

# DESIGN 2014

13<sup>th</sup> INTERNATIONAL DESIGN CONFERENCE

**BOOK OF ABSTRACTS**

May 19 - 22, 2014

Dubrovnik

Cavtat

Croatia

PROGRAMME  
CHAIRS

S. J. Culley

U. Lindemann

T. C. McAloone

C. Weber

D. Marjanović

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## **BOOK OF ABSTRACTS**

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Under the auspices of

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and Sports of the Republic of Croatia**



by

**University of Zagreb  
Faculty of Mechanical Engineering  
and Naval Architecture**



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With the experience and understanding gathered through previous DESIGN conferences the 13<sup>th</sup> International Design Conference - DESIGN 2014 is organised to present intersection of contemporary research in design.

Based on more than 830 reviews programme chairs have selected 214 papers from 313 submitted manuscripts.

The research reports published in DESIGN 2014 three volume proceedings, Book of Abstracts and digital media illustrate the many facets of design. It has been said that changes are the only constant of design. These changes are visible in the DESIGN conference proceedings. Changes in product development, methods and tools used in design and manufacturing lead to outcomes that cost less and use fewer materials, demand less energy and human work, all of the time delivering more of the value for the price. Production is becoming vastly more efficient and the cost of labour as a proportion of the total cost of production is diminishing. As a consequence and in opposition to mass production we are witnessing the growth of products designed and manufactured to address individual needs. With this idea in mind partners, developers and customers are coming ever more closely together in order to plan, engineer, manufacture and fulfil the vast range of projects. The progress visible through DESIGN conference papers is apparent but still does not fulfil the needs.

Being on the verge of new paradigm of “social production” and “sustainable development” the borders between engineering and design, production and use are fading. Does our understanding of the socio-technical context of design meets the needs? How do we react? Are our methods and tools appropriate to answer new demands? How is it possible to improve design projects and processes? How can we improve the development of products and services? Which competencies, information and communication technologies are needed? What is the impact on the everyday design work? What social and legal issues should be considered? What are the new advances in design theory and research? All this questions have been addressed many times, but we are still seeking for the right answers and new paradigms.

The reality of change in technology, environment, demands and expectations is all-too evident. In thirty-three years since the first DESIGN conference took place in Zagreb almost nothing is the same, nothing, but the rationale behind engineering and design.

Contemporary design knowledge is a direct answer to demands, albeit sometimes demands are more cost driven than by societal needs. The need to improve our understanding of the socio-technical context of design and to build a holistic view is more evident than ever.

DESIGN 2014 conference provides a platform to discuss such questions and extend our theoretical foundations.

Dorian Marjanović  
Steve Culley  
Udo Lindemann  
Tim McAlloone  
Christian Weber





**CONFERENCE VENUE**

The conference will take place at the Hotel Croatia CAVTAT.

Registration desk working hours are:

**Sunday, 18<sup>th</sup> May:** 18:00 - 20:00

**Monday to Thursday 19<sup>th</sup> - 22<sup>nd</sup> May:** 08:00 - 19:00

**SPECIAL EVENTS**

**MONDAY, 19<sup>th</sup> May**

09:15 - 17:45

14:15 - 17:45

**CONFERENCE WORKSHOPS**

**PHD STUDENTS' FORUM**

**WEDNESDAY, 21<sup>st</sup> May**

12:00 - 12:45

**DESIGN DEBATE**

**OPENING SESSION**

**TUESDAY, 20<sup>th</sup> May**

Congress Hall Ragusa

08:45 - 09:30

**UNIVERSITY OF ZAGREB WELCOME ADDRESS**

Melita Kovačević - vicerector University of Zagreb (HRV)

**THE DESIGN SOCIETY WELCOME ADDRESS**

Kristina Shea – Board of Management the Design Society (CHE)

**A WORD BEFORE**

Dorian Marjanović – Conference Chair (HRV)

**CLOSING SESSION**

**THURSDAY, 22<sup>nd</sup> May**

Congress Hall Ragusa

16:30 - 17:00

**EUROPEAN DESIGN INNOVATION PLATFORM - DRIVING INNOVATION THROUGH DESIGN**

Claire Fennelw - Design Council (GBR)

17:00 - 17:45

**CONFERENCE REFLECTION AND CLOSING**

Udo Lindemann - Technical University Munich (DEU)

**REFRESHMENTS AND LUNCHES**

Refreshments and lunches will be served in the Hotel Croatia from 19<sup>th</sup> – 22<sup>nd</sup> May

**SOCIAL EVENTS**

**MONDAY, 19<sup>th</sup> May**

18:30 - 19:30

Welcome cocktail - Hotel Croatia

**WEDNESDAY, 21<sup>st</sup> May**

19:30

Conference dinner - Hotel Croatia

**THURSDAY, 22<sup>nd</sup> May**

19:30

Farewell party - Hotel Croatia

**GUEST PROGRAMME**

Although designed especially for accompanying guests, delegates are, of course, very welcome to attend. Information, schedule and reservations are available at the desk.

Hours	MONDAY, MAY 19					TUESDAY, MAY 20				
08:00	REGISTRATION					REGISTRATION				
08:15										
08:30						OPENING				
08:45										
09:00	D111 WORKSHOP 1: DESIGNING PRODUCTS FOR LIFETIME PERCEIVED VALUE					D2-P PLENARY SESSION I				
09:15										
09:30										
09:45										
10:00										
10:15	D112 WORKSHOP 2: CHALLENGES FOR MODELLING AND MANAGING ENGINEERING PROCESSES					REFRESHMENT BREAK				
10:30										
10:45										
11:00										
11:15										
11:30	D113 WORKSHOP 3: THE BENCH GAME: AN ECO-DESIGN WORKSHOP					D221 DESIGN TACTICS AND METHODS FOR SPECIFICATION				
11:45										
12:00										
12:15										
12:30										
12:45	D114 WORKSHOP 4: PRESCRIBING A ROBUST DESIGN PROCESS					D222 ENVIRONMENTAL OPPORTUNITIES				
13:00										
13:15										
13:30										
13:45										
14:00	LUNCH					LUNCH				
14:15										
14:30										
14:45										
15:00										
15:15	D121 WORKSHOP 5: BRIDGING INNOVATION AND SUSTAINABILITY IN ENGINEERING DESIGN					D231 CASE STUDIES OF DESIGN METHODS				
15:30										
15:45										
16:00										
16:15										
16:30	D122 WORKSHOP 6: PRODUCT/SERVICE-SYSTEMS (PSS)					D232 PRODUCT DEVELOPMENT MANAGEMENT				
16:45										
17:00										
17:15										
17:30										
17:45	D123 WORKSHOP 7: A FRAMEWORK FOR DECISION MAKING IN THE INNOVATION MANAGEMENT PROCESS					D233 CREATIVITY IN DESIGN				
18:00										
18:15										
18:30										
18:45										
19:00	WELCOME COCKTAIL					D234 MODULARISATION				
19:15										
19:30										
19:45										
20:00										
	D124 WORKSHOP 8: RISK MANAGEMENT PRACTICES IN PRODUCT DESIGN AND DEVELOPMENT					D235 DESIGN THEORY AND RESEARCH METHODS				
	D125 PHD STUDENTS' FORUM TIHI SALON (QUIET SALON)					REFRESHMENT BREAK				
	REGISTRATION					D241 VALIDATION, USABILITY AND BENEFIT OF METHODS				
	D242 GLOBAL PRODUCT DEVELOPMENT					D243 USER PARTICIPATION				
	D244 PRODUCT-SERVICE SYSTEMS					D245 VISUALISATION AND VIRTUALISATION				



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WEDNESDAY, MAY 21					THURSDAY, MAY 22					Hours
REGISTRATION					REGISTRATION					08:00
D311 APPLICATION OF DESIGN MODELS AND METHODS	D312 ECO-DESIGN IMPLEMENTATION	D313 SIMULATIONS WITHIN COMPLEX SYSTEMS	D314 PRODUCT DEVELOPMENT MODELS	D315 SOCIO-TECHNICAL ISSUES	D411 GENERATING SOLUTIONS	D412 PRODUCT FOCUSED PROPERTIES	D413 DFX TOOLS I	D414 COMPLEX SYSTEMS DESIGN	D415 ENGINEERING DESIGN PRACTICE	08:15
REFRESHMENT BREAK					REFRESHMENT BREAK					08:30
D3-P PLENARY SESSION II + DESIGN DEBATE					D421 ANALYSING PRODUCT PROPERTIES	D422 DFX TOOLS II	D423 INNOVATION MANAGEMENT	D424 KNOWLEDGE TOOLS AND APPLICATIONS	D425 MODELS AND PROTOTYPES	08:45
										09:00
										09:15
										09:30
										09:45
LUNCH					LUNCH					10:00
D331 DESIGN FOR X	D332 KNOWLEDGE MANAGEMENT	D333 USER CENTRED DESIGN	D334 SOCIETAL CHALLENGES	D335 MODELLING AND SIMULATION IN INDUSTRIAL DESIGN	D431 VALIDATION AND USABILITY	D432 DFX CASE STUDIES	D433 PLM/PDM	D434 USER NEEDS	D435 DESIGN EDUCATION STRATEGIES	10:15
REFRESHMENT BREAK					REFRESHMENT BREAK					10:30
				MEETING: COLLABORATIVE DESIGN RESEARCH METHODOLOGIES	D4-C CLOSING					10:45
				MEETING: DISCUSSION OF PDTEACHING ACTIVITIES						11:00
										11:15
										11:30
										11:45
CONFERENCE DINNER					FAREWELL PARTY					12:00
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MONDAY, MAY 19					Hours	
REGISTRATION					08:00	CONGRESS HALL RAGUSA
					08:15	
					08:30	
					08:45	
					09:00	
D111 WORKSHOP 1: DESIGNING PRODUCTS FOR LIFETIME PERCEIVED VALUE	D112 WORKSHOP 2: CHALLENGES FOR MODELLING AND MANAGING ENGINEERING PROCESSES	D113 WORKSHOP 3: THE BENCH GAME: AN ECO-DESIGN WORKSHOP	D114 WORKSHOP 4: PRESCRIBING A ROBUST DESIGN PROCESS	09:15	CONGRESS HALL BOBARA	
				09:30		
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				11:45	CONGRESS HALL ORLANDO	
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LUNCH					14:15	CONGRESS HALL KONANJE
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D121 WORKSHOP 5: BRIDGING INNOVATION AND SUSTAINABILITY IN ENGINEERING DESIGN	D122 WORKSHOP 6: PRODUCT/ SERVICE- SYSTEMS (PSS)	D123 WORKSHOP 7: A FRAMEWORK FOR DECISION MAKING IN THE INNOVATION MANAGEMENT PROCESS	D124 WORKSHOP 8: RISK MANAGEMENT PRACTICES IN PRODUCT DESIGN AND DEVELOPMENT	D125 PHD STUDENTS' FORUM  <i>TIHI SALON (QUIET SALON)</i>	15:30	CONGRESS HALL ŠIPUN
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REGISTRATION					18:00	CONGRESS HALL
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WELCOME COCKTAIL					18:45	
					19:00	
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					20:00	

CONGRESS HALL  
RAGUSA

CONGRESS HALL  
BOBARA

CONGRESS HALL  
ORLANDO

CONGRESS HALL  
KONAYLE

CONGRESS HALL  
SIPUN

## D111 WORKSHOP 1: DESIGNING PRODUCTS FOR LIFETIME PERCEIVED VALUE

Hosted by DS SIG Emotional Engineering

**Chairs:** Monica Bordegoni (ITA), Suichi Fukuda (USA)

*Congress Hall Bobara*

Currently, most hardware products are designed for a one-time value. Their values are evaluated at the time of delivery. Hardware is developed to meet the design requirements and it is developed to realize these fixed functions of a final product. And its development is basically one way, or an open loop system. The product lifecycles are getting shorter and shorter to cope with the quick changes and growing diversifications. But if we introduce such a closed loop way of product development, customers will be more attached and affectionate to the products, and they will enjoy using our products much longer. To such product development in hardware, we could introduce systems approach, where common platform or primary system does not substantially change over time while sub-components are changed from time to time to satisfy our customers more emotionally. This approach to change can be driven by collaborative design decision making processes, or even by new personal design and fabrication paradigms, which would lead to a more democratic view of creative design.

## D112 WORKSHOP 2: CHALLENGES FOR MODELLING AND MANAGING ENGINEERING PROCESSES

Hosted by DS SIG MMEP

**Chairs:** Claudia Eckert (GBR), Kilian Gericke (LUX)

*Congress Hall Orlando*

A considerable fraction of the effort involved in the developing new products, is concerned with the effort of managing large teams of engineers with different backgrounds and goals. The workshop will discuss challenges that the engineering community is facing managing the development of complex products and the challenges that we are facing as a research community in supporting them. The workshop will gather members of the MMEP SIG and other interested researchers together to identify issues that we have encountered and to gain an overview of who is working on which problem. The aim is to help researchers to get in touch with each, share information, ideas and references to tackle these problems.

## D113 WORKSHOP 3: THE BENCH GAME: AN ECO-DESIGN WORKSHOP

Hosted by DS SIG ECODESIGN

**Chairs:** Elies Dekoninck (GBR), Tim McAloone (DNK), Daniela Pigosso (DNK) *Congress Hall Konavle*

Brought to you by the Eco-Design SIG, The Bench Game is a unique interactive game-based workshop that combines product design, environmental and supply chain issues with the aim of introducing participants to both the practical aspects of eco-design and the wider business considerations necessary in the implementation of environmental product development. The game is based on the G.EN.ESI methodology ([www.genesi-fp7.eu](http://www.genesi-fp7.eu)), which supports companies in the integration of environmental considerations into their product development process. During the workshop, the participants will be introduced to the G.EN.ESI methodology before the commencement of the game. Exercising the knowledge gained through the prior presentation and reflections on their own experiences of industry based eco-design implementation, the participants will partake in The Bench Game. To kick-start the game, the participants will be divided into groups, with each group representing a design team in a manufacturing company. After being split into groups, the facilitator will commission a re-design of a bench, based on a provided base-model, which has particular environmental performance improvements. The groups must work collaboratively, with each team member assuming a pre-defined role, to successfully redesign the bench to ensure an improved environmental profile based on the LCA results of the base-model. Following the game, a discussion session will be held to reflect upon the methodology and the interactive exercise. The workshop will conclude with the Eco-Design SIG reporting on its business since ICED13 and planning activities for the coming year.

## D114 WORKSHOP 4: PRESCRIBING A ROBUST DESIGN PROCESS

Hosted by DS SIG Robust Design

**Chairs:** Thomas J. Howard (DNK), Steven Hoffenson (SWE)

*Congress Hall Šipun*

This workshop will focus on placing robust design approaches onto both generic and company-specific, product development processes. The workshop organising committee will gather several product development process models from industry along with one or two generic process models. The tools and methods will be sourced from the list developed during the previous workshop, but participants will also be encouraged to place their own approaches onto the process in terms of where they are applicable. The second half of the workshop we will try to synthesize a prescribed Robust Design Process. Participant are also encouraged to come with proposals that can be presented during the workshop.

## D121: WORKSHOP 5: BRIDGING INNOVATION AND SUSTAINABILITY IN ENGINEERING DESIGN

**Chairs:** Cassandra Telenko (SGP), Kristin Wood (SGP)

*Congress Hall Bobara*

Innovation and creativity research seeks to help designers break the mold of everyday, expected designs and discover the delightful, but unexpected through novel approaches to engineering problems. This workshop invites innovation and creativity experts and experts in sustainable design to bridge the gap between techniques in engineering design innovation and applications of sustainable engineering design. Sustainability is one “wicked problem” that requires innovative design thinking to change the interface between nature, society, economy and artifact. Current solutions to sustainability have debatable novelty and impact, indicating that current state-of-the-art is limited to a surface understanding of issues, and requires more innovative approaches. Workshop participants are invited to explore emerging areas at the interface of engineering design innovation and sustainability. Expert participants are encouraged to apply and submit proposals for 5-minute presentations of the most exciting, relevant topics in their field. After debating and sharing the state of the art in these two fields, participants will engage in practical discussions as design teams solving a sustainable design challenge. The design challenge will serve as a prompt for an in depth discussion of current and future research in sustainability and innovation. Participants will leave this workshop with an understanding of emerging areas for future research, a network of collaborators, references to major works in sustainability and innovation.

## D122: WORKSHOP 6: PRODUCT/SERVICE-SYSTEMS (PSS)

**Chair:** Tim C. McAloone (DNK)

*Congress Hall Orlando*

PSS has been a growing research activity in the Design Society over recent years. Both the DESIGN and ICED conference series have experienced a large increase in the amount of PSS papers submitted, which reflects the growing number of research projects active in this area. As an initiative to engage the active researchers in this area and to make a first attempt at charting the PSS knowledge in the Design Society, the organisers of the DESIGN conference have initiated a PSS workshop at DESIGN 2014. The Technical University of Denmark, which has been actively researching in PSS since 2000, has agreed to host this first workshop. The PSS workshop will begin by presenting the results of a charting exercise, showing all of the PSS contributions at DESIGN and ICED over the past decade. Through an exercise subgroups will organise the charted contributions into PSS research aspects and we will map the coverage and the gaps in the Design Society's PSS research performance to date. A second exercise will use a PSS case from the Danish maritime industry to organise product and service offerings into PSS concepts, leading on to a discussion of the vital elements of a whole PSS concept. Finally we will facilitate a discussion of the need for and interest in a follow-on PSS research activity within the Design Society.

## D123: WORKSHOP 7: A FRAMEWORK FOR DECISION MAKING IN THE INNOVATION MANAGEMENT PROCESS

**Hosted by** DS SIG Decision Making and DS SIG Design Creativity

**Chairs:** Julie Le Cardinal (FRA), Sandro Wartack (DEU), Gaetano Cascini (ITA)

*Congress Hall Konavle*

The focus of the workshop is decision making in the innovation management process in order to stimulate the identification and discussion about new methods or tools for supporting product developers in different decision making situations during the product development process. So as to get into deeper discussion during the workshop at the DESIGN 2014, two groups are planned. The first group has to work at the interface between the creative challenge exploration and the generation of ideas and therefore has to think about the question “How can decision making techniques help to formulate the borders of the design task so as to avoid hindering the generation of creative solutions?” The second group works at the interface between the generation of ideas and the transformation of ideas into concepts and consequently has to work on the question “How decision making techniques can help comparing and selecting preliminary and potentially radically new ideas to be conceptualized?” Expected outcome of this workshop will be an understanding of chances and limits of existing decision making methods for the idea and innovation management process, as well as the challenges for further activities on the interaction between creative idea generation and decision making.

## D124: WORKSHOP 8: RISK MANAGEMENT PRACTICES IN PRODUCT DESIGN AND DEVELOPMENT

**Hosted by** DS SIG Risk Management Processes and Methods in Design

**Chair:** Joseph Oehmen (DNK)

*Congress Hall Šipun*

The workshop will be covering the following topics. Coordinating the Risk SIG Activities: Review of Risk SIG mission and activities; Discussion of Risk SIG priorities for 2014-2015; Call for presentations at the Risk SIG online meetings, discussion of possible presenters to be invited. Joint publication activities: Risk SIG Whitepaper: Completion of outline and responsibilities during workshop; Edited book on RM in design: Review of chapter structure, expression of interest. Exchange and networking: Publication and research highlights 2013-2014; Current risk-related papers in the pipeline; Current risk-related project activities and project proposals.



### D125 PHD STUDENTS' FORUM

**Chairs: Philip Cash (DNK), Kilian Gericke (LUX)**

*Tihi salon (Quiet Salon)*

Research within the DESIGN community offers many possibilities of exchange and collaboration between fellow researchers. While these opportunities cover a broad scope from young researchers to senior members of the community with a range of research interests, we aim to support the specific needs of PhD students. Therefore, the DESIGN 2014 conference offers a PhD Forum.

The aims of the PhD Forum are:

- To provide an opportunity to air, discuss, and attempt to offer resolution for your issues, methodological, practical, or otherwise related to your PhD project
- To foster the exchange of ideas, methodological best practice, and research approaches between younger researchers
- To enhance networking and collaboration with both PhD students and experts

The forum will be an opportunity for PhD students to discuss their research ideas and their key issues with both experienced researchers, and younger researchers (who have just finished dealing with many of these issues and can offer tangible help and advice) in order to facilitate their research efforts. Therefore, small discussion groups will be organised in which individual research topics are presented to and discussed within the group. Discussion groups will consist of 5-6 PhD students and 1-2 experts.

The PhD Forum is aimed at PhD students participating at the DESIGN 2014 conference. To facilitate meaningful discussion it is essential that potential participants should already have defined their PhD research topic, undertaken an initial literature study and formulated aims and objectives.

