach A., Blessing L. - *Technical University Berlin (DEU)* 1025

Connections are an essential part of engineering. To meet the various requirements and the many – sometimes contradictory – design aims, the design engineer needs sufficient knowledge about the characteristic features and peculiarities of connections. We therefore undertook research to determine these characteristics to provide designers with the necessary information and to extend the use of these connections. The paper focuses on the results of the tests used to analyse the strength characteristics of the connections which can be disassembled without destruction e.g. quarter-turn fasteners. The determined parameters help to describe the state-of-the-art regarding these connections and are necessary for choosing them.

VISUALIZATION OF VARIATION IN EARLY DESIGN PHASES: A CONVEX HULL APPROACH

Lööf J., Söderberg R., Lindkvist L. - *Chalmers University of Technology (SWE)* 905

As the demand on productivity in the manufacturing industry always increases, it’s important with tools that shorten the time from concept to production phases. Visualization has become a popular tool for fast and easy verification regarding many aspects of a product in the design phase.
In this paper three algorithms are developed and investigated to capture and visualize the total volume a part or assembly creates when it is affected by variation or motion. The algorithms are general and work on all kinds of problem where there is variation or motion involved. The data used to create the total volume is collected either from simulation data or from real measurement data.

DEVELOPING OF THE BEARING ORGANS COMPUTATIONAL MODULE FOR GEAR BOXES OPTIMALISATION SYSTEM

Vanek V., Hosnedl S., Nemec L. - *University of West Bohemia (CZE)* 1009

By the solution of the problems of the mathematical modelling of gear boxes (GS) predetermined particularly for regional railway vehicles, i.e. the dynamical behaviour of shaft type assembly systems the models of particular organs contained in shaft assembly groups have to be crated. The model of the gear organ (BO) is one of the most significant representatives of these organs and its correctness and accuracy participate significantly in the resulting behaviour of the whole system. The BO model with radial clearances is used in the presented computational system. The complex compact system was successfully used throughout optimisation process of the GS, produced by the Skoda Transp. Company.

INFLUENCE OF DIFFERENT GEAR LOAD MODELS ON CRACK PROPAGATION PREDICTIONS

Podrug S., Jelaska D. - *University of Split (HRV)* 983

In conventional fatigue models of the gear tooth root it is usual to approximate actual gear load with pulsating force acting in the highest point of the single tooth contact. However, in actual gear operation, the magnitude as well as the position of the force, changes as the gear rotates through the mesh. A study to determine the effect of moving gear tooth load on crack propagation predictions was performed. Finite element method and linear elastic fracture mechanics theories are used. Moving load produces a non-proportional load history in a gear's tooth root, consequently the maximum tangential stress theory will predict a unique kink angle for each load increment, but herein crack’s trajectory is computed at the end of the load cycle.

MODULE SHEETS FOR ADAPTING MODULAR PRODUCT FAMILIES

Avak B. - *ETH Zürich (CHE)* 783

Modular product families are now broadly applied in industry. There is, however, no concept in place yet to effectively manage the interfaces within a modular product family. That is why module sheets are introduced to explicitly capture all the information that is necessary to effectively maintain a modular product family's interfaces. The module sheets consists of three sections: Module characterization, module interfaces, and module configuration. The overall concept and utility of the module sheets are shown up. It is described how the module sheets have been implemented and particularized at three industrial partners.

SYNTHESIS OF PRODUCT FUNCTION/MEANS STRUCTURES BASED ON VISUAL THINKING

Napalkov E., Zars V. - *Riga Technical Univrsity (LVA)* 579

The paper describes a compositional method of top-down synthesizing product function/means structures in collaborative environment. This method is compared with the process of visual thinking that enables the designers to build graphical images by taking small parts of these images in their imagination and coupling them together. Imagery graphical images are considered as visual knowledge captured in accordance with the multistage and critical understanding functional, behavioral and structural properties of existent products. Also, compositional techniques used for coupling visual knowledge are studied.

ON THE BENEFIT, COST AND UNCERTAINTY OF PREPARING COMPONENTS FOR REUSE

Nilsson C. - *NTNU (NOR)* 959

The paper explores design reuse between product generations, especially considering assembled products (or parts of) that evolve incrementally yet cannot be predicted with confidence enough to justify investments that reduce flexibility (e.g. certain platform investments). The paper argues that in such cases there is need for a proactive and incremental reuse approach based on: 1) monitoring of the reuse potential of old and new design solutions considering potential benefits and costs of reuse; and 2) the preparation of selected components to increase their reusability in future products.