TUESDAY, MAY 20					Hours	
REGISTRATION					08:00	CONGRESS HALL RAGUSA
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OPENING					09:00	CONGRESS HALL BOBARA
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D2-P PLENARY SESSION I					10:00	CONGRESS HALL ORLANDO
					10:15	
					10:30	
					10:45	
REFRESHMENT BREAK					11:00	CONGRESS HALL KONAYLE
					11:15	
D221 DESIGN TACTICS AND METHODS FOR SPECIFICATION	D222 ENVIRONMEN- TAL OPPORTUNITIES	D223 INFORMATION MANAGEMENT	D224 AESTHETICS AND PERCEPTION	D225 TOOLS AND ENVIRONMENTS FOR DESIGN EDUCATION	11:30	CONGRESS HALL SIPUN
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LUNCH					12:30	CONGRESS HALL SIPUN
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D231 CASE STUDIES OF DESIGN METHODS	D232 PRODUCT DEVELOPMENT MANAGEMENT	D233 CREATIVITY IN DESIGN	D234 MODULARI- SATION	D235 DESIGN THEORY AND RESEARCH METHODS	14:30	CONGRESS HALL SIPUN
					14:45	
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REFRESHMENT BREAK					15:30	CONGRESS HALL SIPUN
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					16:00	
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D241 VALIDATION, USABILITY AND BENEFIT OF METHODS	D242 GLOBAL PRODUCT DEVELOPMENT	D243 USER PARTICIPATION	D244 PRODUCT- SERVICE SYSTEMS	D245 VISUALISATION AND VIRTUALISATION	16:45	CONGRESS HALL SIPUN
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					20:00	



## RESEARCH FOR DESIGN - RESEARCHING BY DESIGNING

**Krcmar H. / Technical University Munich (DEU)**

The talk will investigate the relationship between the process and results of Research and Design using an Information Systems perspective. Using a Design Science framework that relationship will be analyzed on a software, product, product service system and service ecosystems level as well as from a managerial point of view. The analysis will show how different modes of research are interlinked and why the stance of engaged scholarship supports the quest for really useful rigorous research (RURR).

## 3D PRINTING: DESIGN WITHOUT LIMITS?

**Ederer I. / Voxeljet AG (DEU)**

Triggered by the availability of highly affordable personal 3D Printers, the 3D printing industry is attracting wide public interest in a similar way to the attention internet based applications attracted in the late nineties. The reasons for this are clear: 3D printing promises accessible, individual product design in connection with a fully automated print process and easy handling. However, the promise of personal 3D printers is limited with respect to build size, scalability and choice of materials. In such cases, voxeljet can offer a viable, industrial solution. With its unique 3D platform, voxeljet provides the largest commercially available build volume, together with industrial grade materials. The presentation provides an overview of current and possible applications, and gives an insight into future developments in this space.

Congress Hall Ragusa

SESSION D2-P

19 May 2014  
Monday

20 May 2014  
Tuesday

9:30 - 10:45

21 May 2014  
Wednesday

22 May 2014  
Thursday

## BIO-INSPIRED DESIGN CHARACTERISATION AND ITS LINKS WITH PROBLEM SOLVING TOOLS

Fayemi P.-E., Maranzana N., Aoussat A., Bersano G. / *Arts et Métiers ParisTech (FRA)*

173

Although bio-inspiration is a well-known instrument for innovation, the problem-solving process that leads to the solution has not been fully investigated yet. The purpose of this article is to understand what bio-inspiration is, by defining its relative concepts and boundaries. After the outlining of a generic biomimetic process, a direct correspondence with TRIZ tools is presented. Each phase of the proposed process has been classified according to the type of tool that is needed. For the two first class, an ideal set of features has been defined.

## COMPENSATION OF BENDING MOMENTS AS A NATURE-INSPIRED DESIGN PRINCIPLE?

Goessling R., Herzog M., Witzel U., Bender B. / *Ruhr-University Bochum (DEU)*

193

The application of natural phenomena in technical environments is well known in design research as biomimetic design. One phenomenon largely unnoticed in biology research is the strategy to compensate bending moments in the musculoskeletal system by means of muscle activation to minimize stress in bones. This provides opportunities for weight and resource optimization. Even though the approach appears promising for technical applications, its potential is yet unknown. To reveal its suitability, the biological phenomenon is abstracted and demonstrated by FE simulations.

## GENERAL-PURPOSE REQUIREMENTS CHECKLIST FOR IMPROVING THE COMPLETENESS OF A DESIGN SPECIFICATION

Becattini N., Cascini G. / *Politecnico di Milano (ITA)*

111

Stemming from the need of better supporting the product development processes with methods and tools that improve their effectiveness and efficiency, the authors propose a set of abstract criteria for populating a design specification in order to both cover a wide range of potentially relevant objectives and preserve their applicability to various technical domains. In this paper the authors assess and discuss the applicability of the proposed set of criteria and their benefits against an intuitive definition of system requirements with a group of more than 80 engineering students.

## BIOSCRABBLE – THE ROLE OF DIFFERENT TYPES OF SEARCH TERMS WHEN SEARCHING FOR BIOLOGICAL INSPIRATION IN BIOLOGICAL RESEARCH ARTICLES

Kaiser M.K., Hashemi Farzaneh H., Lindemann U. / *Technical University Munich (DEU)*

241

Against the background of solution search in bio-inspired design, a closer look at the types of search terms which result, e.g., in a crab claw-inspired knife is taken here. A study is carried out to examine the effectiveness and efficiency of the search term categories “function”, “property” and “environment” for searching for useful biological information for solving technical problems in biological research articles. There are indications that the effectiveness of the categories depends on the technical problem addressed. For the efficiency, differences were observed between the categories.

SESSION D221

Congress Hall Ragusa

19 May 2014  
Monday

20 May 2014  
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11:15 - 12:45

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**ECO-INNOVATION: THE OPPORTUNITIES FOR ENGINEERING DESIGN RESEARCH****O'Hare J.A., McAloone T.C. / *Technical University of Denmark (DNK)*****1631**

Eco-innovation is an approach that has the potential to deliver step change improvements in the environmental performance of products, but the uptake by industry to date has been disappointing. The paper presents a selective review of the academic literature, choosing examples of research that give a flavour of the key trends and interesting topics that are emerging from the eco-innovation body of knowledge. We conclude by suggesting 10 areas where we see potential for the engineering design research community to contribute to the advancement of eco-innovation.

**ECO-DESIGN VS ECO-INNOVATION: AN INDUSTRIAL SURVEY****Cluzel F., Vallet F., Tyl B., Bertoluci G., Leroy Y. / *Ecole Centrale Paris (FRA)*****1501**

This paper aimed at defining the features and goals of eco-innovation compared to eco-design in industry. Both academic and normative approaches have difficulties establishing sharp boundaries, as shown by a survey conducted with 12 French industrial organizations. As an emerging topic, eco-innovation is not supported by any structured process. Eco-innovative products are sometimes created but they mainly result from economic and environmental constraints. A crucial question is thus the transfer of academic methods and tools towards industry.

**ENVIRONMENTAL NEW PRODUCT DEVELOPMENT THROUGH THE THREE DIMENSIONAL CONCURRENT ENGINEERING APPROACH****Mombeshora I.M., Dekoninck E.A., Cayzer S. / *University of Bath (GBR)*****1601**

Supported by concurrent engineering, three dimensional concurrent engineering (3DCE) is a simple yet powerful model of new product development (NPD) in which the traditional focus on an appropriate match between product and process is augmented by an additional consideration of supply chain configuration. This paper presents the results from an in-depth study of 3DCE theory, explores its impact on the integration of environmental considerations into the NPD process and maps its benefits onto environmental NPD.

**THE APPLICABILITY AND COHERENCE OF KEY PERFORMANCE INDICATORS IN GLOBAL PRODUCT DEVELOPMENT****Taylor T.P., Ahmed-Kristensen S. / *Technical University of Denmark (DNK)*****1703**

The potential risks and opportunities as a result of the decision to globalise product development requires the use of key performance indicators to measure and monitor the process, providing feedback on the performance. Research towards the selection and use of key performance indicators in global product development is relatively unexplored. With the results from a survey and workshop for industry, this paper contributes towards understanding the applicability and coherence between strategic level risks and opportunities with operational level key performance indicators.

Congress Hall Bobara

SESSION D222

19 May 2014  
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**TOWARDS IDENTIFYING PATTERN IN ENGINEERING DOCUMENTS TO AID PROJECT PLANNING**

**Shi L., Gopsill J.A., Snider C.M., Jones S.L., Newnes L., Culley S.J. / *University of Bath (GBR)* 1873**

The increasing complexity of current engineering projects causes uncertainty for project execution, and creates challenges for project design and management. To attempt to reuse the information of previously completed projects for current project planning, this paper introduces the definition of the "Engineering Document Pattern" (EDP), and proposes some EDP identification methods. EDP is really a form of knowledge and activity representation and as an approach is suitable for representing large scale projects, and can potentially be used to help decision makers understand the initial requirements and potential risks of current projects. The experimental study evaluates the EDP identification methods by analysing and profile some completed In-Service design repair reports, and the result shows the identified EDPs accurately represent the report-related project characteristics.

**SUPPORTING THE MODELING OF TRACEABILITY INFORMATION**

**Koehler N., Naumann T., Vajna S. / *Daimler AG (DEU)* 1811**

The paper analyzes the application of traceability approaches in the automotive industry. In the past years, original equipment manufacturers have struggled to handle the increased complexity of their mechatronic products. To demonstrate the technical capabilities of a well-defined traceability approach, a software prototype for the modeling of mechatronic systems was developed at Daimler's research department. This paper analyzes the prototype's functionalities qualitatively and quantitatively. The analyses confirm the need for additional research supporting the modelling of traceability.

**VISUALIZATION OF INFORMATION TRACEABILITY IN PRODUCT DEVELOPMENT**

**Martinec T., Pavković N. / *University of Zagreb (HRV)* 1831**

Presented research reports on usage of computer-based diagramming tools towards establishing and visualizing traceability of engineering information in product development processes. Diagrams have been used as means of information recording, and diagram networks as pathways for users to access requested information. Communication visualization, product structure and specification, and design rationale were recorded using diagrams. A new explorer environment has been developed in order to integrate diagrams into project documentation and automatically visualize networks of diagrams.

**INFORMATION MANAGEMENT IN PRODUCT DEVELOPMENT WORKFLOWS – A NOVEL APPROACH ON THE BASIS OF PSEUDONYMIZATION OF PRODUCT INFORMATION**

**Gerhard D., Reinauer G., Krumboeck A., Ljuhar R. / *University of Technology Vienna (AUT)* 1763**

Information stored in the documentation of a product constitutes in many aspects the intellectual property (IP) of an enterprise. This valuable knowledge, built over years of extensive research and development deserves special attention and protection. Especially the context of distributed product development activities and increased collaborations with external partners puts companies at a growing risk that unauthorized individuals obtain access to this prized capital. In this paper, we present a novel concept for managing and sharing sensitive information in product development processes. Product information is separated and subsequently pseudonymized into independent blocks of data fragments which can be reassembled to specific information levels depending on the requirements of the organization. Thus, a user can be given access to that level of information specifically required to complete the task. The product information itself is only available as unordered data fragments and no longer interpretable even in case of data theft. By doing so, a comprehensive protection against internal and external abuse of sensitive product information can be realized which can easily be combined with existing concepts in the field of information protection.

SESSION D223

Congress Hall Orlando

19 May 2014  
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11:15 - 12:45

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**DELIMITING INCLUSIVE DESIGN****Herriott R. / Aarhus School of Architecture (DNK)****2051**

This paper asks if Inclusive Design (ID) can be delimited by examining design for accessibility in the areas of assistive technology (AT) and public transport (PT) with reference to consumer product design. This paper takes product design, AT and PT as the key test areas of industrial design in its broadest sense, and it synthesises earlier work which considered (1) cases of ID and AT as reported in two major Inclusive Design conference series and (2) design processes in AT and PT. Synthesising these papers, the case is made that the extent to which users can participate directly in the design process determines how applicable Inclusive Design can be and in so doing separates the process (means) from its ends.

**MEASURING AESTHETIC IN DESIGN****Khalighy S., Green G., Scheepers C., Whittet C. / University of Glasgow (GBR)****2083**

Measuring aesthetics as a substantial part of design has not been considerably developed yet due to its qualitative nature. This research aims to develop a capable system in order to measure the defined qualities of aesthetics. This process is achieved by conducting design experiments in which eye-tracking technology is used as an objective tool to quantify the major qualities of beauty. The results of the experiments confirm the potential of using this approach in order to reach the ultimate model of aesthetic measurement.

**QUANTIFYING SHAPE DESCRIPTORS FOR AESTHETIC CONCEPTS****Zuniga M.D., Prieto P.A., Fantoni G. / Universidad Técnica Federico Santa María (CLE)****2187**

A new approach to quantitatively estimate the degree of perception of aesthetic concepts for object silhouettes is proposed. First, a survey has been conducted to obtain statistical measurements of the perception degree of the interviewees with respect to the opposite concept pair Gentle-Aggressive for a set of object silhouettes. Then, a new shape descriptor and the statistical measurement, associated to each silhouette, are utilized to train an artificial neural network. The obtained model allows predicting the perception degree of the studied aesthetic concepts for new silhouettes.

**SOUNBE, A TOOLKIT FOR DESIGNERS DEALING WITH SOUND PROJECTS****Dal Palu D., De Giorgi C., Astolfi A., Lerma B., Buiatti E. / Politecnico di Torino (ITA)****2011**

The theme of multisensory product experience appears to be today very up-to-date in the design research. But even if some senses such as sight and touch have been deeply examined, other senses such as hearing still represent a gap in the current scientific research. The purpose of this paper is to present an innovative tool conceived in aid to designers dealing with sounding objects, in order to integrate this aspect into the meta-projectual phase; furthermore, this work will demonstrate the validity of the cognitive investigation methodology applied to the sound perception in design.

Congress Hall Konavle

SESSION D224

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Monday20 May 2014  
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11:15 - 12:4521 May 2014  
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**LEARNING EFFECT EVALUATION OF AN EDUCATIONAL TOOL FOR PRODUCT-SERVICE SYSTEM DESIGN**

**Uei K., Fujiwara T., Nemoto Y., Shimomura Y. / Tokyo Metropolitan University (JPN)**

**1431**

In the design of a Product-Service System (PSS), it is important for designers to embrace the objective of amplifying the value of product by combining with services throughout its life cycle. To teach such viewpoints, the authors have developed a business game named "EDIPS." However, the learning effects through the game-playing have not been analyzed sufficiently. This paper analyses changes in players' cognizance through the game-playing and activity transition during the game-playing. On the basis of the results of analysis, the learning effect of EDIPS is evaluated and discussed.

**NEW APPROACH FOR DESIGN EDUCATION IN DESIGN FOR ADDITIVE MANUFACTURING**

**Junk S. / University of Applied Sciences Offenburg (DEU)**

**1391**

In addition to traditional methods in product development, the increasing availability of additive manufacturing AM technologies offer new opportunities in product development processes today. This contribution explores several ways in which AM can productively be used in education. New to this approach is amongst others that the students assemble and install the 3D-printers themselves. In two case studies is demonstrated how students in design education are able to autonomously research and realize technical possibilities and limitations of AM technologies, as well as economic constraints.

**HOW TO TEACH 3D CAD TO PRODUCT DESIGN STUDENTS PROVIDING INTEGRATED DESIGN EXPERIENCE**

**Kim K.M. / Ulsan National Institute of Science & Technology (KOR)**

**1399**

This article introduces a newly developed 3D CAD training course for industrial design students, including design rationales, course content and structure, as well as some pedagogical methods, and reports the results of the implementation with achievements throughout the course. The course is designed with three principles; 1) providing a holistic and integrated experience in product development, 2) adopting a designerly way of the formgiving principle and 3) employing top-down & bottom-up modelling strategies. Design educators and researchers could have insight into a better CAD education.

**PROTOTYPING WITH LASER CUTTERS IN LARGE ENGINEERING DESIGN CLASSES**

**Meboldt M., Lohmeyer Q., Leutenecker B. / ETH Zurich (CHE)**

**1411**

Laser cutters are small machine tools that process CAD data to accurately cut sheet material made of wood or acrylic glass. This paper investigates the question of how prototyping with laser cutters affects a first year engineering design project conducted in 2013 with 456 mechanical engineering students, who designed and manufactured more than 80 high-fidelity prototypes. Based on a document analysis of 456 individually written reflections on most important experiences during the project, six clusters of key learning are deduced and discussed by means of exemplary student statements.

SESSION D225

Congress Hall Šipun

19 May 2014  
Monday

20 May 2014  
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11:15 - 12:45

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22 May 2014  
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**VALUATION OF PRODUCT ADAPTABILITY IN ARCHITECTURE DESIGN****Schrieverhoff P., de Neufville R., Lindemann U. / *Technical University Munich (DEU)*****373**

The evolution of stakeholder needs and the resulting desire to adapt system properties to those needs is key to high lifecycle value of enduring systems. The paper contributes to the assessment of the decisive Key Parameters (KPs) of systems to determine the value of adaptability in technical systems in order to compare different architectures. Using Monte-Carlo Simulation the monetization of those performance criteria is performed under consideration of technological progress and uncertainty and the approach illustrated along an industrial example.

**DEVELOPMENT OF A VENDING MACHINE USING VIRTUAL COLLABORATION****Benedičič J., Krek J., Leben V., Velez Voros G., Beravs T., Potočnik S., Žavbi R. /*****University of Ljubljana (SVN)*****131**

This industrial paper describes development of an automatic vending machine with emphasis on the percentage of using various communication technologies. It was decided to use development done by a virtual team that would also include a couple of students. The presented case indicates that virtual team members should have appropriate technical and professional competencies. They should have an introductory face-to-face meeting, they should have good command of ICT use and should follow a systematic developmental process. These findings are in line with the findings of many virtual team studies.

**DEVELOPING NPD BEST PRACTICE THROUGH KTP INDUSTRY-ACADEMIA PARTNERSHIPS - A CASE STUDY OF HOWDEN****Fain N., Wagner B., Liu Y. / *University of Strathclyde (GBR)*****163**

This paper discusses a Knowledge Transfer Partnership project between University of Strathclyde and Howden, a UK based manufacturing company. The project aim is to develop a bespoke new product development (NPD) model for the company and the paper discusses the initial analytical steps undertaken to achieve this. Based on interviews with key stakeholders from the company a framework, resulting from in-depth literature study of NPD best-practices, is revised to fit the needs of the company and the relevance of resulting changes discussed.

**DIAGNOSIS OF CURRENT SMART HOME APPLIANCE DEVELOPMENT PROCESS FOR APPLICATION OF PSS DESIGN METHODOLOGY****Kim S., Baek J.S. / *UNIST (KOR)*****263**

This paper aims at exploring how Product-Service System (PSS) can contribute to Smart Home Appliance (SHA) development. The notion of the SHA is identified and the potential of adopting PSS to SHA development is discussed based on literature reviews. Existing SHA development process is diagnosed using a unified PSS development process and expert interviews with SHA development practitioners, leading to the discovery of the pain points of the existing SHA development.

**USING ECODSIGN GUIDELINES FOR CONCEPT EVALUATION: FINDINGS FROM AN EXPERIMENT****Midžić I., Štorga M., Marjanović D. / *University of Zagreb (HRV)*****313**

Research presented in this paper considers eco-evaluation of product's concepts. Literature review shows that there is a wide variety of analytic environmental methods and tools, but they are not ideally fitted for evaluation of products at their conceptual development stage. Analytical tools provide detailed and usually systematic analysis at specific stages of product development process or its life cycle. A case study that compares work of novice designers with and without ecodesign guidelines is presented.

**EMPIRICAL INDUSTRIAL STUDY OF THE COOPERATION OF TESTING AND DESIGN DEPARTMENTS****Karthauss C., Roth D., Binz H. / *University of Stuttgart (DEU)*****251**

In the literature, information recirculation is required to increase the efficiency and effectiveness of product development. The aim of this study was to investigate the state of the art of recirculation of testing knowledge in the industrial practice. 40 persons were interviewed. The information relevant for the engineers in design or testing departments was identified. Within the field of participants, it can be stated that the recirculation of testing knowledge in product development should be improved in many cases. The reasons for an insufficient use of testing knowledge were presented.

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## **MAPPING THE PRODUCT DEVELOPMENT PROCESS FOR DYSFUNCTION IDENTIFICATION**

**El Gamoussi S., Costa Affonso R., Cheutet V., Lelievre A. / *LISMMA-SUPMECA (FRA)* 1521**

In the current competitive industrial context, controlling and improving the Product Development Process (PDP) are of prior interest to meet the multiple customer requirements at the shortest time. To this purpose, it is necessary to understand the whole PDP, and identify dysfunctions to improve the process. Nevertheless, a lack of process mapping tool which take into account the PDP specificities is currently recognized. This article proposes a tool that models a process mapping in the PDP context, fitting the above requirement. Such tool is being deployed in our industrial partner.

## **IMPLEMENTATION ANALYSIS OF LEAN ENABLERS FOR MANAGING ENGINEERING PROGRAMS**

**von Arnim J., Oehmen J., Rebentisch E. / *RWTH Aachen (DEU)* 1713**

Lean thinking improves the success of engineering program management. The successful "Siemens PM@IA" project management maturity improvement program was analyzed for the way it incorporates 43 so-called Lean Enablers. The Lean Enablers, developed at MIT, not only improve engineering program management but can also be applied in organizational change programs. An implementation approach for the Lean Enablers based on a change program is presented in this paper. The Lean Enablers are grouped into seven topical Lean Program Management themes, which are suggested to be implemented in three phases.

## **ASSESSING AND MITIGATING RISKS OF ENGINEERING PROGRAMS WITH LEAN MANAGEMENT TECHNIQUES**

**Fritz A., Oehmen J., Rebentisch E. / *ETH Zurich (CHE)* 1531**

Large-scale engineering programs can suffer from a variety of serious risks, which can lead to delays or even complete failure. To address these risks the "Lean Enablers for Managing Engineering Programs" were developed. The method presented in this paper tailors these Lean practices to a specific program via a cost-utility analysis, where the benefits are found in risk mitigation by implementing Lean Enablers, with the costs of change as a side effect. Necessary data is obtained through a survey. A pilot test in two companies found the approach and the results to be useful and applicable.

## **TOWARDS CYCLE-ORIENTED TRACEABILITY IN ENGINEERING CHANGE MANAGEMENT**

**Chucholowski N., Wolfenstetter T., Wickel M.C., Krcmar H., Lindemann U. / *Technical University Munich (DEU)* 1491**

Engineering changes and requirement changes strongly interfere with each other. Traceability helps to formalize this interface on a process and organizational level. We propose a data model that includes information elements for different change stages and all related requirement artifacts, solution artifacts or production artifacts. It facilitates the access to necessary information about relations or dependencies between these artifacts. Hence, change effects can easily be estimated and relevant people/information for the decision about a change and its implementation can be identified.

## **TOWARDS A DECISION SUPPORT SYSTEM FOR ENGINEERING CHANGE MANAGEMENT**

**Niknam M., Huang E., Ovtcharova J. / *Karlsruhe Institute of Technology (DEU)* 1611**

With the growing complexity in product development processes, the rapid market alterations and the raising criticality of leadtime, the Engineering Change Management (ECM) is becoming important to all organizations. One of the primary challenges in this area is the management of all information associated with the change and taking a wise decision respectively. As the human brain, could only consider limited amount of variables at a time, this paper conceptualizes the development of a Decision Support System for ECM to utilize the past information for current decision making processes.

## **PRODUCT DEVELOPMENT IN CHINA: COMPARISON BETWEEN DANISH AND CHINESE COMPANIES**

**Li X., Ahmed-Kristensen S. / *Technical University of Denmark (DNK)* 1581**

The manufacturing industry is interested in emerging markets, together with gaps in literature point to the need of new knowledge about product development in China and other emerging lands. The paper presents the patterns and challenges of product development process in China through investigating the practice. A study was conducted through interviews in two Danish companies and four Chinese companies. The analyses also undertook a supporting investigation on product development organization with three insights: decision making, user involvement, and product strategy.

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## NATURALLY ORIGINAL: STIMULATING CREATIVE DESIGN THROUGH BIOLOGICAL ANALOGIES AND RANDOM IMAGES

Ahmed-Kristensen S., Christensen B.T., Lenau T. / *Technical University of Denmark (DNK)* 427

Numerous methods exist to support divergent thinking in creativity, Bioinspired design is one such method, where distant analogies are used to support the creative process. This paper focuses upon understanding the effects of using stimuli from biology as compared to other creative methods. The research is primarily interested in the benefit of using inspiration from biology for supporting engineering design, hence the effect of using biological analogies was investigated and rather than comparing this to no stimuli, random images were used as a control. Experiments were conducted with two industrial problems, and industrial participants. The experiment showed that it is possible to use distant analogies, i.e. biocards, to increase originality of the solutions.

## STIMULATION OF CREATIVE OUTPUT BY MEANS OF THE USE OF CREATIVITY TOOLS – A CASE STUDY

Yan Y., Jiang P., Squires A., Childs P.R.N. / *Imperial College London (GBR)* 633

In this paper, a theoretic framework was proposed on how to select the most appropriate creativity tools to stimulate designers' creativity in terms of the nature of the design task to be tackled, and the personality traits and preferences of the designers. This is illustrated in an engineering problem solving case study. The results were overall positive, many and diverse ideas were obtained although designers reported few challenges when using the creativity tools. The findings address the need to carefully choose creativity tools suited to designers' personality and the type of design task.

## EVALUATION OF THE EFFECT OF AN IDEATION SPACE ON DESIGN BRAINSTORMING SESSIONS

Dong Y., Mougenot C. / *Tokyo Institute of Technology (JPN)* 473

Because working spaces are now designed to supposedly foster creativity, we aimed at quantifying the effect of the physical environment on people conducting creative activities. Our experimental approach consisted in (1) designing a "creative space" (2) asking group of participants to conduct brainstorming sessions in a "normal" room (control condition) and in the "creative space" (3) assessing the creative performances and the subjective perception of the participants. The results show a higher "originality" score of generated ideas and a better perception, for the "creative space" condition.

## THE INFLUENCE OF CREATIVE SELF-EFFICACY ON CREATIVE PERFORMANCE

Brockhus S., van der Kolk T.E.C., Koeman B., Badke-Schaub P.G. / *Delft University of Technology (NLD)* 437

Creativity can be expressed within different forms of representations such as writing, painting or reasoning. This paper argues the influence of creative self-efficacy on creative performance, which was measured by conducting a questionnaire and an assignment on creative performance. The results were assessed on three categories of creativity: fluency, flexibility and originality. A statistical comparison between these categories and creative self-efficacy resulted in a correlation which induces that creativity can be increased by enhancing creative self-efficacy.

## A STUDY OF CREATIVE BEHAVIOUR IN THE EARLY AND LATE STAGE DESIGN PROCESS

Snider C.M., Dekoninck E.A., Culley S.J. / *University of Bristol (GBR)* 605

While the study of creative behaviour is important within design research, there has to date been little study of that within later-stage design; an issue due to its inherent differences to early stages. Through the results of two studies, this paper presents findings in two streams: firstly the differences between stages of design in relation to the behaviour within, and second to the nature of creative behaviour in late stage design itself. Through such understanding, there is potential to develop methods of support and education particularly appropriate to the late stage design situation.

## CREATIVITY IN TRANSACTIONAL DESIGN PROBLEMS: NON-INTUITIVE FINDINGS OF AN EXPERT STUDY USING SCAMPER

Moreno D.P., Yang M.C., Hernández A.A., Wood K.L. / *MIT (USA)* 569

Over the last three decades, transactional processes (services) have grown steadily and currently add more than 65% of global economic value. This study expands our understanding of designers' interactions with ideation methods using a heuristic method known as SCAMPER, focusing on a transactional design problem in a transactional domain expert of sample size (n=60). The study shows that design fixation is not shown to be effectively mitigated by the method; yet, despite this finding, resulting concepts have significantly higher novelty when compared to a non-assisted scenario.

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**COSTS IN MODULARIZATION APPROACHES: A CO-CITATION ANALYSIS**

**Ripperda S., Krause D. / *Hamburg University of Technology (DEU)***

**965**

Economic aspects of modular product structures can be considered under several aspects and is becoming a research trend of increasing interest. The purpose of this systematic literature review, based on a co-citation analysis, is to clarify the consideration of costs in modularization approaches. It gives an overview of research trends and gaps. Six different research focuses are identified. In summary, the integration of cost prognoses, cost assessment and cost reduction in one complexity cost management approach results to be an interesting challenge for further research.

**COMMON MODULE PRODUCT FAMILY DESIGN IN VIEW OF COMPROMISE IN FUNCTION AND INTEGRITY**

**Oizumi K., Aruga K., Aoyama K. / *The University of Tokyo (JPN)***

**945**

Common module design has been focused on the need to contend with an ever divergent global market. Although its ability to realize wide variety of product family are acknowledged, Japanese industries have not implemented very well due to concerns on loss of competitive edge. Japanese industries have advantages in their integral quality improvement - Suriawase. However, modular design may impede such Suriawase. This paper proposes a method for the design of module commonization structure of a product family that incorporates Suriawase. The case study is conducted on solar boats.

**METHOD TO INTEGRATE MODULAR PRODUCT ARCHITECTURE INFORMATION INTO STANDARD IT-SYSTEMS**

**Heilemann M., Culley S.J., Schlueter M., Lindemer V. / *University of Bath (DEU)***

**863**

Availability of product architecture information within companies is an important enabler for the transition toward modularisation. The aim of this paper is to present a method for integration of such information into standard IT-Systems. The method evolved from a requirement study in industry. It consists of introducing, classifying, relating product architecture items and adding modularisation data to those items. The application of the method results in an information model that supports engineers in designing a set of coherent modules from which a wide range of products can be derived.

**INVESTIGATING ON THE RISE OF MODULARITY DURING THE CONCEPTUAL DESIGN PHASE**

**Fiorineschi L., Rissone P., Rotini F. / *University of Florence (ITA)***

**811**

Literature acknowledges modular architectures to give rise to a series of positive effects, and advantages given by considering modularity early in the design process have also been inferred. However, current modularization methods operate only after, at least, a preliminary conceptual design process. But, although informally, modularity needs may arise also in such an early design phase. The aim of the present paper is to perform some preliminary investigations about a research approach aimed at analysing the occurrences of modularity issues during the concept design phase of a new product.

**FORECASTING OF FUTURE DEVELOPMENTS BASED ON HISTORIC ANALYSIS**

**Bauer W., Werner C., Elezi F., Maurer M. / *Technical University Munich (DEU)***

**735**

Due to a high required variety and changes in the environment, product platforms should represent a stable, unchanged core over its lifecycle. Flexible modules provide the product differentiation. We developed an three-step analysis and forecast approach: the first step includes a historic analysis of offered variants. Based on this, a prognosis of future developments is executed by mathematical models. In the last step, the previous results are compared to determine the dynamics of the characteristics for a robust product platform design. The approach is validated by an industrial case study.

**GENERATING A META-MODEL FOR MODULARIZATION METHODS**

**Hackl J., Gumpinger T., Krause D. / *Hamburg University of Technology (DEU)***

**821**

For handling complexity in product family design modularization methods exist, but often in isolation from each other. This paper contributes to consolidation of applied methods, analysing them for data acquisition needs and information flows. The methods' information flow is traced on an abstract level using multiple-domain matrices. This reveals the underlying scheme of each method, which enables comparison of different methods. By combining method schemes a common meta-model is extracted. Its evaluation indicates the core domains for modularization and the relations they are connected with.

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**MODELING BIOLOGICALLY INSPIRED DESIGN WITH THE C-K DESIGN THEORY****Freitas Salgueiredo C., Hatchuel A. / University of Evry/Renault (FRA)****23**

Biologically inspired design uses biological systems as a source of inspiration to improve technical ones. Based on three case examples of biologically inspired design modeled using the C-K design theory, this research disentangles the roles of the biological knowledge and of the traditional knowledge in the bio-inspired design process. The proposed model for bio-inspiration using the C-K framework shows in which ways this interplay leads to novel concepts and highlights different aspects of the engaged collaboration process.

**DEVELOPMENT OF A DATA CAPTURE TOOL FOR RESEARCHING TECH ENTREPRENEURSHIP****Andersen J.A.B., Howard T.J., McAloone T.C. / Technical university of Denmark (DNK)****1**

Startups play a crucial role in exploiting the commercial advantages created by new, advanced technologies. Surprisingly, the processes by which the entrepreneur commercialises these technologies are largely undescribed - partly due to the absence of appropriate process data capture tools. This paper elucidates the requirements for such tools by drawing on knowledge of the entrepreneurial phenomenon and by building on the existing research tools used in design research. On this basis, the development of a capture method for tech startup processes is described and its potential discussed.

**ANALYSIS OF EMPIRICAL STUDIES IN DESIGN RESEARCH****Toh W.X., Hashemi Farzaneh H., Kaiser M.K., Lindemann U. / Technical University Munich (DEU)****59**

To achieve scientific findings, design research relies on data – data which has to be collected in empirical studies. Design researchers have to choose between a multitude of data collection and analysis methods and a variety of possible study designs. But how to choose the most suitable methods and study designs? To learn from best practice, we analysed empirical studies in journal and conference publications. This provided insights with regards to successful use of data collection and analysis methods and study designs. Moreover, we observed “gaps” of data collection in design research.

**THE METHOD OF PHOTO-ELICITATION FROM A PHENOMENOLOGICAL PERSPECTIVE****Schaeffer J., Carlsson A.-L. / Maelardalen University (SWE)****49**

This article intend to discuss the use of photo-based interview methods in design research, more specifically if and how the Photo Elicited Interview is useful in getting information from interviewees about their relation to their workspaces and innovation. The article provides background theories from phenomenology and examples from an empirical study to discuss the method. It is discussed how PEI opens up a space for reflection, and the kind of stories that come forward: for example the relation between innovation, bodily experience, feelings, habits and physical space.

**CONCEPTIVE ARTIFICIAL INTELLIGENCE: INSIGHTS FROM DESIGN THEORY****Kazakci A.O. / Mines ParisTech (FRA)****33**

Can design research help AI? Design involves possibly the richest forms of reasoning, providing a privileged context for the study of intelligence. Yet, AI models are often used to describe design, and not the other way around. Based on previous research, the current paper offers a model of conceptive intelligence (CAI) that eludes current AI models – CAI is the capacity of an agent to continuously think of new objects (tasks, problems, etc) and to look for methods to realize or build them. Using our framework, we discuss major AI paradigms in their merits and shortcomings for modeling design.

**PROPOSAL TO IDENTIFY THE ESSENTIAL ELEMENTS TO CONSTRUCT A USER EXPERIENCE MODEL WITH THE PRODUCT USING THE THEMATIC ANALYSIS TECHNIQUE****Ariza N., Maya J. / Universidad EAFIT (COL)****11**

User experience, UX, has become very important to product design today as a way to add value and differentiate products. Many different UX models exist but most of them lack of empirical research through their construction, restraining a theoretical advance to support the creation of design methods for the UX. Consequently we used a qualitative structured method, thematic analysis, to identify the elements an UX model should consider. Eight main internally homogeneous and externally heterogeneous themes and 18 subthemes were found as the essential elements for a further UX model construction.

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**PROCEDURE MODEL FOR THE INDICATION OF CHANGE PROPAGATION**

**Helms S., Behncke F.G.H., Lindlöff L., Wickel M.C., Chucholowski N., Lindemann U. /  
Technical University Munich (DEU)**

**221**

Engineering changes (EC) are part of product development and are both source of innovation and costs. Their propagation challenges product development and occur wherever there are dependencies within the product and thus a change to one part of the system triggers subsequent changes in other parts. Literature provides numerous methods on Engineering Change Propagation (ECP) that apply to different scopes and intend to answer different questions. This paper aspires a procedure model for product developers as a guide to decide what method for ECP fits best to a certain application environment.

**TRANSFER OF METHODS FOR DEVELOPING MODULAR PRODUCT FAMILIES INTO PRACTICE – AN INTERVIEW STUDY**

**Beckmann G., Gebhardt N., Krause D. / Hamburg University of Technology (DEU)**

**121**

Many methods for developing modular product families exist in academia, but are rarely transferred into companies. This paper presents requirements on such methods from practice along with success factors of method transfer, which have been extracted from literature, form feedback of teaching workshops and from an interview study with designers and managers working in companies opposed by high product variety (further results of the interviews are presented in paper 303 of Design2014 conference). The findings are used to derive a framework to transfer methods into practice.

**TAILORING RISK MANAGEMENT APPROACH FOR THE PRODUCT DEVELOPMENT ENVIRONMENT**

**Škec S., Štorga M., Rohde D., Marjanović D. / University of Zagreb (HRV)**

**385**

The paper presents overview of the risk management practices and bridges different approaches for coping with risk issues within the product development (PD) environment. Existing risk management maturity (RMM) model is used to evaluate and monitor as-is RM situation in organizations, but also to set required objectives in terms of future RM practice. In order to expand a model and allow its usage for prescriptive purposes, the paper describes recommendations for tailoring RM process within the PD context. Proposed approach is preliminarily tested and validated through a case study.

**INTEGRATION OF DESIGN METHODS FOR THE PRODUCT GENERATION DEVELOPMENT OF ELECTRIC ENERGY STORAGE SYSTEMS**

**Albers A., Wagner D., Hammami W., Spadinger M., Höfler T. /  
Karlsruhe Institute of Technology (DEU)**

**101**

This paper presents an application and interconnection of design methods for the development of product generations in the context of Electric Energy Storage Systems (EESS). For this purpose a SysML model of the predecessor generation in a specific use case (pole side impact) is modeled using the Contact & Channel Method. In the presented case study this model serves as basis for an approach to prepare a topology optimization by calculating impact values and analyzing the available space. Therefore the identification of new concepts for lightweight system design and embodiment is facilitated.

**ANALYSING THE CONCEPT OF VALUE TO IDENTIFY RELEVANT STAKEHOLDERS' PREFERENCES TO DESIGN FOR ADAPTABILITY**

**Carro Saavedra C., Schrieverhoff P., Lindemann U. / Technical University Munich (DEU)**

**141**

The preferences of stakeholders susceptible to change are the source to determine future value and should therefore be given special attention in terms of designing them for adaptability. But value is a subjective term, whose meaning and quantification have been extensively discussed in literature and no consensus has been reached. This paper presents a structured description and characterization of value. It lays out a taxonomy of different dimensions to support a systematic value assessment in technical systems and increase the understanding of the benefits and outreach of adaptability.

**A MODEL OF TRANSDISCIPLINARY PRODUCT DEVELOPMENT IN AUTOMOTIVE INDUSTRY**

**Erenda I., Cerovšek M., Makovec I., Božič M., Geršič M., Koncilja P., Kralj S., Potočar Papež I.,  
Savšek T. / TPV d.d. (SVN)**

**1937**

The aim of the article is to present a model of an effective product development in the automotive industry based on the transdisciplinary approach and concurrent engineering. The intention of the article is also to identify possible correlation between level of emotional intelligence and intuitive decision-making among top and middle-level managers, and to present the use of business intelligence in the company. An important part of the model consists of a modern information environment which is consistent with the company's strategic goals.

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## DEPLOYMENT AND IMPLEMENTATION OF THE GRUNDFOS' SUSTAINABILITY STRATEGY BY MEANS OF THE ECODESIGN MATURITY MODEL

Pigosso D.C.A., Pattis A.T., McAloone T.C., Rozenfeld H. /

*Technical University of Denmark (DNK)*

1663

Companies are increasingly realizing the needs and opportunities for implementing sustainability into their business processes and corporate culture. This paper describes the approach followed by Grundfos to deploy its Sustainability Strategy for the development of Sustainable Product Solutions, by means of the Ecodesign Maturity Model (EcoM2), which included the diagnosis of their current maturity profile, the definition of a strategic roadmap for ecodesign implementation and the implementation of the defined projects.

## TRAPPED ON THE WASTE NET: A METHOD FOR IDENTIFYING AND PRIORITIZING THE CAUSES OF A CORPORATION'S LOW PRODUCT DEVELOPMENT PERFORMANCE

Pessôa M. V. P., Seering W. / *CISCEA (BRA)*

1641

This work describes a method for analyzing the Product Development Systems waste drivers and its causes. Although waste identification and elimination along the value chain has proven useful to PDS improvement, previous work focuses on the waste identification, rather than diagnosing the waste causes on a particular company. This work aims to fill this gap by proposing a method that determines the possible root causes to wastes on a project, and shows the expected wastes from the most common "problems in projects" faced by a particular enterprise.

## HOW GLOBAL TEAMS SHARE EXPERIENCES – A STUDY OF CULTURAL DIFFERENCES

Holmqvist J., Ericson A. / *Lulea University of Technology (SWE)*

1561

Experience sharing implies a diversity of issues related to processes, behaviours, people, technologies and culture. It is important to stress that those issues are not only framed by the organization, but also by the individuals' different backgrounds and positions. Having insights into the organizational as well as three national cultures at the case company, the paper shed light on knowledge conversations in global teams. This is done by using three perspectives, i.e. internal structure, external structure and individual competence.

## IDENTIFICATION OF FLEXIBLE DESIGN OPPORTUNITIES (FDO) IN OFFSHORE DRILLING SYSTEMS BY MARKET SEGMENTATION

Allaverdi D., Herberg A., Lindemann U. / *Technical University Munich (DEU)*

1451

In early phases of system design the offshore drilling industry faces significant uncertainties regarding the utilization of drilling rigs over their lifecycle. Nevertheless, the incorporation of flexible design is very limited in this industry. Drilling system suppliers must play a key role in introducing flexible systems but have to account for the market by customer dependent acceptability thresholds. This paper introduces a methodology for efficiently and effectively narrowing down the solution space of flexible designs based on a dedicated market segmentation approach.