POSSIBLE EXPLANATIONS TO THE LIMITED USE OF PRODUCT PLATFORMS IN INDUSTRY

Pedersen R., Mortensen N.H. - *Technical University of Denmark (DNK)* 975

The paper discusses present research within product architectures and product platforms. Emphasis in the paper is on the modelling techniques and design and optimisation methods found in literature. The hypothesis is that the focus of present research within the field is too narrow. In particular the lack of a platform model applicable for R&D employees is discussed. In the paper a broadening of research focus is proposed along with two lists of demands for future product platform models. First, the procedures, rules and contents of a platform model is discussed in relation to organisational implications. Then, a multilevel platform model is proposed in order to make future research efforts broader.

COMPLEXITY OF PRODUCT STRUCTURE CONFIGURATIONS

Salonen N.V. - *Tampere University of Technology (FIN)* 991

There is need for flexible change management to enable dynamic changes of documents linked to parts. This requirement is one of the most important needs of structure configurations versus current industry de-facto description of document to part relation. This study concentrates on CAD documents, which are identified in this industry sector as the principal document of defining parts. The aim of the study is to identify issues, which should be discussed in appropriate academic, industry and standardization forums and changed to de-facto definition within product data management systems.

MODULE SHEETS FOR ADAPTING MODULAR PRODUCT FAMILIES

Avak B. - *ETH Zürich (CHE)* 783

Modular product families are now broadly applied in industry. There is, however, no concept in place yet to effectively manage the interfaces within a modular product family. That is why module sheets are introduced to explicitly capture all the information that is necessary to effectively maintain a modular product family's interfaces. The module sheets consists of three sections: Module characterization, module interfaces, and module configuration. The overall concept and utility of the module sheets are shown up. It is described how the module sheets have been implemented and particularized at three industrial partners.

SYNTHESIS OF PRODUCT FUNCTION/MEANS STRUCTURES BASED ON VISUAL THINKING

Napalkov E., Zars V. - *Riga Technical Univrsity (LVA)* 579

The paper describes a compositional method of top-down synthesizing product function/means structures in collaborative environment. This method is compared with the process of visual thinking that enables the designers to build graphical images by taking small parts of these images in their imagination and coupling them together. Imagery graphical images are considered as visual knowledge captured in accordance with the multistage and critical understanding functional, behavioral and structural properties of existent products. Also, compositional techniques used for coupling visual knowledge are studied.

ON THE BENEFIT, COST AND UNCERTAINTY OF PREPARING COMPONENTS FOR REUSE

Nilsson C. - *NTNU (NOR)* 959

The paper explores design reuse between product generations, especially considering assembled products (or parts of) that evolve incrementally yet cannot be predicted with confidence enough to justify investments that reduce flexibility (e.g. certain platform investments). The paper argues that in such cases there is need for a proactive and incremental reuse approach based on: 1) monitoring of the reuse potential of old and new design solutions considering potential benefits and costs of reuse; and 2) the preparation of selected components to increase their reusability in future products.

POSSIBLE EXPLANATIONS TO THE LIMITED USE OF PRODUCT PLATFORMS IN INDUSTRY

Pedersen R., Mortensen N.H. - *Technical University of Denmark (DNK)* 975

The paper discusses present research within product architectures and product platforms. Emphasis in the paper is on the modelling techniques and design and optimisation methods found in literature. The hypothesis is that the focus of present research within the field is too narrow. In particular the lack of a platform model applicable for R&D employees is discussed. In the paper a broadening of research focus is proposed along with two lists of demands for future product platform models. First, the procedures, rules and contents of a platform model is discussed in relation to organisational implications. Then, a multilevel platform model is proposed in order to make future research efforts broader.

COMPLEXITY OF PRODUCT STRUCTURE CONFIGURATIONS

Salonen N.V. - *Tampere University of Technology (FIN)* 991

There is need for flexible change management to enable dynamic changes of documents linked to parts. This requirement is one of the most important needs of structure configurations versus current industry de-facto description of document to part relation. This study concentrates on CAD documents, which are identified in this industry sector as the principal document of defining parts. The aim of the study is to identify issues, which should be discussed in appropriate academic, industry and standardization forums and changed to de-facto definition within product data management systems.