## BOUNDLESS COLLABORATION - DISTRIBUTED CONCURRENT DESIGN IN AN INTER-REGIONAL COLLABORATION BETWEEN EMERGENCY AUTHORITIES

Nyström C.A., Asproth V.R., Persson Slumpi T., Olsson H. / *Mid Sweden University (SWE)*

1621

The aim of the article is to evaluate how Distributed Concurrent Design works during collaboration in a distributed system development project. We studied collaboration between emergency authorities in Sweden and Norway developing a demonstrator for emergency training. Evaluation criteria were people, processes, and tools. We have used a multi-method approach with the evaluation criterion as a lens. Findings has so far shown that distributed concurrent design works as a method in system development projects but much effort must be put on planning, management and training in available tools.

## DECISION MAKING IN GLOBAL PRODUCT DEVELOPMENT

Soendergaard E., Ahmed-Kristensen S. / *Technical University of Denmark (DNK)*

1683

This paper investigates the underlying reasons for decisions made in global product development cases that have failed or been changed over time. The research is based on a literature study combined with case data from Danish industry. The paper identifies a need for further research into decision making methods in a global product development context, in order to develop effective decision support tools for manufacturing companies involved in global product development.

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**TASK-DEPENDENT VISUAL BEHAVIOUR OF ENGINEERING DESIGNERS - AN EYE TRACKING EXPERIMENT**

**Lohmeyer Q., Matthiesen S., Meboldt M. / ETH Zurich (CHE)**

**549**

The paper presents an eye tracking experiment transferring the research approach of investigating the dependency of different tasks on visual behaviour into the context of engineering design. In contrast to conventional experiments, the stimulus is not a painting, but a 2D sectional drawing representing a technical system. In order to closely analyse the basic question of how different tasks influence the visual behaviour of engineering designers, the experiment is conducted by application of modern remote eye tracking systems and by participation of a larger sample of test persons (n=26).

**DEVELOPING THROUGH PROTOTYPING: A RESOURCE MATERIAL ON USER INVOLVEMENT FOR WORKSPACE DESIGN**

**Conceição C., Lundsgaard C., Broberg O. / Technical University of Denmark (DNK)**

**465**

This paper presents the prototyping process for developing a resource material in planning and performing participatory workspace design processes. This material brings up design dialogues into focus and gives insights on how to stage them, bridging the gap of merging user involvement with the well-defined design work-practice. The material was gradually built during a research project, including three workshops emphasizing joint exploration by designers. The result was a flexible resource material for designers as a tool to help building a participatory process specifically for each project.

**HUMAN-CENTRED EARLY PROTOTYPES OF CONSUMER PRODUCTS: INSIGHTS FROM HCI**

**Graziosi S., Ferrise F., Bordegoni M. / Politecnico di Milano (ITA)**

**507**

In the paper a point of view on the prototyping activity in the engineering design process is provided. The discussion is focused on early prototypes since they play a key role in determining the rejection or approval of an idea. What is the specific design dimension the prototype should render according to the interested audience? What is the right prototyping technique to use? The authors answer to these questions combining the insights derived by their experience on virtual prototyping and the ones coming from the Human Computer Interaction (HCI) community.

**INFORMATION PROCESSING THEORY IN THE EARLY DESIGN STAGES**

**Cash P.J., Kreye M.E. / Technical University of Denmark (DNK)**

**455**

The aim of this paper is to explore the applicability of Information Processing Theory (IPT) for understanding empirical designer activity in the early design stages. Critically we investigate the relationship between uncertainty perception, information seeking, and knowledge exchange in design teams using an experimental study of student engineers. Ultimately the results show that IPT is indeed a useful theory and we highlight a number of key implications for the field.

**ISSUE OF USING STUDENTS AS TEST USERS – SOME FINDINGS IN VE TESTING**

**Tiainen T., Ellman A. / Tampere University of Technology (FIN)**

**615**

In designing prototypes in virtual environments (VE) it is common practise to use students as test users. This paper outlines if this approach gives relevant information. The issue is analysed through three alternative test cases by comparing student's and other test user's behaviour. The first case compares user's evaluation of the sizes of physical and virtual products. The second case studies user's locomotion in VE. The third case focuses on operating a virtual mobile work machine. This paper outlines the issues and possibilities on using students as test users.

**CHOOSE THE RIGHT MATERIAL! EXPERT AND USER INTERACTION IN PARTICIPATORY DESIGN**

**Donati C., Vignoli M. / Università degli studi di Modena e Reggio Emilia (ITA)**

**623**

The only way to create a shared understanding of an idea in the design process is to convert it in a tangible prototype. This paper investigates how the tangibility level of a prototype can affect the interaction between designers and end users. We found that the sequence of prototyping materials to use for each phase of the design process depends upon the end user. Things such as age, background and personal skills are very important in choosing the right material. Less tangible prototypes works in brainstorming while ones that are more tangible are perfect for the testing phase.

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## SERVICE DESIGN FOR DEATHCARE: SOCIAL INNOVATION THROUGH GAMIFICATION

Woo J., Choi Y., Jordan P.W. / *Brunel University (GBR)*

1015

The main purpose of the paper is to present a design approach based on a role-playing game through avatars, that explores a new concept of Death Care Service (DCS). In this research, the elements of design and gamification were exploited to change the mindset of death positively for people living the most of life. This research underpinned to trigger design discourse around death in communities as a breakthrough for social problems via a game. DCS is re-defined as a platform to draw people in conversation beyond a communication tool. Hence, the game-based learning can be of value for everyone.

## AN INTEGRATED PRODUCT DEVELOPMENT MODEL FOR AIRCRAFT FOOD DISPENSING MACHINES

Fenech G., Farrugia P. / *University of Malta (MLT)*

801

The aim of this research is to generate an Integrated Product Development (IPD) model aimed specifically at developing aircraft food dispensing machines (AFDM) to be retrofitted into the galley of a commercial aircraft. The developed model, recognised as AFDM\_IPD, consists of six phases and although it is based on already established design and IPD principles, it is being represented in a completely unique way, through a simple IDEF0 modeling language syntax. The major benefit of using IDEF0 is that it applies dynamic information into the model to handle problems involving parallel activities.

## A REAL-WORLD EXPERIENCE OF PRODUCT-SERVICE SYSTEM DEVELOPMENT FOR INTELLIGENT LED SYSTEM

Baek J.S. / *UNIST (KOR)*

721

Despite governmental supports to facilitate the growth of ESCO industry in South Korea, the industry has suffered from stagnancy over the past decade. The development of business models with improved economic viability and environmental sustainability through PSS design is thus supported. The paper introduces the process of developing sustainable PSS for LED luminaires from stakeholders' needs analysis to generation of PSS concepts. It provides insights to policy makers, manufacturers and ESCOs who are interested in supporting or developing new services for LED.

## GFBS: A PSS DESIGN MODEL APPLIED TO THE BRIEFING PROCESS OF CONSTRUCTION PROJECTS

Mauger C., Dantan J.-Y., Dubois E. / *Public Research Center Henri Tudor (LUX)*

905

A building can be considered as a PSS with a product part (i.e. the building) and a service part (i.e. human-intensive activity). Its requirements definition consists inter alia in defining which part will assume the different functions to provide, alone or in an integrated way. Existing design models in architecture do not fully support the service part of buildings. This paper crosses the concepts of PSS, Goal, and FBS approach in a design theory to support such requirements definition. This design theory is illustrated ex post facto on the requirements definition of a school building.

## A METHOD FOR ASSESSING THE INNOVATIVENESS OF PRODUCT-SERVICE SYSTEMS

Schenkl S.A., Elser H., Nilsson S., Ölundh Sandström G., Mörtl M., Srinivasan V. / *Technical University Munich (DEU)*

985

Innovativeness is commonly accepted as a strong competitive advantage, which even enables companies to gain new market shares. One strategy towards more innovative market offers is to combine products with services. These so-called Product-Service Systems (PSS) integrate product and service components in one market offer. This paper proposes a method for assessing innovativeness of PSS concepts in terms of novelty, usefulness and market success. Further the applicability of the method is demonstrated by applying it in two case studies within a student project.

## COMPARING LCC WITH LCA TO ASSESS PSS SUSTAINABILITY: THE CASE OF THE ECO-BOX

Chong K.N., Dreijer L.S., Howard T.J., Birkved M., Kreye M.E., Bey N., McAloone T.C. / *Technical University of Denmark (DNK)*

783

Product/Service-Systems strategies are increasingly proving to be a source of competitive advantage and environmental improvement for engineering companies, the main hypothesis being that PSS should allow to decouple functionality, user satisfaction and financial income on the one hand, from the total environmental impact of the function-delivering technology on the other. This paper describes an integration of Life Cycle Assessment (LCA) and Life Cycle Costing (LCC), in an attempt to see if the two life cycle elements are related.

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**SIMULATING GLOBAL UTILITY OF DESIGN SOLUTIONS TO ELDERLY FALLS BY BUILDING RELEVANT USAGE SEGMENTATION****Bekhradi A., Yannou B., Farel R., Jena S., Zimmer B. / *Ecole Centrale Paris (FRA)*****1025**

Usage coverage simulations are proposed for evaluating the global effectiveness of design solutions for the widespread issue of the elderly fall. A Design Oracle is set to simulate the usage segments, or space, based on experts' heuristic rules in a declarative way. For this usage scenarios space, two existing design solutions are evaluated in terms of real performances vector. Comparing solutions' performances with the ideal performances, i.e. where there are no pain points, shows that there are important "value buckets" to be covered by innovative solutions, maximizing the utility creation.

**DESIGNING AND SIMULATING SMART HOME ENVIRONMENTS AND RELATED SERVICES****Peruzzini M., Capitanelli A., Papetti A., Germani M. / *Universita Politecnica delle Marche (ITA)*****1145**

Nowadays smart homes allow achieving higher performances and support the users' everyday life by device cooperation and related service. However the simulation of their behaviour is neither investigated. This paper presents a smart home reference model able to represent the home items and defines an information management model to support design and simulation of its devices as well as the enabled services. The paper describes the tool application on a real use case, where a smart home is modelled and services simulated to support smart home design.

**TRIPLE HELIX IDEATION: COMPARISON OF TOOLS IN EARLY PHASE DESIGN PROCESSING****Wendrich R.E. / *University of Twente (NLD)*****1229**

This paper presents a case study on design interaction and processing incorporating triple tool modalities. The methodology and processes applied are directly related to our research and exploration of new design tools, mixed reality, user-interfaces and user experiences based on a holistic framework and learning-by-doing approach in early phase design processing. We deployed three separate collaborative design-task tests based on the same problem definition. We studied the correlation between the ease of tool use, tool performance, tool satisfaction, tool expectations and experience.

**INTUITIVE VIRTUAL REALITY - CAD ASSEMBLY SYSTEM****Fechter M., Miehl J., Stangl T., Wartzack S. / *Friedrich-Alexander University Erlangen (DEU)*****1053**

The application of virtual reality during the design engineering process possesses the potential to experience and to interact with virtual products in a natural and intuitive manner. Some workflows in the field of computer-aided design, like assembling components, exhibit disadvantages that result from the two-dimensional vision and the limitations of common human-computer interaction. To support the design engineer, this paper focuses on developing a framework that harnesses the benefits of intuitive gesture based hand interaction and stereoscopic visualisation.

**PROPOSAL OF A DESIGN SUPPORT TOOL FOR EMPLOYEES TO REPRESENT SERVICES****Watanabe K., Fujimitsu S., Harada Y., Niino Y., Kobayakawa M., Yamada K., Sunaga T., Sakamoto Y., Nishimura T., Motomura Y. /*****National Institute of Advanced Industrial Science and Technology (JPN)*****1219**

Recently, various service design methods and tools have been developed and introduced into actual service fields. Meanwhile, many of service firms do not have sufficient financial and human resources to apply them. It is expected that employees in a service field could examine and redesign their work independently. For this purpose, it is necessary to support their design activity. The authors propose a design support tool to encourage employees to present their work and design ideas. The authors explain its functionality, features and its trial results.

**KEY PROCESS VARIABLE DRIVEN MANUFACTURING PROCESS SELECTION****Tuckwood M.S.C., Conway A.P., Whitfield R.I. / *University of Strathclyde (GBR)*****1209**

In some cases, manufacturers may have buy-to-fly ratios of less than 20%, prompting questions as to whether the most efficient manufacturing process is being selected in the design stage. There is a lack of objective pre-selection techniques and a need for a quick, broad and comparative study using key variables to assess potential processes. Proposed is a flexible down-select methodology that addresses this requirement while offering traceability and justification to the decision-maker. The need within the aerospace sector has been validated, while identifying scope for future development.

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WEDNESDAY, MAY 21					Hours	
REGISTRATION					08:00	
D311 APPLICATION OF DESIGN MODELS AND METHODS	D312 ECO-DESIGN IMPLEMENTA- TION	D313 SIMULATIONS WITHIN COMPLEX SYSTEMS	D314 PRODUCT DEVELOPMENT MODELS	D315 SOCIO- TECHNICAL ISSUES	08:15	CONGRESS HALL RAGUSA
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REFRESHMENT BREAK					10:15	
D3-P PLENARY SESSION II + DESIGN DEBATE					10:30	CONGRESS HALL BOBARA
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LUNCH					12:15	CONGRESS HALL ORLANDO
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D331 DESIGN FOR X	D332 KNOWLEDGE MANAGEMENT	D333 USER CENTRED DESIGN	D334 SOCIETAL CHALLENGES	D335 MODELLING AND SIMULATION IN INDUSTRIAL DESIGN	14:00	CONGRESS HALL KONAYLE
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REFRESHMENT BREAK					15:15	CONGRESS HALL SIPUN
			MEETING: COLLABORATIVE DESIGN RESEARCH METHODOLOGIES	MEETING: DISCUSSION OF PD TEACHING ACTIVITIES	15:30	
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**ESTIMATING UNCERTAINTY OF SCALED PRODUCTS USING SIMILARITY RELATIONS AND LAWS OF GROWTH****Lotz J., Kloberdanz H., Freund T., Rath K. / *Technical University Darmstadt (DEU)*****273**

This paper presents an approach to address size dependent uncertainty occurring in size range development. A brief introduction of handling estimated uncertainty using scenario based laws of growth is given. Monte Carlo simulation is used to determine the size dependency of stochastic uncertainty in size range products. The results of best- and worst case scenario laws of growth are compared to the results generated using the stochastic approach. Guidelines for the designer of how to face size-dependency of uncertainty are proposed.

**APPLICATION OF THE IFM FRAMEWORK FOR MODELLING AND ANALYSING SYSTEM FUNCTIONALITY****Eisenhart B., Gericke K., Blessing L. / *University of Luxembourg (LUX)*****153**

Recently, the concept of an integrated function modelling IFM framework has been proposed, which aims at integrating different perspectives prominent in function modelling across disciplines. It provides a clearly structured, DSM-based modelling approach. In this article, function modelling with the framework is illustrated based on an exemplary system. Furthermore, the potentials for function analysis that result from the framework's matrix-based setup are explored. Finally, the paper discusses the implications for application of the framework in practice.

**FURTHER DEVELOPMENT OF TRIZ FUNCTION ANALYSIS BASED ON APPLICATIONS IN PROJECTS****Münzberg C., Michl K., Heigl H., Jeck T., Lindemann U. / *Technical University Munich (DEU)*****333**

This paper presents an adaptation of the TRIZ Function Analysis to increase the interpretability of function models. An introduction to the TRIZ Function Analysis is given. With the application of Function Analysis in projects interpretability problems in terms of the abstract system representation occurred. To overcome these problems a graphical adaptation which links the graph model with a system illustration is introduced. The application evaluation of the adapted TRIZ Function Analysis in two student projects is presented. Concluding further ideas to improve the approach are discussed.

**ENERGY REPRESENTATION VIA DESIGN FUNCTION STRUCTURE FOR MULTI-ATTRIBUTE OPTIMIZATION OF TRACTION ELEVATOR SYSTEMS****Markos P.A., Dentsoras A.J. / *University of Patras (GRC)*****303**

The concept of a new design method for energy-efficient electromechanical systems is proposed. According to that, the function structure of a system represents the energy flows and conversions performed between its subfunctions. A systematic procedure leads to the design parameters that affect the energy consumption for its basic function. These are correlated with the parameters that affect service performance. The values of all that parameters are defined by computational intelligence methods so that optimum overall efficiency is obtained. Traction elevators are used as a case study.

**FBS ONTOLOGY TO EXTEND THE EFFICACY OF 40 TRIZ INVENTIVE PRINCIPLES****Russo D., Spreafico C. / *University of Bergamo (ITA)*****363**

The TRIZ inventive principles are a set of problem solving guidelines universally tested and accepted by academic and industry. This article offers a review of this tool through the formalism of Function Behaviour Structure theory in order to enlarge the resolutive space and increasing at the same time the user's awareness about the solutions found. It is further proposed a test running on engineering students and researchers, based on the comparison between the original and the reformulated principles, for the resolution of two case studies.

**THE DILEMMA OF MORPHOLOGICAL ANALYSIS IN PRODUCT CONCEPT SYNTHESIS – NEW APPROACHES FOR INDUSTRY AND ACADEMIA****Heller J.E., Schmid A., Löwer M., Feldhusen J. / *RWTH Aachen (DEU)*****201**

Morphological analyses are used for researching and subsequently combining various individual solutions to one overall solution in the course of product development. Its application is often challenging. The paper discusses the dilemma of morphological analyses in detail and reviews the reasons for this. Optimisation approaches and algorithms are presented and investigated. A new approach that focuses on choosing the right elements rather than optimising the shape of the box and its implementation in a software prototype is presented. It is achieved by introducing two quality indicators.

Congress Hall Ragusa

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**THE ROLE OF RELIABLE INFORMATION AND PACKAGING ON SUSTAINABLE CONSUMPTION IN CHILE, A DEVELOPING COUNTRY**

**Cereceda G., Betancourt Velasco M.C. / Icesi University (COL)**

**1483**

A field study to identify the role of environmental certification and design factors that influence sustainable purchasing of Chilean consumers decisions, was made. A mixed quantitative and qualitative environmental communication strategy was designed and applied in to a product packaging prototype, testing it on a comparative survey. Result defined that, the use of environmental believable quantitative information mixed with a qualitative governmental certification, combined with the use of an ecological packaging were effective, increasing the sustainable purchasing on Chilean consumers.

**SYSTEMATIZATION OF BEST PRACTICES FOR ECODESIGN IMPLEMENTATION**

**Pigozzo D.C.A., McAloone T.C., Rozenfeld H. / Technical University of Denmark (DNK)**

**1651**

Despite the recognition of ecodesign potential benefits, its application has not reached companies over the last decades mainly due to difficulties in ecodesign implementation and management and lack of a systematization of existing practices. In order to support companies in dealing with those challenges and provide a structured classification of ecodesign practices, a systematic literature review was performed for the identification and classification of the existing practices, supporting the selection of the most suitable ones according to companies' specific needs and characteristics.

**INTEGRATION OF ENVIRONMENTAL CRITERIA IN THE CO-DESIGN PROCESS: CASE STUDY OF THE CLIENT/SUPPLIER RELATIONSHIP IN THE FRENCH MECHANICAL INDUSTRY**

**Michelin F., Vallet F., Reyes T., Eynard B., Duong V.L. / Université de Technologie de Compiègne (FRA)**

**1591**

This paper investigates how the environment is taken in account in the client/supplier relationship. This issue is particularly important given the growing influence of suppliers' design choices on the environmental performance of the client's product. An empirical study has been performed with twenty companies of the French mechanical industry from SMEs to large multinational companies. The survey highlights the weakness of environmental information exchanges between the different actors, yet comitted in the same design process at different levels.

**THE INFLUENCE OF ALTERNATIVE RECYCLING PROCESSES ON EMPLOYEE NUMBERS**

**Coric M., Lommatzsch N., Kloberdanz H., Birkhofer H. / Technical University Darmstadt (DEU)**

**1511**

The designer of sustainable products has to require economic, ecological and social goals. Based on a mass-flow specific model, the influence of alternative recycling processes for metal offcuts as by-products of manufacturing on the number of employees in single value-added steps is shown. The model of employment variation in industry based on alternative recycling shows the impact of designer's decisions. The number of employees as a cost driver and as an indicator of the social dimension of sustainability can be used as decision support for or against alternative recycling processes.

**SUPPORTING ECO-DESIGN IMPLEMENTATION WITHIN SMALL AND LARGE COMPANIES**

**Buckingham M., Pigozzo D.C.A., Dekoninck E.A., McAloone T.C. / University of Bath (GBR)**

**1473**

There is a need for a strategic and systematic approach towards eco-design implementation. By bringing together two case studies (one in a SME, the other in a multi-national company) this paper examines the impact of the organisational context and chosen eco-design implementation methodologies. As well as providing empirical evidence of the opportunities and challenges faced in these two industrial contexts, the paper also highlights important generalities and differences. The learning outcomes are relevant to researchers and industry managers engaged in eco-design implementation.

**EXPLORING STAKEHOLDER-CENTRED TOOLS TO IMPROVE THE MATURATION OF THE FRONT-END OF ECO-INNOVATION PROCESS (FEEI)**

**Real M., Lizarralde I., Tyl B., Legardeur J., Millet D. / IMS-ESTIA/APESA (FRA)**

**1671**

Eco-innovations fosters organizational ruptures which involve to rethink the network of stakeholders from the early stages of development. Actually, there is a lack of tools to support the identification and the construction of new stakeholder's networks during the front end of eco-innovation (FEEI). In this paper, we propose a study to test the effect of different stakeholder-centred tools during the maturation of FEEI process. In future research, an interactive stakeholder-centred toolkit will be designed and tested to improve the management of FEEI.

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## AN APPROACH TO NONLINEAR BEHAVIOUR PREDICTION OF TECHNICAL SYSTEMS

Osman K., Štorga M., Marjanović D. / *University of Zagreb (HRV)*

1307

The objective of the research presented in this paper is to develop an approach modeling and predicting the nonlinear behaviour of complex technical systems in the operating environment, based on a presentation of the system's dynamic behaviour and recording of such behaviour by using the rules. This approach should help develop new architectures of nonlinear complex systems and improve existing ones, by mapping in both directions, from the structural to the behavioural domain and vice versa. Verification of this approach is presented on the example of a load lifting device.

## SIMULATION-BASED CONCEPT GENERATION FOR MECHATRONIC SYSTEMS

Dohr F., Vielhaber M. / *Saarland University (DEU)*

1271

Simulation has become an indispensable part in engineering design for evaluation purposes. Despite that, simulation has not been fully integrated into design methodologies yet. Hence the authors developed a simulation-based design framework for mechatronic systems. In this paper the framework is validated for the conceptual design phase by demonstrating its application on the development of a mechatronic system. This includes concept generation and evaluation through several levels of system simulation. Finally, the results of the validation are discussed and open issues are identified.

## EVOLUTION OF INFORMATION CONTROL AND CENTRALISATION THROUGH STAGES OF COMPLEX ENGINEERING DESIGN PROJECTS

Parraguez P., Eppinger S.D., Maier A.M. / *Technical University of Denmark (DNK)*

1329

This paper investigates how to identify potential misalignments between actual and expected information flow patterns among activities at each design stage. We develop a dynamic network model that quantifies how much information control each activity has over time and how the overall control of information is distributed among activities. The model is applied to the design of a biomass power plant. As a result we demonstrate an empirical relationship between information control patterns and design process stages that can be used to guide information flow improvements.

## INTERACTION BETWEEN COMPUTER-BASED DESIGN ANALYSIS ACTIVITIES AND THE ENGINEERING DESIGN PROCESS – AN INDUSTRIAL SURVEY

Eriksson M., Petersson H., Bjärnemo R., Motte D. / *Lund University (SWE)*

1283

In the large majority of product development projects, computer-based design analyses are performed to assess the feasibility of potential technical solutions. As a first step to bring about a deeper understanding of the interactions between the engineering design and the design analysis activities, a survey has been performed in industry. The results of the survey cover: the use of design analysis within product development, the interactions of engineering design along the design analysis process, and the treatment of uncertainties and errors connected to the design analysis activities.

## CONCEPTUAL BLIND SPOTS IN COMPLEX SYSTEM ENGINEERING PROJECTS – A COMPUTATIONAL MODEL

Thomas R.C., Gero J.S. / *George Mason University (USA)*

1361

This paper presents an approach to studying how conceptual blind spots emerge in complex system engineering projects—i.e. when the value systems and conceptual schemas of collaborating teams are incongruous and not seen. It uses methods derived from computational social science founded on agent-based modeling using social agents. The paper describes the agents and their capabilities, and also a NetLogo implementation of an abstracted version of a space launch system. Agents choose how much to invest in discovering unknown dependencies. Results are portrayed in a Design dependency matrix.

## APPROACH FOR SCENARIO-BASED TEST SPECIFICATIONS FOR VIRTUAL COMMISSIONING

Schneider M., Gausemeier J., Schmüdderrich T., Trächtler A. /

Heinz Nixdorf Institute, University of Paderborn (DEU)

1339

Growing competitive pressure requires the companies to plan their systems without cost-intensive iteration loops. A promising approach for decreasing the commissioning time is the virtual commissioning (VC). The primary objective of VC is the validation of the system's control program due to the fact that correcting software errors is the time-consuming part during commissioning. For this reason, the approach for scenario-based test specifications enables the verification of the control program regarding desired and undesired system behaviour at an early stage of the development process.

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**PRODUCT LIFE CYCLE DISPOSITION MODEL**

**Halonen N., Lehtonen T., Pakkanen J., Juuti T., Ellman A., Riitahuhta A. /  
Tampere University of Technology (FIN)**

**831**

This paper introduces Product Life Cycle Disposition Model (PLDM), which is an explanatory model to improve the understanding of dispositional mechanisms within product development projects to support the decision making process. PLDM explains the dispositional mechanisms between product characteristics and product life cycle characteristics and represents a process to manage these dispositions. The initial model is constructed based on a literature review and is further developed in a pilot study with a company from the Finnish manufacturing industry.

**DESIGN OF PRODUCT DEVELOPMENT PROCESS: A MULTIPLE CASE STUDY OF MEDIUM-SIZED ENTERPRISES**

**Lavayssiere P., Blanco E., Le Dain M.-A., Chévrier P. / Grenoble University (FRA)**

**873**

In order to innovate better and faster, enterprises can work on their product development process (PDP). The literature provides several PDPs, but also recommend to adapt these processes to the specificities of each enterprise. The aim of this paper is to analyze how the product development process and its formalized representation stemmed from the literature are appropriate for medium-sized firms. We studied the PDPs of three SMEs and made a cross-case analysis. The PDP and its representation enhanced the performance on projects with clear specifications but hindered innovative developments.

**ACTOR-BASED SIGNPOSTING: A SOCIAL PERSPECTIVE ON MODELLING DESIGN PROCESSES**

**Hassannezhad M., Cantamessa M., Montagna F. / Politecnico di Torino (ITA)**

**841**

As a central issue in design research, there currently is no generic and overarching model than can satisfy common features on various design processes (DPs). The objective of providing actionable DP modelling frameworks that can be of practical use to design managers provided us to propose Actor-Based Signposting (ABS) as an extension of this established process modelling framework, and as a novel and integrated viewpoint on modelling DPs with a specific attention being cast on understanding the behaviour of actors involved in DP, along with their mutual influences as a source of uncertainty.

**IMPLEMENTATION OF IDEA PROCESSES IN THE SPECIFIC CONTEXT OF BUSINESS PRACTICE**

**Messlerle M., Binz H., Roth D. / University of Stuttgart (DEU)**

**915**

In business practice, a large number of problems exist relating to idea processes, despite the fact that many proposals for idea processes and associated methods can be found in literature. The adaption of existing idea processes to the specific circumstances in a company is one possibility to solve these problems. Therefore, a procedure especially for the implementation of an idea process in companies is developed in this contribution based on the state of the art in terms of implementation processes in general. Additionally, the results of an initial evaluation are shown.

**SUSTAINABLE PRODUCT-SERVICE DESIGN IN MANUFACTURING INDUSTRY**

**Peruzzini M., Marilungo E., Germani M. / Università Politecnica delle Marche (ITA)**

**955**

The interest of manufacturing enterprises in Product-Service systems (PSS) is growing to achieve new strategic advantages and greater earnings. However, companies still adopt product-centred design processes and lack of methods and tools to handle the relations between tangible and intangible items and manage a multifaceted design process involving multiple stakeholders. In this context, the paper proposes a methodology to support the design of manufacturing of PSS. It is demonstrated by an industrial case study focusing on a service-enhanced mechatronic appliance.

**A METHOD FOR THE SITUATION-SPECIFIC EVALUATION OF PRODUCT DEVELOPMENT PROCESS MODELS**

**Heck J., Braun A., Meboldt M. / ETH Zurich (CHE)**

**851**

There is a broad range of PDP models, and decision-makers face the problem how to identify the best-suited model for the specific situations of their organisations. Based on a literature search for requirements and influences to be considered in a PDP model evaluation, 33 criteria are established, and a eight-step evaluation method is described. The method is positively evaluated by academic experts, and is successfully applied on 3 PDP models in 2 case studies. It is highlighted that influences on and requirements for PDP models can vary in industrial product development situations.

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## DESIGN FOR AN OPTIMAL SOCIAL PRESENCE EXPERIENCE WHEN USING TELEPRESENCE ROBOTS

Bamoallem B.S., Wodehouse A.J., Mair G.M. / *University of Strathclyde (GBR)*

653

The use of telepresence robots in social environments is increasing. It is therefore important to create an optimal social presence experience for anyone interacting with the robot and the vicariously present operator. Engagement behaviour is seen as an important aspect of this. This paper reviews relevant research in the social presence field that can be used to inform the design of telepresence robots and enhance engagement. It also considers existing telepresence robot designs, and suggests further research into the human-telepresence robot interface.

## THE REFLECTIVE DESIGNER: A DISCUSSION ON ETHICS BASED ON END-USER INVOLVEMENT IN KEBRI BEYAH REFUGEE CAMP

Nielsen B.F. / *Norwegian University of Science and Technology (NOR)*

689

Involving end-users in the design process is rare, and end-user access in humanitarian relief settings is often hindered partly due to ethical considerations. Contextual challenges unpredictably interfere with the execution of end-user research conducted in Kebri Beyah refugee camp and demanded continuous reflection, readjustment and improvisation from the design team. Designers could benefit from a more ethically reflective design practise that makes them able to think about ethics 'in action' and design in a more conscious manner. This ethical reflection however, is strengthened in context.

## ONLINE COLLABORATION SYSTEM FOR PRODUCT DEVELOPMENT IN VALUE CHAINS OF SMALL AND MEDIUM MANUFACTURING ENTERPRISES

Jung S.-Y., Choi H.-Z., Oh J., Kim B.H. / *Korea Institute of Industrial Technology (KOR)*

673

Small and medium manufacturing enterprises are making multifaceted efforts to survive the change in the manufacturing paradigm, but they face many difficulties due to changes of manpower, lack of capital, poor technology, and other factors. This study examines the definition and classification of collaboration in various aspects above all and describes how collaboration types to affect collaboration activity. Our research group has developed and operated an Online Collaboration-Hub for SMMEs of a value chain to conduct the collaboration without any constraints of time and space.

## SCENARIO ANALYSIS OF RENEWABLE ENERGY BUSINESSES: A CASE STUDY OF WOODY BIOMASS IN A JAPANESE RURAL COMMUNITY

Kishita Y., Nakatsuka N., Fuchigami Y., Akamatsu F. / *Osaka University (JPN)*

679

Toward realizing a low-carbon society, much attention is paid to renewable energy businesses. To clarify conditions for economically sustainable renewable energy businesses, this paper undertakes scenario analysis for evaluating the profits of the business. We carry out a case study regarding a woody biomass energy business in a Japanese rural community. The results reveal that the business becomes economically feasible if the current feed-in tariff (FIT) scheme is maintained. Also, the usage of wood residues for producing wood pellet and electricity results in reducing the disposal cost.

## DESIGN THROUGH FAILURE: A NETWORK PERSPECTIVE

Ellinas C., Hall M.J., Hultin A. / *University of Bristol (GBR)*

663

Sociotechnical systems are central in the way our modern society is structured. Thus, understanding their global reaction to local failures is of great importance. Within the context of cyber-security, a worst case scenario of random and targeted attacks is numerically simulated in order to evaluate the resilience of three distinct system architectures. Of special interest is the capacity to provide early -warning signs and the trade-off between resilience and efficiency, in terms of the underlying architecture. The paper concludes with design implications based on the evidence presented.

## EMERGENT TRENDS IN THE DESIGN ECONOMY AND THEIR IMPACT ON CONSUMPTION, PRODUCTION AND DESIGN

Petrova M.N. / *University of Forestry (BGR)*

701

The paper presents an overview of the key factors shaping the new social and technological paradigm shift. It aims to identify the emerging agents of innovation, to describe the impact they have on design so far and to outline possible future perspectives. Results of the research are presented in scenarios for the development of consumption, manufacturing and design. In conclusion implications about the role of design as a powerful instrument for harnessing these technologies and innovations are made.

Congress Hall Šipun

SESSION D315

19 May 2014  
Monday

20 May 2014  
Tuesday

21 May 2014  
Wednesday  
8:15 - 10:15

22 May 2014  
Thursday



## INDUSTRY NEEDS AND ENGINEERING DESIGN RESEARCH

**Ahmed-Kristensen S. / *Technical University of Denmark (DNK)***

Research activities in Engineering Design have traditionally focused upon supporting industry through a better understanding of design activities, design processes, products and the engineering designers themselves. This understanding provides the basis for tools and methods to create better product and faster processes. As industry needs change, new demands are set. This talk discusses the implication for possible future needs from the engineering design research communities and, how these affect the problems we choose to research and, the methods we employ.

## PROJECT TO PRODUCT

**Morgan T. / *Mountain Trike Company (GBR)***

The Mountain Trike is a revolutionary all terrain wheelchair designed to give wheelchair users far greater freedom and independence to access and enjoy the countryside. It is the brainchild of British design engineer Tim Morgan who was inspired by his love of Mountain Biking to develop a true manual all terrain wheelchair that would enable wheelchair users to ride off road in the same way he does on his bike. He identified a significant gap in the market for a manual wheelchair that was off road capable, but also combined this performance with everyday practicality in order to fit into the person's lifestyle. Over a period of 4 years, the Mountain Trike was developed from Tim Morgan's Final Year Masters Project at the University of Bath to a fully certified product launched to the market in August 2011. Since then the product has been very well received with sales avenues developed worldwide and manufacture facilities setup in the UK. This keynote address outlines the processes used and the challenges faced in this journey from Project to Product.

## THE DESIGN DEBATE

**Moderators: Steve Culley (GBR), Christian Weber (DEU)**

Organizers and debaters expect the audience will actively and lively participate in this event that is organized for the second time at DESIGN conference. The purpose of the debate is to investigate in a forensic manner some key topics that affect the engineering design research community. This will be achieved by key players in the community presenting evidence for or against a particular topic.

Congress Hall Ragusa

SESSION D3-P

19 May 2014  
Monday

20 May 2014  
Tuesday

21 May 2014  
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22 May 2014  
Thursday

10:45 - 12:45

**SUPPORTING LIGHTWEIGHT DESIGN POTENTIAL ASSESSMENT IN THE CONCEPTUAL PHASE**

**Posner B., Binz H., Roth D. / University of Stuttgart (DEU)**

**353**

In this contribution a method is presented, which supports designers in systematically analysing existing components of solutions and uses these results to estimate which working principle, sub-function and thus working structure or function structure has the greater lightweight design potential. The developed method, the Function Mass Estimation, can be used at different levels of abstraction already in the conceptual design phase and thus prepares the assessment and selection of solutions with regard to lightweight design aspects.

**INTEGRATED DESIGN AS AN APPROACH TOWARDS DFμMA**

**Omidvarnia F., Hansen H.N., Bissacco G., Islam A. / Technical University of Denmark (DNK)**

**343**

In this paper, DFA (Design for Assembly) and its associated considerations in micro area are investigated and the differences between the DFA rules for macro and micro manufacturing are discussed. The applicability of conventional DFA rules in micro area and the necessity of defining a set of DFμMA (Design For Micro Manufacturing and Assembly) principles are argued in this paper based on two case studies. The case studies are an on-off switch in the hearing aid devices and an optical unit used in the mobile phone camera. Since manufacturing and assembly are not separable in micro domain, and they have a great inter-dependency in micro scale, a DFμMA (Design For Micro Manufacturing and Assembly) methodology is required as a feasibility assurance during the design phase.

**DESIGNING FOR VALUE, USING ANALYTICS OF MEDICAL DEVICE FIELD DATA**

**Akinluyi E.A., Ison K., Clarkson P.J. / University of Cambridge (GBR)**

**71**

The engineering design process outputs plans for a product, to be sold to the customer. However, the ultimate objective is the desired impact that the product delivers throughout its life, after this transaction. If the impact of design decisions can be forecasted, and if this impact can be mapped to some model of Value, then design decisions may be modelled to deliver a net 'Value' gain. Using the example of infusion device reliability, this paper outlines a framework within which it may be possible to derive Value-based design support, from predictive analytics of medical device field data.

**SUPPORTING INDUSTRIAL EQUIPMENT DEVELOPMENT THROUGH A SET OF DESIGN-FOR-MAINTENANCE GUIDELINES**

**Mulder W., Basten R.J.I., Jauregui Becker J.M., Blok J., Hoekstra S., Kokkeler F.G.M. / University of Twente (NLD)**

**323**

This paper presents a leaflet with design-for-maintenance guidelines. It aims at supporting developers of industrial equipment in their design-for-maintenance practices. The use of this leaflet should lead to increased attention for design-for-maintenance aspects and to improve idea generation. The way of presenting the guidelines to the user should ensure that the support will be adopted in practice. The feedback that we have received from industrial partners indicates that the support is useful in practice. A thorough evaluation study has been planned in order to confirm this.

**SYSTEMATIC DETERMINATION OF SECONDARY WEIGHT IMPROVEMENTS**

**Luedeke T., Meiser P., Vielhaber M. / Saarland University (DEU)**

**283**

Weight optimization methods are a key approach of sustainable product engineering. Nevertheless, they may lead to unforeseeable secondary effects in multi-dimensional optimization steps. Especially, secondary weight improvements arising from primary ones seem to bring weight optimization to a higher level. This contribution proposes a holistic approach where the identification and handling of these secondary improvement are represented through the introduction of weight impact factors. This first approach shows the calculation of these improvements for simply hierarchically decomposed system.

**WEIGHT AND COST REDUCTION OF THE THERMAL MANAGEMENT FOR TRACTION BATTERIES BY USING THE DSM METHODOLOGY**

**Luft T., Klein F., Wartzack S. / Friedrich-Alexander University Erlangen (DEU)**

**293**

This paper provides a methodology to reduce weight and costs of thermal management systems for traction batteries in vehicles by using value engineering approaches and a matrix-based product description. This allows product developers to analyze and to improve the complex dependencies and relationships between all requirements, functions, properties and characteristics of the product as well as the respective associated costs and weights. This methodology is used and validated in the contribution for a simplified sealing plate of one cell module.

SESSION D331

Congress Hall Ragusa

19 May 2014  
Monday

20 May 2014  
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21 May 2014  
Wednesday

14:15 - 16:15

22 May 2014  
Thursday

## EVALUATION OF KNOWLEDGE TO FUTURE-PROOF THE KNOWLEDGE BASE

Schmidt D.M., Schenk S.A., Maurer M. / *Technical University Munich (DEU)*

1863

Companies have to develop their knowledge base to ensure that employees provide suitable knowledge to follow changes in market and customer requirements. We built a methodology to evaluate the degree of knowledge usage and of knowledge depth. In order to analyze how knowledge will change in the future regarding those two dimensions, we incorporate an approach of scenario technique into the methodology. In the methodology, the degrees of knowledge usage and depth are identified by interviews with employees and managers. Finally, this methodology was applied in a company's service department.

## KNOWLEDGE CLASSIFICATION FOR DESIGN PROJECT MEMORY

Dai X., Matta N., Ducellier G. / *Universite de Troyes (FRA)*

1753

Design projects have evolved to be collaborative, concurrent and multi-disciplinary. Due to these changes, knowledge management for design projects faces new challenges. Efforts has been made to save design project information in order to build a knowledge repository. However, project information without context can prove to be impossible to reuse. Hence a new knowledge engineering solution is called for to represent design information with its context, and necessary classification is required for knowledge extraction.

## GAUSSIAN PROCESS BASED APPROACH FOR AUTOMATIC KNOWLEDGE ACQUISITION

Breitsprecher T., Kestel P., Dingfelder C., Wartzack S. /

*Friedrich-Alexander University Erlangen (DEU)*

1733

New manufacturing processes like sheet-bulk metal forming offer a high degree of freedom to the design engineer, because complex features elements (teeth, grooves, etc.) can be manufactured, that were not realizable before or only at high costs.

## KNOWLEDGE MANAGEMENT LIFE CYCLE: AN INDIVIDUAL'S PERSPECTIVE

Stenholm D., Landahl J., Bergsjö D. / *Chalmers University of Technology (SWE)*

1905

Product development projects are expected to deliver results according to project goals. However, long-term success (over product generations) is diminishing when little time is given for knowledge capture and reuse. Effects of inefficient knowledge management (KM) become apparent when valuable knowledge is lost over time. Core barriers that decrease efficiency in KM, at the case companies, are mapped into a knowledge life cycle model, based on an individual's perspective. To improve KM, instant knowledge work (acquisition, creation, refinement, sharing) is presented as a mind-set and a tool.

## SUPPORTING ENGINEERING DESIGN COMMUNICATION THROUGH A SOCIAL MEDIA TOOL - INSIGHTS FOR ENGINEERING PROJECT MANAGEMENT

Gopsill J.A., McAlpine H.C., Hicks B.J. / *University of Bristol (GBR)*

1785

Engineering Design Communication (EDC) is highly collaborative, multi-disciplinary and often relates to one or more artefacts associated with the product. This results in the need for a method of communication that can deliver the required engineering context, enable multiple-perspectives to be expressed and represent the artefact of interest. Therefore, this paper presents some initial insights from the analysis of user behaviour using a custom-built Social Media tool (PartBook), which has been specifically designed to support EDC and has been deployed in a Formula Student Team.

## DESIGN PROCESS ACCELERATION BY KNOWLEDGE-BASED ENGINEERING IN AUTOMOTIVE AND AEROSPACE INDUSTRY

Stjepandić J., Rulhoff S., Verhagen W.J.C., Liese H., Bermell-Garcia P. / *PROSTEP AG (DEU)*

1915

The handling of knowledge represents the key to competitiveness, with company-specific product and process knowledge. Knowledge-based engineering facilitates new product development by automating repetitive design tasks through acquisition, capture, transform, retention, share, and (re-)use of product and process knowledge. This paper highlights two case studies: Automation of the validation procedure in the concept development of passenger cars, in particular in case of modular architecture and multi-brand product strategy, and a process chain template for application in aerospace industry.

Congress Hall Bobara

SESSION D332

19 May 2014  
Monday

20 May 2014  
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14:15 - 16:15

**SYMBOLIC INTERACTIONS AS INSPIRATIONS**

**Lai M.T. / *Tsinghua University (CHN)***

**529**

Designing interactions for products and services, interaction designers often look for inspiration from microinteractions and user interfaces. The sociological perspective of symbolic interactionism can provide a new source of inspiration in the form of symbolic interactions. This paper explores how designers can use symbolic interactions to inspire new interactions by identifying, analyzing and applying meanings embodied in people's actions into new designs. The author reflects on the application of symbolic interactions in an interaction design graduate studio workshop.

**MANAGING COMPLEXITY IN USER EXPERIENCE DESIGN: MATRIX-BASED METHODS FOR CONNECTING TECHNOLOGIES AND USER NEEDS**

**Michailidou I., von Saucken C.C., Kremer S., Lindemann U. / *Technical University Munich (DEU)*** 559

Users need tools to accomplish complex tasks in dynamic use situations; but meanwhile want the experience of product interaction to be intuitive and enjoyable. To face the challenge of making complex products understandable, a matrix-based approach is introduced. The suggested method for handling technologies and motives and ordering/mapping functions from the users' perspective, is summarized in five steps, whose application is exemplarily highlighted in a case study in the automotive domain. The method's applicability and positive effect on UX were assessed within a research project.

**NUANCES OF EMOTIONS IN PRODUCT DEVELOPMENT: SEVEN KEY OPPORTUNITIES IDENTIFIED BY DESIGN PROFESSIONALS**

**Yoon J., Pohlmeier A.E., Desmet P.M.A. / *Delft University of Technology (NLD)***

**643**

This paper explores when and how roles involved in product development can benefit from emotion knowledge, focusing on a nuanced understanding of positive emotions. Through an interview study, we identify how having a structured overview of positive emotion types and discerning nuances in terms of meanings, eliciting conditions, and influences on behaviors can serve design activities in product development processes. The obtained insights can help ensuring practical relevance when developing tools and methods to support designers in incorporating emotion knowledge in their design processes.

**USER CENTRED DESIGN OF AN ELECTROMYOGRAPHY SWITCH TO IMPROVE USER EXPERIENCE, ACCESSIBILITY AND INDEPENDENCE**

**Dorrington P., Mihoc A. / *Cardiff Metropolitan University (GBR)***

**481**

This research adopts a user centred approach to explore the needs of standalone switch users with severely limited movement in their home environment. Inductive coding and a facilitated rapid contextual design process organised raw user data into 100+ infinity notes, divided into 22 segments, highlighting the 'voice of the user'. Reviewed findings resulted in 3 key themes: Technology Push; Contextual Observation; and Voice of the Users. The paper provides a new application of known methods and tools to revise the Product Design Specification to include user input, and inform future products.

**IDENTIFYING DESIGN OPPORTUNITY SPACES IN NEW USER INTERFACES FOR EXOSKELETON MOBILITY DEVICES**

**Kim E., Jeong Y.J., Mock K., Stanton Kocsik V., Agogino A.M. / *UC Berkeley (USA)***

**517**

Although there are many academic researchers and practitioners who are developing exoskeleton robots for a range of applications, the user interface design for these devices has not yet been sufficiently explored. As the user interface for exoskeleton devices is the crucial link between the user and the machine, in this paper a human-centered design approach was used to 1) identify UI design opportunity spaces and four primary personas, 2) define the most critical user needs for each persona, and 3) present four concepts for new UIs for exoskeleton devices for future concept development.

**USER PARTICIPATION IS NOT ALWAYS AN EASY THING WHEN DEVELOPING AN INNOVATION**

**Ottosson S., Sterten J. / *Gjovik University (NOR)***

**579**

This paper is about experiences from two development projects (an ambulance simulator and a web based system for occupational therapists) ending up in innovations for which qualified users were invited to be parts of the development teams. The studies showed that there were a number of cultural barriers and lack of expertise and knowledge that blocked effective communication. Seen from an industrial point of view the studies showed that pure technical disciplines to create functional solutions are not enough to develop products in a cost efficient way.

SESSION D333

Congress Hall Orlando

19 May 2014  
Monday

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## INNOVATION INTERMEDIATION ROLE FOR THE DESIGN OF NEW PRODUCTS IN THE BIO-INDUSTRIES

**Lorentz R., Pensé-Lhéritier A.-M., Aoussat A. / *Arts et Métiers ParisTech (FRA)***

**883**

This paper questions the role of innovation intermediation in the new product development process. Based on a qualitative research approach, we investigate two cases of intermediaries : an innovation consulting firm and an online open innovation platform. The main performance features of these intermediary activities are illustrated by the development of a new ingredient for the bio-industries. The obtained results highlight the increasing potential of web-based intermediation strategies, especially in the design process of new bio-industrial technologies.

## CAN DESIGN THINKING BE USED TO IMPROVE HEALTHCARE IN LUSAKA PROVINCE, ZAMBIA?

**Watkins C.A., Loudon G.H., Gill S., Hall J.E. / *Cardiff Metropolitan University (GBR)***

**1005**

This case study explores the effectiveness of using a design thinking approach for the development of appropriate, transformative medical product solutions for Zambia. Findings are presented from an initial 10-day field trip to Zambia by an interdisciplinary team that undertook preliminary ethnographic research. As a consequence of taking a design thinking approach and focusing on factors relating to the desirability, viability and feasibility of possible solutions it has been possible to identify new development opportunities, including some surrounding rural trauma and childbirth.

## DESIGN INNOVATIONS AND IMPLEMENTATION CHALLENGES - A CASE OF SMART TEXTILES IN FUTURE HOSPITAL INTERIORS

**Mogensen J.E., Jorgensen P.-E., Poulsen S.B. / *Aalborg University (DNK)***

**935**

Concerned with the overall challenges of implementing design innovations, this paper relates to the specific case of applying smart textiles in future hospital interiors. The methodological approach is inspired by design thinking and implementation processes, and through the scope of a developed strategic framework, the implementation challenges will be discussed from a holistic integrative design perspective. With this explorative initiative, our aim is to present specific approaches to progress the design innovation of smart textiles, and the implementation climate of future hospitals.

## THE AESTHETICS OF PROSTHETIC DESIGN: FROM THEORY TO PRACTICE

**Sansoni S., Wodehouse A.J., Buis A. / *University of Strathclyde (GBR)***

**975**

Aesthetics of prosthetic devices is an emerging academic field, concerned with the visual attraction of a particularly intimate category of medical device. Our belief is that prosthetic users can gain psychological well-being when wearing prostheses perceived as aesthetically pleasing. This research focusses on exploring the concept of “concinnity” for below-knee prostheses, and develops current aesthetic theory in this area by considering elements and principles of visual design. The applicability of these to practice has been illustrated through two case studies of conceptual designs.

## A NEW BUSINESS MODEL FOR THE ORTHOPAEDIC AND CUSTOMIZED FOOTWEAR SECTOR

**Carloni Vitali M., Germani M., Mandolini M., Raffaelli R. /**

***Università Politecnica delle Marche (ITA)***

**771**

This research work aims to develop and demonstrate a new business model for the orthopaedic and customized footwear sector, called “Orthopaedic Footwear Cluster”. The peculiarity of this idea consists in splitting the shoe, and related accessories, design and manufacturing processes, between the hub (big industry) and the nodes (small orthopaedic shops), in order to joint the benefits of each subject of the cluster, without losing the customization required by the customers. It is expected to reduce the time to market (50%), costs (30%) and environmental impacts.

## MEDICAL DEVICE DESIGN PROCESS: A MEDICAL ENGINEERING PERSPECTIVE

**Böhmer A.I., Zöllner A.M., Kuhl E., Lindemann U. / *Technical University Munich (DEU)***

**749**

An approach for the planning phase of a medical device design process is presented. Challenges are discussed and a strategy to identify all required specifications is proposed. Hereby, the interdisciplinary collaboration of engineer, patient and clinician will be examined. As an exemplary case a shortened version of the development of an instrumented tissue expander is illustrated. The proposed procedure gives a profound knowledge of the medical background, existing devices and resulting limitations as well as their correlations. New aspects of other fields are included, giving a new attempt.

Congress Hall Konavle

SESSION D334

19 May 2014  
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20 May 2014  
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14:15 - 16:15

22 May 2014  
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**STUDY OF HUMAN ACCESSIBILITY: COMPARISON BETWEEN PHYSICAL TESTS AND NUMERICAL SIMULATION RESULTS**
**Delange M., Poirson E., Petiot J.-F. / Ecole Centrale de Nantes (FRA)**
**2023**

Using numerical model of static human body commonly assesses the human accessibility, essential part of an ergonomic approach of product. Considering the body as a simple assembly of static parts of different anthropometry is limiting. The physical skills and muscles compliance are to take into account in the digital human model. In this paper, the validity of this approach is assessed by comparing the reach envelopes obtained from a numerical method to those obtained experimentally on a simple situation of accessibility of the upper body.

**DEVELOPING A COMFORT EVALUATION METHOD FOR WORK EQUIPMENT HANDLES**
**Gust P., Ünlü A. / Bergische Universität Wuppertal (DEU)**
**2043**

Comfort optimization for work equipment handles fails in practice because of high temporal complexity and high development costs, coupled with the pressure of shorter development times. In addition, handle design lacks an objective method to make comfort measurable. The aim is therefore to develop an objective method for comfort evaluation of work equipment and to enable the verification of handle design. After determining significant factors of the work equipment, a work equipment dependent pressure discomfort model is derived. The paper then focuses on practical validation of the method.

**FACILITATION WITH DIGITAL TOOLS, PICTURES AND TANGIBLE OBJECTS IN FACE-TO-FACE WORKSHOPS**
**Illi M.M. / Aalto University (FIN)**
**2061**

Facilitated face-to-face -meetings in a digital environment are hardly ever being recorded as researched activity. When we combine the wave of digitalisation with the usage of pictures and tangible materials we have a combination of facilitated meetings, or 'workshops', that take into consideration the usage of latest digital tools and creative team-working processes. This paper develops our understanding of few key touch points of the usage of different 'groupware' through three real company case examples of facilitated workshops by using emphatic user research methods.

**SENTIMENT RATING ALGORITHM OF PRODUCT ONLINE REVIEWS**
**Raghupathi D., Yannou B., Farel R., Poirson E. / Ecole Centrale Paris (FRA)**
**2135**

Social media give new opportunities in customer and market survey to improve design; comments posted online by users spontaneously, in a near-oral language is almost free of biases. This new source however has huge size, so complexity of data needs to be processed. In this paper, we propose an automated method to process these comments into a sentiment rating useful for future designs. We validate it on the example of a commercial home theatre system, comparing our automated sentiment predictions with human ratings on a group of 15 test subjects, resulting in a satisfactory correlation.

**A CODING SCHEME FOR USE IN THE DESIGN OF ELECTRONIC CONSUMER PRODUCTS FOR OLDER ADULTS**
**Morris L.D., McKay A., Cassidy T. / University of Leeds (GBR)**
**2115**

People's ability to live independently depends increasingly on their ability to interact with electronic consumer products. Usability of controls and displays is key to effective interaction. This paper presents a coding scheme for the analysis of interfaces with a view to identifying design improvement opportunities. Verbal protocol analysis and videotape recordings were used to capture cognitive and physical aspects of interactions by two older users. The study found symbolic user interface elements were the most disabling because they caused most interaction breakdowns and focus-shifts.

SESSION D335

Congress Hall Šipun

 19 May 2014  
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 20 May 2014  
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14:15 - 16:15

 22 May 2014  
Thursday

**D344 MEETING: COLLABORATIVE DESIGN RESEARCH METHODOLOGIES****Hosted by Collaborative Design SIG****Chair: Withfield Ian (GBR)***Congress Hall Konavle*

This meeting is aimed at PhD students who are conducting their PhD research within the domain of Collaborative Design. The workshop will focus on the different types of research methodologies that are available and will take the form of an interactive discussion relating to how particular Collaborative Design research maps onto specific research methodologies. The workshop will provide a forum for PhD students to discuss the context of their research, and exchange ideas relating to different research methodologies. The workshop will be beneficial to PhD students at all stages of their research studies, and will additionally aim to initiate the creation of a formal mapping between Collaborative Design research contexts and appropriate research methodologies.

**D345 MEETING: DISCUSSION OF PD TEACHING ACTIVITIES****Chairs: Oehmen Joseph (DNK), Gericke Kilian (LUX)***Congress Hall Šipun*

This is an informal meeting to discuss current teaching portfolios and activities relating to product development. The objective of the meeting is to decide whether the participants want to engage in a more in-depth collaboration, exchange and benchmarking of their teaching material and approaches.

**D344 & D345  
MEETING****19 May 2014  
Monday****20 May 2014  
Tuesday****21 May 2014  
Wednesday  
16:30 - 18:00****22 May 2014  
Thursday**



THURSDAY, MAY 22					Hours	
REGISTRATION					08:00	
D411 GENERATING SOLUTIONS	D412 PRODUCT FOCUSED PROPERTIES	D413 DFX TOOLS I	D414 COMPLEX SYSTEMS DESIGN	D415 ENGINEERING DESIGN PRACTICE	08:15	CONGRESS HALL RAGUSA
					08:30	
					08:45	
					09:00	
					09:15	
					09:30	
					09:45	
					10:00	
REFRESHMENT BREAK					10:15	
D421 ANALYSING PRODUCT PROPERTIES	D422 DFX TOOLS II	D423 INNOVATION MANAGEMENT	D424 KNOWLEDGE TOOLS AND APPLICATIONS	D425 MODELS AND PROTOTYPES	10:30	CONGRESS HALL BOBARA
					10:45	
					11:00	
					11:15	
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					12:00	
					12:15	
LUNCH					12:30	CONGRESS HALL ORLANDO
					12:45	
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					14:15	
D431 VALIDATION AND USABILITY	D432 DFX CASE STUDIES	D433 PLM/PDM	D434 USER NEEDS	D435 DESIGN EDUCATION STRATEGIES	14:30	CONGRESS HALL KONAYLE
					14:45	
					15:00	
					15:15	
					15:30	
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					16:00	
					16:15	
REFRESHMENT BREAK					16:30	
D4-C CLOSING					16:45	CONGRESS HALL ŞİPUN
					17:00	
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					18:15	
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					18:45	CONGRESS HALL
					19:00	
					19:15	
FAREWELL PARTY					19:30	
					19:45	
					20:00	



## ENGINEERS ARE USING SOCIAL MEDIA FOR WORK PURPOSES

Sarka P., Ipsen C., Heisig P., Maier A.M. / *Technical University of Denmark (DNK)*

589

Given the nowadays often distributed nature of product development and the tendency of engineers to rely on their colleagues and people they can easily reach, social media may offer solutions to support information seeking and efficient and effective knowledge sharing. This paper explores the use of social media in the Danish engineering industry. Results from over 130 survey participants show that 88% report to actually use social media for work purposes. The most addressed purposes are to search for information, knowledge and solutions, together with networking.

## A PHYSICAL AND EMOTIONAL JOURNEY INTO THE DESIGN PROCESS

Canina M., Anselmi L., Coccioni E., Fattorossi M. / *Politecnico di Milano (ITA)*

445

The IDEACTivity Center research team focuses on the synergy between various creativity techniques and the typical tools employed by Design. As a result a method and supporting toolkit have been developed to guide project design towards innovation. This paper presents a learning event covering the typical phases, concepts and techniques of the design process in only 90 minutes. The alternation between different types of communication and the emphasis on sensory perception enabled participants to achieve a fast understanding of the Design process providing a positive setting for learning.

## CONTROLLING DEGRADATION TO ENJOY FEELING OF BEST FIT: A POSITION PAPER

Fukuda S. / *Keio University (JPN)*

501

This is a position paper to point out that if we control degradation appropriately, we can keep the feeling of best fit and enjoy using our products for much longer time, because it permits us to use our machines and products in the best working condition in spite of the widely and frequently changes of situations and environments. In addition, we can avoid producing too many wide variety of products. Then, we can focus our attention more to each product and we can avoid build up a complicated and high expertise demanding high mix, low volume production system, thereby reducing energy, time and cost considerably.

## HOW INTUITION AFFECTS DESIGNERS' DECISION MAKING: AN INTERVIEW STUDY

Ling T., Xiao Y.G., Badke-Schaub P.G. / *Delft University of Technology (NLD)*

537

This paper focuses on the relations between intuition and decision making within the field of design. The findings are detailed descriptions of when, where and how designers use intuition and how organizations' environments affect the use of intuition. The results show that no clear boundary is found to entirely separate intuition from rationality. Besides, though intuition is intangible, it is manageable. Furthermore, different types of companies treat intuition differently, which has great impacts on designers.

## DEVELOPING GUIDELINES FOR PROBLEM SOLVING

Duci S., Russo D. / *Universita degli Studi di Bergamo (ITA)*

491

A conceptual framework is proposed to explicitly evaluate the completeness of the guidelines for problem solving, with the aim of a better understanding of existing methodologies. The proposed template is composed of five parts: problem type, Sub-goal, General Suggestion, Specific Suggestion and example. Thanks to a template of comparison, a method can be studied to highlight shortcomings and identify where it can be improved. In this paper, the proposed template has been used to improve the 76 standard solutions, obtaining a simpler and more complete set of guidelines.

## PROBLEM-SOLVING TEAMS: COMMONALITIES AND DIFFERENCES OF OPERATIONAL AND DESIGN TEAMS

Schaub H. / *IABG (DEU)*

599

Design teams need, like operational teams, shared team mental models for different type of teams acting in complex technical systems. The significance of contextual characteristics of the task in terms of performance suggests that adaptation to the specific operational demands is essential for performance. Dealing with novelty is a task characteristic that operational teams sometimes, yet design teams often have to cope with. Novelty is a key factor of critical situations in which problem-solving teams show (or fail to show) their ability to solve problems.

Congress Hall Ragusa

SESSION D411

19 May 2014  
Monday

20 May 2014  
Tuesday

21 May 2014  
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22 May 2014  
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## **UNCERTAINTY CONSIDERATIONS BY CONTEXT FACTORS FOR THE MONITORING OF THE DEGREE OF PRODUCT MATURITY**

**Luft T., Reitmeier J., Wartzack S., Paetzold K. / *Friedrich-Alexander University Erlangen (DEU)* 893**

As the product development process is a knowledge and information handling process, information acquisition, processing and sharing is very important. However, information is often subject to uncertainty and influenced by the context. Therefore, this paper presents a novel approach for uncertainty considerations with contextual factors by using a matrix-based product description. This will be used to facilitate the situation-specific planning of virtual validations, an efficient monitoring of the degree of product maturity and the management of goal-oriented iteration cycles.

## **EXPLORING THE DIMENSIONS OF VALUE: THE FOUR DIMENSIONS FRAMEWORK**

**Bacciotti D., Borgianni Y., Rotini F. / *Universita di Firenze (ITA)* 711**

Companies have to develop innovative and valuable products in order to achieve competitive advantage. To this aim, the idea generation task should be effectively supported within the Product Planning phase, whose goal is defining the main product features. According to this objective, the paper proposes a tool, namely Four Dimensions framework, that urges designers looking for new customer requirements through the mapping of General Demands, Stakeholders, Life Cycle and Systems. The tool has been simulated through an application to the first Apple iMac (1998), obtaining promising results.

## **LIFECYCLE AND STAKEHOLDER-ORIENTED INTEGRATION OF COGNITIVE FUNCTIONS INTO PRODUCT CONCEPTS**

**Metzler T., Witzmann M., Deubel T., Lindemann U. / *Technical University Munich (DEU)* 925**

The integration of cognitive functions into products and systems is often an intuitive-driven process. The results are often influenced by the designers and their environment, experience and expertise. The systematic integration of cognitive functions is important to exploit the whole solution space and make conscious decisions. This paper presents and evaluates a formal approach that supports the systematic integration of cognitive functions into product concepts. A holistic procedural model is presented and linked to methods that assist the implementation of single procedural steps.

## **HANDLING SUBJECTIVE PRODUCT PROPERTIES IN ENGINEERING, FOOD AND FASHION**

**Eckert C.M., Bertoluci G., Yannou B. / *Open University (GBR)* 791**

While many product properties can be tested objectively, others are subjective, but no less important. This paper compares how the testing of subjective properties is handled across industry sectors. Engineering companies typically try to break these properties down into measurable aspects of the product, but refer to the judgement of test engineers for emergent properties. By contrast the fashion industry sees the assessment of subjective properties a core competence of designers. The food industry also tries to measure objective properties, but relies heavily on user and expert panels.

## **A SUPPORT FOR DESIGN OF USE IN CONSIDERATION OF USE PHASE**

**Shimada S., Ogata T., Ota J., Hara T., Kurata Y. / *The University of Tokyo (JPN)* 995**

Users change design of products/ services in use phase to adapt to their own environment, based on a solution in pre-use phase. This adaptive design can contribute to great improvements in products/services. Thus, this study aims to encourage adaptation by customers through support for design in pre-use phase. We focus on co-design by users with support system for design and propose a methodology to support design in pre-use phase with the case of tourism service. With the supports, users can understand their requirement deeply and can design products/ services with some alternative solutions.

## **ANALYSIS OF THE SYSTEMATIC APPROACH TO DEVELOP COGNITIVE PRODUCTS IN ACADEMIC RESEARCH PROJECTS**

**Bossemer M.T., Aydin K.T., Metzler T., Lindemann U. / *Technical University Munich (DEU)* 759**

This paper presents the results of an analysis of systematic development approaches for cognitive products found in literature and extracted from interviews with 13 researchers in academic research projects. Based on a harmonized order of applied development steps in the academic research projects and the understanding and expertise of their developers, a procedural model supporting the development of cognitive products is proposed, emphasizing the specific development steps required for cognitive products. The proposed procedural model builds on and is structured according to the V-model.

## ROBUST TOLERANCE DESIGN OF SYSTEMS WITH VARYING AMBIENT TEMPERATURE INFLUENCE DUE TO WORLDWIDE MANUFACTURING AND OPERATION

Spruegel T.C., Walter M., Wartzack S. / *FAU (DEU)*

1189

In today's industrial environment products must be developed and brought to market in short time. Thereby the product developer faces additional challenges, such as globally distributed manufacture and use of technical products at several locations (with different climate conditions) around the world. The authors present an approach on tolerance analysis, taking into account dimensional and geometrical deviations as well as thermal expansions of parts. The goal is to achieve a robust tolerance design of systems for global manufacture and usage. Its practical use is shown in a case study.

## IMPROVING PROCESS CAPABILITY DATABASE USAGE FOR ROBUST DESIGN ENGINEERING BY GENERALISING MEASUREMENT DATA

Okholm A.B., Rask M., Ebro M., Eifler T., Holmbeg M., Howard T.J. /

*Technical University of Denmark (DNK)*

1133

There is little disagreement that better understanding and early incorporation of production variation data into design and development is conducive to success. However, existing process capability databases (PCDB) are largely unused for design purposes so far. To overcome this situation and to support the early application of approaches, such as Tolerancing, Robust Design, etc., challenges as well as the potential benefits of PCDBs in design are examined. The applicability of an elaborated new PCDB-structure is then analysed using a test-data base with examples of injection moulded parts.

## USE OF VECTORIAL TOLERANCES IN CAD DURING THE DESIGN PROCESS

Husung S., Oberänder A., Weber C., Geis A. / *Technical University Ilmenau (DEU)*

1083

Mechanical engineers have to consider all product characteristics and properties as well as the deviations from their nominal values. The paper deals with vectorial tolerances. By direct representation of mathematically evaluable tolerances in the CAD-model, the designer can analyse the impact of deviations along the tolerance chain. A focus of the paper is the handling of partially closed tolerance loops. A real product often consists of partially closed tolerance loops. Even if the total tolerance chain can be considered as an open chain, many products have partially closed tolerance loops.

## MULTI-CRITERIA RELIABILITY-BASED DESIGN OPTIMIZATION FOR COMPLIANT MECHANISMS

Kobayashi M., Higashi M. / *Toyota Technological Institute (JPN)*

1105

Safety factor is widely introduced to improve reliability of mechanical products / structures. However, since compliant mechanisms are quite different from traditional mechanisms, it is difficult to configure safety factor empirically. In order to design reliable compliant mechanisms, we extend optimal safety factor (OSF) and develop a multi-criteria reliability-based design optimization based on the extended OSF for compliant mechanisms. In the case study, the proposed method is applied to a design of a thermal actuated compliant valve used for a micro water cooling system.

## ASSEMBLY TIME ESTIMATION BASED ON PRODUCT ASSEMBLY INFORMATION

Eigner M., Roubanov D., Sindermann S., Ernst J. / *Technical University Kaiserslautern (DEU)*

1043

A design engineer's major task is the fulfilment of design requirements like form, fit and function while production relevant properties are typically not in scope yet. Unfortunately the designer determines the biggest part of future production costs and time although being hardly aware of this task. To reduce time-to-market and increase quality it is important that design and production departments share their information during the whole Product Development Process. This paper presents a concept and prototype to improve information exchange between product development and assembly planning.

## MODELING OF USE PHASE VARIABILITY AND APPLICATION IN ROBUST DESIGN AND ECODESIGN

Freund T., Sarnes J., Kloberdanz H., Würtenberger J. / *Technical University Darmstadt (DEU)*

1063

This paper introduces a technique called the scenario matrix to represent diverse use cases of a technical system, based on the CRC 805 process model. Applications in two fields of research design, Robust Design and EcoDesign, are presented. An overview of different sources of information is given. Future research will focus on enabling the applications presented for the scenario matrix.

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## **VISUALIZATION OF INTERDISCIPLINARY FUNCTIONAL RELATIONS IN COMPLEX SYSTEMS**

**Becerril L., Kasperek D., Roth M., Lindemann U. / *Technical University Munich (DEU)*** **1239**

Complex mechatronic systems are developed in an interdisciplinary environment. However, they are often represented in several single-discipline diagrams, leading to communication issues and inefficient development processes. Existing visualization concepts revealed a shortage of tools that support complexity and interdisciplinarity. The model, presented in this paper, visualizes mechatronic systems as integrated systems and provides tailored diagrams with different perspectives and levels of abstraction that could support the different interdisciplinary design activities.

## **COMPLEXITY AS INFORMATION CONTENT AND ITS IMPLICATIONS FOR SYSTEMS DESIGN**

**Colombo E.F., Cascini G. / *Politecnico di Milano (ITA)*** **1249**

Even though Engineering literature concerning "Complexity" is huge, there is still much discussion about the meaning of this word. This paper attempts to provide an operational definition of Complexity in Engineering design and to explain its implications for the design process. To this end, the concept of technical holon is introduced from Soft system thinking and the effort required to deal with Complexity is highlighted through the notion of Complicatedness. The usefulness of the proposed concepts is shown thanks to the analysis of some design practices in the field of Systems Engineering.

## **INTERDEPENDENCIES DURING THE CONCEPTUAL DESIGN OF AN ANALYTICAL TELEMEDICAL DEVICE**

**Gausemeier J., Schierbaum T., Westermann T. / *Heinz Nixdorf Institute, University of Paderborn (DEU)*** **1297**

Interdependencies are versatile but are often not easy to recognize. A direct link between partial models (product and production system) is missing. Hence requirements, process parameters and resource parameters are not connected directly. The following paper presents a method for the description of interdependencies between the partial models e.g. active structure, resources and process sequences. Therefore the given information in each partial model is used to divert the matrices in which the interdependencies are visualized. The method is validated on an analytical telemedical device.

## **SIMULATION AND OPTIMIZATION METHODOLOGY OF PROTOTYPE ELECTRIC VEHICLE**

**Targosz M., Skarka W., Przystalka P. / *Silesian University of Technology (POL)*** **1349**

The paper presents simulation and optimization methodology of lightweight electric vehicles. The mathematical model of the vehicle, the route, the weather conditions and the control unit have been described. Importance and potential usage of the simulation model mainly for verification of design assumption, optimization of design and kinematics parameters have been presented. The importance of the parameters of optimization evolutionary algorithm have been investigated. The verification research has been carried out for prototype vehicle for two different, well identified travel tracks.

## **A SYSTEM INTEGRATION METHOD FOR THE CONTINUOUS SUPPORT OF THE DESIGN PROCESS**

**Paetzold K., Köbler J. / *Bundeswehr University Munich (DEU)*** **1319**

The management of data and information flows is getting more and more important for the system integration and thereby the product quality. In this paper the model-based system engineering is used for a description of interfaces with respect to the requirements of the system. By the use of simulations the system's behavior is validated with the help of parameter-based modelling approaches. As a result a procedure is illustrated how to specify interfaces between system components and sub-functions of a technical system and to integrate in the development process to support decision situations.

## **CONCEPT FOR MODELLING A CONTROL SYSTEM USING THE CHARACTERISTICS-PROPERTIES MODELLING (CPM)**

**Crostack A., Heidingsfeld M., Binz H., Sawodny O., Roth D. / *University of Stuttgart (DEU)*** **1261**

The development of mechatronic systems necessitates co-operation and communication between all involved development departments. Literature shows, that there is a lack of a generally accepted model-based system documentation for engineers of all involved departments. To examine the capabilities of CPM a concept for modelling control systems is presented. Based on a generic model of a two-degree-of-freedom control structure a positioning control of a hydraulic cylinder is modelled. Additionally, the characteristics determining the dynamic behaviour of the cylinder are also presented.

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## OPTIMISATION OF PRODUCTS VERSUS OPTIMISATION OF PRODUCT PLATFORMS: AN ENGINEERING CHANGE MARGIN PERSPECTIVE

Isaksson O., Lindroth P., Eckert C.M. / *GKN Aerospace (SWE)*

1947

A truck manufacturer having a platform strategy typically balance between platform compliance and product specific optimisation. This paper argues that the key to balancing product optimisation and platform optimisation, or platform efficiency, lies in understanding the margins that components have with regards to different sets of requirements. This paper draws on eight interviews with ten engineers in a Swedish truck company and examples from the authors' industrial practise.

## LEAN DIGITAL VALIDATION METHODS WITHIN THE DESIGN PROCESS OF AUTOMATED ASSEMBLY SYSTEMS IN AUTOMOTIVE INDUSTRY

Kiefer J. / *University of Applied Sciences Ulm (DEU)*

1957

In automotive industry, the development and operational use of lean digital validation methods takes a significant role to cope with current challenges in the field of production engineering. This paper focuses on these new developed value-focused digital validation methods that are recently used within the design process of automated assembly systems. In this context, the characteristics, interactions, operational applications and benefits of the three lean digital validation methods of virtual engineering, virtual commissioning and physics-based analysis are presented.

## A COMPOSITE INDEX FOR THE EVALUATION OF STANDARDIZATION LEVEL OF MECHANIC SYSTEMS

Sinigalias P.C., Dentsoras A.J. / *University of Patras (GRC)*

1979

Standardization of components of assemblies is important in both reverse engineering and design. In design, it leads to cost reduction by minimizing the number of items designed from scratch and the number of new manufacturing processes. The work presented introduces a composite standardization index by combining a commonality index and an absolute standardization index. The index counts the populations of common parts in assemblies and the degree of absolute conformance of those parts with engineering standards. It is a tool that represents reliably the level of standardization of a system.

## INTEGRATION OF STRUCTURAL OPTIMIZATION IN THE ENGINEERING DESIGN PROCESS

Stangl T., Pribek M., Wartzack S. / *Friedrich-Alexander University Erlangen (DEU)*

1989

Structural optimization enables the product developer to compute a lightweight design proposal of a considered component during the design process. If topology optimization is integrated as early as possible in the product development process, the design engineer will act more and more frequently as a simulation engineer. To support the product developer to use topology optimization successfully in a methodical way, the paper focuses on the development of an extended design guideline during a design study.

## IMPLEMENTING ARCHITECTURE IN INDUSTRY

Kreimeyer M. / *MAN Truck & Bus AG (DEU)*

1967

This paper reviews the industrial implementation of product architecture design at a large commercial vehicle manufacturer. The steps taken towards a full implementation as well as the value of architecture as perceived at the different stages of implementation are reviewed and discussed. As a basis, an architecture framework in its specific implementation is presented to illustrate the scope of architecture design at the company. It is discussed in its evolution to show how the implementation progressed and how the know-how about architecture was built.

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### ANALYZING THE PROJECT-SPECIFIC RELEVANCE OF ENERGY EFFICIENCY AS A DESIGN OBJECTIVE

**Albers A., Martin P., Geiger S. / Karlsruhe Institute of Technology (DEU)**

91

Design to Energy Efficiency (DtEE) is caused by different motivations leading to different meanings of energy efficiency (EE). This paper presents an approach that aims to systematically identify relevant motives and support a differentiated evaluation of the project specific relevance of EE as a design objective. Thereby it gives guidance and recommendation regarding an adequate scope to be considered. This early and differentiated consideration supports a better and project specific understanding of EE and facilitates the following choice of suitable methods supporting an improvement of EE.

### EARLY ANALYSIS OF THE SYSTEM DYNAMICS OF SELF-OPTIMIZING SYSTEMS

**Vassholz M., Graessler I. / Heinz Nixdorf Institute, University of Paderborn (DEU)**

407

Self-optimizing (s.o.) systems have inherent partial intelligence and are able to adapt their behaviour during operation autonomously, due to changing objectives. Application examples have shown their costs and benefits. These properties are influenced by design decisions. The benefit of s.o. systems appears during its operation. Its behaviour in this phase is strongly influenced by its dynamic. To be able to estimate costs and benefits within the conceptual design, this dynamic must be taken into account. This paper provides a method to analyse the dynamic of s.o. systems model-based.

### FATIGUE LIFE STUDY OF THE KINETIC SCULPTURE BLADE

**Spencer T.D., Gooch S.D. / University of Canterbury (NZL)**

397

Blade is a kinetic sculpture designed by the late artist Len Lye. Lye built a prototype to confirm the concept of the work which he intended to be built at a much larger size. Dr. Shayne Gooch built Big Blade in 1996 at approximately twice the scale of this prototype and discovered that the constraining factor on the feasible size of the sculpture was the fatigue life of the blade material. This paper will establish an in-depth prediction for the fatigue life of the blade material at various sizes and suggest a maximum economic scale of Blade.

### VISUAL REPRESENTATION FOR DEVELOPING MODULAR PRODUCT FAMILIES – LITERATURE REVIEW AND USE IN PRACTICE

**Gebhardt N., Beckmann G., Krause D. / Hamburg University of Technology (DEU)**

183

Modular product families are a splendid strategy to offer variant products while maintaining a low internal variety. The paper highlights the use of visualisations of product structures and influencing factors in the development of modular products. A literature review demonstrates the notion of visualisations as tools in product development. In order to give insights into practice the results of an interview survey with 12 designers from industry are presented (further results of the study are presented on the DESIGN 2014 conference paper no. 295).

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## CONDUCTING VALUE ENGINEERING ANALYSIS AROUND A COMPUTER SUPPORTED COOPERATIVE WORK IN DESIGN PLATFORM

Guerra A.L., Gidel T., Vezzetti E., Jones A., Lenne D. /  
*Université de Technologie de Compiègne (FRA)*

1073

Computer supported cooperative tools in design are introduced to improve the preliminary design process. A design strategy called Methodological Circulation is also presented, which is based on a co-evolutionary perspective of tools and methods. The impact of computer tools is assessed through comparative design observations. Practitioners are observed performing the same design activity collaboratively, supported by paper-based and computer-based tools. Results show that computer tools enhance involvement, motivation, and users' satisfaction as well as their accuracy and time-efficiency.

## WEIGHT OPTIMIZATION WITH A MECHATRONIC DESIGN CATALOGUE

Luedeke T., Scheid S., Vielhaber M. / *Saarland University (DEU)*

1123

In a wider context of sustainable product engineering, this contribution presents an approach to a design catalogue consisting of mechatronic concepts and systems which can be used for weight reduction and weight distribution. Mechatronic solutions in different abstraction levels are classified and characterized with specific criteria and support designers during solution finding. It is possible to achieve a knowledge shift to earlier design phases and to reduce development time when taking this catalogue into account and get access to available lightweight design knowledge.

## ENHANCED DESIGN FOR ASSEMBLY IN SERIES PRODUCTION BY USING DATA MINING METHODS

Kretschmer R., Rulhoff S., Stjepandić J. / *PROSTEP AG (DEU)*

1113

This paper introduces a new concept and the corresponding data model for application of data mining methods in the field of product design and production assembly planning. The approach contains the extraction and preparation of existing linked product and process data in order to extrapolate assembly processes. The concept presents assistance potentials for synchronous development of new products variants along the product creation process. With this approach an early cost estimation of assembly processes in series production can be achieved using innovative data mining methods.

## A DISCUSSION ON ALGORITHMIC THINKING IN PRODUCT DESIGN PROCESS

Betancourt M.C., Quintero L.M., Cereceda G. / *Icesi University (COL)*

1035

This paper presents the identification of patterns of difficulty that design students face at the moment of applying algorithmic thinking and parametric modeling from the generation of the idea, to the final model. The results have been based on surveys, observations, and evaluations by parametric design students during one year. A new way of algorithmic thinking is being proposed in order to find a correspondence between the original concept and the resulting form in design projects.

## A NOVEL APPROACH FOR THE EVALUATION OF COMPOSITE SUITABILITY OF LIGHTWEIGHT STRUCTURES AT EARLY DESIGN STAGES

Klein D., Witzgall C., Wartzack S. / *Friedrich-Alexander University Erlangen (DEU)*

1093

Special characteristics like high stiffness and strength at low weight make Carbon Fibre Reinforced Plastic (CFRP) an interesting material for many different industries. However, the costs for carbon parts are very high compared to other lightweight materials and the material characteristics of CFRP can only be exploited if a suitable fibre orientation is chosen. Therefore, not every part is suitable for CFRP and the material choice should be considered carefully. Within this article a novel approach to evaluate the composite suitability of parts at the early design stage is shown.

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**IDEA CAPACITY ASSESSMENT FOR PRODUCT INNOVATION**
**Stevanović M., Marjanović D., Štorga M. / Markot.tel (HRV)**
**1693**

A correct selection of ideas for product innovation, from the set of collected ideas, often is uncertain and demanding job with potential significant consequences. This paper presents results of research which includes attempts of defining the methodology of idea selection, and defining the criteria and attributes for assessing the value of an idea through the idea capacity assessment for product innovation. Verification is demonstrated by applying the selected set of ideas using methods of multi-attribute evaluation.

**EXPERIMENTATION IN INNOVATION: FACTORS AFFECTING EXPERIMENTATION IN ORGANIZATIONS**
**Hassi L., Rekonen S., Paju S. / Aalto University (FIN)**
**1551**

Experimentation is a fundamental innovation activity but the barriers to making experimentation an established approach to innovation in organisations are deep-rooted and numerous. Previous research on creative work provides some insights into experimentation, but little research has set out to directly examine experimentation and organisational conditions that promote experimentation. From empirical data we identify six categories of factors affecting an individual's experimentation behaviour. These factors provide guidelines for managers to create appropriate conditions to experimentation.

**MOTIVATIONS FOR INNOVATION IN PUBLIC TRANSPORT: THE BENEFITS OF A LOW COST PERSPECTIVE**
**Klasing Chen M., Hooge S., Segrestin B., Hatchuel A. /**
**CGS Ecole des Mines Paristech/RATP (FRA)**
**1571**

The public transport sector faces several challenges today, due to increasing demand, aggravated by limited funding. Although the dual need for original solutions and cost reductions has been identified, a lack of innovation has been pointed out in literature. Through a systematic review of scholars' literature and its comparison to a low cost approach by a public transport operator, this article aims to provide relevant data on what really counts to drive public transport innovations. We also show that a low cost perspective can bring benefits to the sector as a powerful innovation driver.

**HOW TO DETERMINE A COMPANY'S OPEN INNOVATION SITUATION?**
**Guertler M.R., Holle M., Guber D., Lindemann U. / Technical University Munich (DEU)**
**1541**

This paper presents an initial pool of attributes for describing a company's Open Innovation (OI) situation. Based on an explorative interview, study we identified an insufficient planning as one of the main reasons for insufficient results or even failures of OI-projects. Specific project goals, boundary conditions and resulting constraints are only rudimentarily considered so far. The presented attributes in this paper lay the basis for a systematic analysis of an OI-situation and efficient planning of an OI-project in terms of selection the right OI-actors and OI-methods.

**SUPPORTING THE CHOICE OF DESIGN ALTERNATIVES UNDERLYING INCREMENTAL AND RADICAL INNOVATIONS**
**Borgianni Y., Rotini F. / Universita di Firenze (ITA)**
**1463**

Decision making during the initial design stages result particularly crucial because of the relevance of the Fuzzy Front End in light of achieving successful product development projects. The situation is even complicated by great uncertainty and lack of information. According to the above criticalities, the paper proposes a quantitative approach to support the preliminary selection of design alternatives. It evaluates the expected success probability of sustainable and feasible incrementally and radically innovative products by considering their basic drivers to engender customer value.

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## UNDERSTANDING THE ENGINEERING DESIGN PROCESS THROUGH THE EVOLUTION OF ENGINEERING DIGITAL OBJECTS

Gopsill J.A., Jones S.L., Snider C.M., Shi L., McMahon C., Hicks B.J. /

*University of Bristol (GBR)*

1773

The generation of digital objects are present throughout the work that is undertaken during the engineering design process. Although it is self-evident that these objects have been created by engineers to support their work, little research has been performed to understand whether there are underlying signatures in their generation that could provide useful insights to the management of the project. In order to address this, this paper presents some initial insights from the analysis of the generation of digital objects from an engineering project, and discusses potential signatures.

## MEASURES AND METHODS FOR SYSTEMATIC KNOWLEDGE MANAGEMENT

von Saucken C.C., Schenkl S.A., Dahlmann P., Maurer M. / *Technical University Munich (DEU)* 1925

The employees' knowledge is the essential success factor for technology-intensive companies, especially within knowledge-intensive processes such as the engineering design process. We see a big challenge in the complexity of knowledge and tasks of multiple employees and corresponding relations. In earlier publications we developed an approach for dealing with this complexity by means of a matrix-based illustration (DMM: Domain Mapping Matrix). In this paper we describe a systematic approach for deriving appropriate means and methods for a department based on results from the DMM analysis.

## ONTOLOGY BASED TOOL FOR TASK TRACKING AND DECISION SUPPORT IN AN AUTOMOTIVE COLLABORATIVE WORKING ENVIRONMENT

Softic S., Rosenberger M., Zoier M., Zernig J., Kaiser C., Stocker A. /

*Virtual Vehicle Research Center (AUT)*

1895

Nowadays, product development in automotive industry is a distributed process which involves a variety of participants with different roles. Intensive changes on product need a high communication effort, which is still carried out in face to face meetings and does not interact directly with engineering artifacts affected by these decisions. Our work aims to overcome this problem by offering a collaborative working tool which enables flexible management of information about collaboration and supports decision-making within collaborative working environment of the automotive product development.

## USING MANUFACTURING TECHNOLOGICAL POTENTIAL IN PRODUCT DESIGN – A COGNITION-BASED APPROACH

Roos M., Gramlich S., Klobberdanz H., Ćorić M. / *Technical University Darmstadt (DEU)*

1853

Most product development approaches consider a manufacturing technology by ensuring the manufacturability of products. Instead a systematic cognition-based approach is developed to emphasize the potential of a manufacturing technology. The return and integration of technological cognition can be described uniformly and formalized by product properties. Considering the correlation between manufacturing-induced properties and further product properties innovative products can be derived as for example multi-chambered profiles with high stiffness or snap-fit connections made of steel.

## A FRAMEWORK FOR THE DEVELOPMENT OF CHARACTERISTIC SIGNATURES OF ENGINEERING PROJECTS

Snider C.M., Jones S.L., Gopsill J.A., Shi L., Hicks B.J. / *University of Bristol (GBR)*

1883

Engineering projects are highly complex, involving many project actors as they produce thousands of files, e-mails and outputs. The premise of this work is that in these complex project eco-systems there is a high amount of implied information, particularly in the digital files produced by each actor, which has potential to be automatically extracted and used to improve process or output. This work presents a framework by which files can be categorised and analysed, thereby generating useful project information directly from the actions of project actors; and gives two real-data examples.

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## TOWARDS CAD INTEGRATED SIMULATION OF USE UNDER ERGONOMIC ASPECTS

Krüger D., Wartzack S. / *Friedrich-Alexander University Erlangen (DEU)*

2095

In this paper biomechanical human models are proposed as a possibility to simulate ergonomic aspects of user-product interaction already in the early stages of the development process. Hereby designers are enabled to quantify the relationship between design parameters and the level of biomechanical stress prevalent during product use within the user's organism. The contribution focuses on a task oriented modelling of user-product interaction employed to synthesise human motion and the seamless integration of biomechanical human models into common CAD/ CAE engineering environments.

## INNOVATIVE DESIGN OF CULINARY MOULDS BASED ON CRUMPLED PAPERS

Rohmer S., Merat A. / *Universite de Technologie de Troyes (FRA)*

2147

The paper proposes experimental flexible moulds usable in the bakery sector. Based on principles derived of origami techniques, a square baking paper sheet becomes a structured baking paper mould (CBPM) able to reproduce structures inspired by nature. Some prototypes are presented to prove their operational ability to achieve the same functions as existing silicone moulds. In a sustainable context, CBPM also have the advantages to be based on agro-resources, recyclable and biodegradable, they can be considered as eco-friendly products.

## CLASSIFYING PHYSICAL MODELS AND PROTOTYPES IN THE DESIGN PROCESS: A STUDY ON THE ECONOMICAL AND USABILITY IMPACT OF ADOPTING MODELS AND PROTOTYPES IN THE DESIGN PROCESS

Isa S.S., Liem A. / *Norwegian University of Science and Technology (NOR)*

2071

This paper discusses model making approaches in the design process and also classifies broadly the different types of physical models and prototypes. It also describes the fundamental principles of different methods of model making and prototyping and questions how they can be used in the conceptual and detailing design stages of the design process. The first part of this paper explains how physical model and prototypes are classified and why it is so important for gaining a better understanding of the designed product in terms of usability and technical functionality. The second part of this paper focuses more specifically on how these tools are helpful or restrictive in facilitating the creation of ideas, concepts and detailed design solutions following the various stages of the design process. Finally a user-centered and cost-efficiency design perspective will be discussed with respect to what extent models and prototypes are able to facilitate design changes throughout the different stages of the design process.

## USING ARCHETYPES TO CREATE USER PANELS FOR USABILITY STUDIES

Stavrakos K., Ahmed-Kristensen S., Goldman T. / *Technical University of Denmark (DNK)*

2157

Designers at the conceptual phase of products such as headphones, stress the importance of comfort, e.g. executing comfort studies and the need for a reliable user panel. This paper proposes a methodology for a reliable user panel to represent large populations and validates the proposed framework to predict comfort factors, such as physical fit. Data of 200 head was analysed by forming clusters, 9 archetypal people were identified out of a 200 people's ear database. The archetypes' responses on physical fit were compared against those of 20 participants interacting with 6 headsets.

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## PRIORITIZATION OF VALIDATION ACTIVITIES IN PRODUCT DEVELOPMENT PROCESSES

Albers A., Klingler S., Wagner D. / *Karlsruhe Institute of Technology (DEU)*

81

Major iterations in the late development process lead to high costs. Therefor validation activities should be part of the process as early as possible. However every development process has requirements to meet as e.g. budget limitations. Therefor a methodological support is needed to prioritize the validation activities. The presented approach is based on the idea that the most critical sub-systems have to be validated first. For determination of the criticality three factors were described. By rating the three factors, the designers are able to estimate the criticality of a certain solution.

## DESIGN METHODS AND FACTORS INFLUENCING THEIR UPTAKE IN PRODUCT DEVELOPMENT COMPANIES: A REVIEW

Jagtap S., Warell A., Hiort V., Motte D., Larsson A. / *Lund University (SWE)*

231

Design methods are necessary to support product development companies in improving their product development processes, and thereby in producing high quality products. The uptake of design methods in such companies is limited and lower than one might expect. There is a wide variety of literature related to factors that influence the uptake of design methods in companies. In this paper, we synthesised this literature, and in particular, developed a framework of factors than can influence the uptake of design methods in product development companies.

## APPLICATION OF THE FMEA DURING THE PRODUCT DEVELOPMENT PROCESS – DEPENDENCIES BETWEEN LEVEL OF INFORMATION AND QUALITY OF RESULT

Würtenberger J., Kloberdanz H., Lotz J., von Ahsen A. / *Technical University Darmstadt (DEU)*

417

The FMEA is a method to analyse failures and their risks to the customer. If it is used as early as possible during the product development process, the usable level of information is very low. The level of information grows and is understood as all available information according to an instant in time. In order to analyse dependencies between level of information and quality of result, the FMEA input and output is systematized and measured with the help of product and process models as well as an Information Quality Framework. It can be used to estimate the ideal time to perform a FMEA.

## CLASSIFICATION OF METHODS FOR THE INDICATION OF CHANGE PROPAGATION - A LITERATURE REVIEW

Helms S., Behncke F.G.H., Lindlöf L., Wickel M.C., Maisenbacher S., Lindemann U. / *Technical University Munich (DEU)*

211

Engineering changes (EC) are an unavoidable part of product development and are both source of innovation and costs. An aspect of ECs is their risk of propagating. Engineering change propagation (ECP) occur wherever there are dependencies within the product and thus a change to one part of the system triggers subsequent changes in other parts. Literature provides various methods to support designers at handling unwanted ECP. Hence, these methods apply to different scopes and intend at answering different questions. This paper aspires a summary of established methods for the indication of ECP.

## OFFSHORING OF ENGINEERING SERVICES: A CASE STUDY FROM THE AUTOMOTIVE INDUSTRY

Simplay S., Hansen Z. / *Coventry University (GBR)*

1999

Offshoring of engineering services in the automotive industry is progressively increasing with organisations taking advantage of low cost regions and highly educated workforce. This paper presents a case study of a large automotive multinational that offshored the body engineering activity of a complete vehicle design for cost advantages. The findings showed that when offshoring complex engineering services this caused complexities and challenges to both organisations. The case company decided to pull back the engineering services and outsource to an engineering service provider based locally.

Congress Hall Ragusa

SESSION D431

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## METHODICAL SUPPORT FOR THE DIMENSIONING OF VARIANT LIGHTWEIGHT STRUCTURES UNDER DYNAMIC EXCITATIONS

Plaumann B., Krause D. / *Hamburg University of Technology (DEU)*

1167

The dimensioning of lightweight structures under stationary dynamic loading is a challenging task, especially in highly variant product structures. A methodical approach using dynamic substructuring algorithms was developed to support simulation based vibration behaviour prediction of a modular product structure and improve the dimensioning for highly variant lightweight structures. The contribution focuses on the methodical model preparation with consistent interface and system boundary definition. The approach is explained using an example from the aircraft cabin.

## FUZZY LOGIC FOR PRODUCTION ENERGY EFFICIENCY ESTIMATION

Stetter R., Witczak P., Staiger B. / *Hochschule Ravensburg-Weingarten (DEU)*

1199

The energy necessary for the production of goods can very often not be analyzed in depth in early stages of product development, because today the common tools of product development, such as CAD-systems, generally do not offer the possibility to support designers and engineers in this endeavor. For some products, such as mobile phones, the portion of energy used for production can rise up to 80%. The energy consumption in production and disposal is determined very early in the product development process by designers and engineers; the presented approach aims to support such decisions.

## TOWARDS A PRODUCTION SYSTEM SPECIFICATION TECHNIQUE FOR FUNCTIONALLY GRADED COMPONENTS

Petersen M., Bauer F., Hess S., Gausemeier J., Graessler I. /

*Heinz Nixdorf Institute, University of Paderborn (DEU)*

1157

Functional gradation means a tailored distribution of properties over the spatial dimensions of a component based on a complex manufacturing process chain. The synthetisation of these processes requires a framework that generates numerous information for the production system elaboration during the further design phases. Therefore a production system specification technique for functionally graded components is presented. The specification technique enables the visualisation of the resulting process chain with all information in a descriptive manner and offers an interface for Microsoft Visio.

## VISUAL MODELLING OF PILOT PRODUCTION TO SUPPORT DECISION MAKING IN PRODUCTION DEVELOPMENT

Ravn P.M., Gudlaugsson T.V., Mortensen N.H. / *Technical University of Denmark (DNK)*

1179

This paper presents the development of a visual production model that emphasizes product variant creation, product characteristics definition, and benefits of updates to the production equipment. The implementation of the model to model three instances of a pilot production ramp-up, including investigating the needs for a model, the data collection, the modeling process, and the experiences from the implementation, is presented. The paper concludes that the model makes tacit knowledge of stakeholders explicit and supports communication of the intended benefits of the production ramp-up.

SESSION D432

Congress Hall Bobara

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## MAPPING REQUIREMENTS TO A PRODUCT ARCHITECTURE SUPPORTED BY A PLM SYSTEM

**Bruun H.P.L., Hauksdóttir D., Harlou U., Mortensen N.H. /**

*Technical University of Denmark (DNK)*

1741

The purpose of this paper is to support the interplay between the problem (requirement) domain and the solution (architecture) domain of a product family. An approach for mapping requirements to architectural views of a product family is presented. In the approach 5 views are suggested, 2 requirement model views, a customer view and a functional view, and 3 views describing the product architecture; functional system, physical module and interface view. The paper furthermore describes how the suggested approach can be accomplished by using a Product Lifecycle Management (PLM) tool.

## SEMANTIC SUPPORT FOR ENGINEERING DESIGN PROCESSES

**Breitsprecher T., Codescu M., Jucovschi C., Kohlhasse M., Schröder L., Wartzack S. /**

*Friedrich-Alexander University Erlangen (DEU)*

1723

The engineering design process follows a series of standardized stages of development, which have many aspects in common with software engineering. For example, the principle solution can be regarded as an analogue of the design specification, fixing as it does the way the final product works. Here, a semantic approach is outlined where development documents are annotated with ontological assertions, thus making the intended requirements explicit and available for machine processing, such as requirement tracing. A spring tester design study is used for a proof of concept.

## BOM-CENTRIC PRODUCT DATA MANAGEMENT FOR SMALL AND MEDIUM MANUFACTURING ENTERPRISES

**Jung S.-Y., Kim B.H., Choi Y.-J., Choi H.-Z. / Korea Institute of Industrial Technology (KOR)**

1799

Even though commercial PDM systems have a lot of nice functions, they are still heavy and expensive system to apply to small and medium manufacturing enterprises. From that reason, this study proposes a light and user-friendly PDM system dedicated for SMMEs which connects with several bill-of-materials (BOMs) and manages drawings, technical documents and design history. The BOM-centric PDM proposed mainly focuses on engineering BOM, green BOM, manufacturing BOM and process BOM. A prototype system implemented is applied to a few cases actually to know the usefulness of the system.

## MODIFIED SAPPHIRE MODEL AS A FRAMEWORK FOR PRODUCT LIFECYCLE MANAGEMENT

**McSorley G., Fortin C., Huet G. / École Polytechnique de Montréal (CAN)**

1843

Testing and in-service information remains difficult to manage under current Product Lifecycle Management (PLM) frameworks. While several researchers have proposed solutions, the temporal and behavioural aspects of the lifecycle have not always been explicitly considered. In this paper, it is demonstrated how the SAPPHIRE model of causality can be applied to PLM. An extended model is proposed, and through the use of design, manufacturing, and in-service scenarios, its feasibility as a future PLM model is explored. Future work includes validating the model through concrete case studies.

## DIFFERENT VIEWS ON THE PRODUCT LIFE CYCLE

**Kroták S., Šimlová M., Štádlér C. / University of West Bohemia (CZE)**

1821

In this paper the possibility of streamlining the implementation of innovations in manufacturing companies to increase their competitiveness by defining and describing a complex product life cycle is presented. This is based on the advantages of more life cycles and on knowledge from Engineering Design Science that has been widely used in recent years. The marketing aspect is integrated in the resulting life cycle because the extent of market success can be greatly affected by marketing. Because innovations bring some risks, some of them are introduced in the paper.

Congress Hall Orlando

SESSION D433

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## VERIFICATION OF QUALITY CRITERIA BY CUSTOMER INTEGRATION

Füller K., Schenkl S.A., Schneider F.-X., Hutterer P., Mörtl M., Kremer H. /

*Technical University Munich (DEU)*

2033

The design and development of new products targeted at unknown market segments is related to challenges such as uncertainty in regard of customers' quality demand. For successfully developing new products, companies need to identify product features that determine the product quality as perceived by customers. To this end, customer integration into innovation processes is a valuable approach. In this paper, we introduce a methodology for evaluating quality criteria by customer integration and illustrate the application of the methodology with a single case study in the automobile industry.

## INFLUENCE OF CONSUMER'S BACKGROUND ON PRODUCT PERCEPTION

Perez Mata M., Ahmed-Kristensen S., Brockhoff P.B. / *Technical University of Denmark (DNK)* 2125

Research in emotional design largely focuses on altering the physical properties of products to make them more appealing, with little attention given to the background of the consumers and the possible effects on the perception of design. This study investigates if the background of consumers influences the desire to own and the perception of beauty of a vase. Surveys with 71 participants gathered perceptions of 11 vases. Results from advanced statistical analyses reveal that only gender influences the perception of beauty from vases. The background does not influence the desire to own them.

## DEMONSTRATING A METHODOLOGY FOR OBSERVING AND DOCUMENTING HUMAN BEHAVIOUR AND INTERACTION

Wilkinson C.R., De Angeli A. / *Cardiff Metropolitan University (GBR)*

2177

A methodology was developed for capturing human behaviour as part of a participatory design approach to creating an intelligent mobility aid for older people. The project aimed to anticipate user intent and predict paths posing minimal risk of collision by way of a prediction engine. The paper describes initial work that examined interaction during a simulated shopping activity and categorised behaviour in terms of active and reactive behaviours. This article informs the direction of the project and future studies with the potential to feed directly into the prediction engine's development.

## SELF-DIRECTION IN A CO-DESIGN PROJECT FOR A HOSPITAL INFORMATION SYSTEM: TOWARD SOCIETY-SHAPING DESIGN

Sunaga T., Fujimitsu S., Harada Y., Niino Y., Kobayakawa M., Yamada K., Watanabe K., Nishimura

T., Sakamoto Y., Motomura Y. / *Tama Art University (JPN)*

2167

Design today plays a role both in posing the questions of what to make and what kind of society to aim for, and also in untangling the solutions to these questions. When pursuing social design, it is important to share these questions with the people who are actually engaged in social practice. This paper focuses the principles that facilitate the self-directed collaboration fostered in a co-design project. A framework of principles for understanding the evolution of the project, a distillation of a model for self-direction, and the factors that make such evolution possible are discussed.

## INTERACTIVE DESIGN AND SAFETY IN URBAN SPACES: TWO CASE STUDIES OF A MOBILITY EXPERIENCE

La Rocca F. / *Seconda Università Napoli (ITA)*

2105

The paper focus on interactive design, representing today a broad spectrum of methodologies and skills. The ability to connect people and the visibility of environments at a distance become decisive factors in increasing safety in the urban environment, as well as being an opportunity to improve the aesthetic quality of specific places. The paper presents two case studies developed at the Second University of Naples, both based on the use of simple interaction systems that converge on the objective of improving living conditions and a feeling of safety while using design tools at different levels.

SESSION D434

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**CAN STUDENT COMPETITIONS FOSTER THE INNOVATIVE DESIGN?****Montagna F., Neirrotti P., Paolucci E. / Politecnico di Torino (ITA)****1421**

Student competitions, besides being designed to foster the educational goal of improving students' skills and knowledge, aim also at fostering innovation, developing leading technology and new solutions. However, it can happen that, instead of bringing positive effects, competitions create collateral effects to innovative research, resulting a large waste of resources. The innovation goal gets lost, leaving to competition the only educational role. In order to prove this, the author has investigated the Shell Eco-Marathon case, being fuel economy competitions among the most known.

**A DECADE OF PROJECT BASED DESIGN EDUCATION – IS THERE A FUTURE?****Vukašinović N., Fain N. / University of Ljubljana (SVN)****1441**

The paper identifies the value of the project-based learning in the aspects of: (1) defined set of skills students perceive as relevant for their transition from theory to practice; (2) identified gap between educational approach to design and design practice. To achieve this, qualitative and quantitative means of data collection have been implemented. Results of project-based learning revealed student lack many communication and teamwork skills despite sufficient technical knowledge. Although academic staff is aware of that, they miss sufficient support from governments and practitioners.

**LEARNING FOR PRODUCT INNOVATION ENGINEERING****Ericson A., Larsson A. / Lulea University of Technology (SWE)****1371**

The paper describes and reflects on a shift in teaching activities and learning objectives for innovation and design thinking. The purpose is to inspire lecturers and instructors to reconsider and redesign their pedagogical approach. A shift in industrial manufacturing practices, from a core product perspective to a user oriented value perspective, is the trigger for proposing a change in engineering educations. The importance to start on a small, but broad scale (i.e. in different types of courses), to be persistent and to understand that the effects often are lagged is the core message.

**EXPERIENCE IN THE USE OF ENGINEERING PRODUCT DESIGN PRINCIPLES TO EXTEND NOVICE ENGINEER CAPABILITY****Jiang P., Lee S., Childs P.R.N. / Imperial College London (GBR)****1381**

In the educational context different design activities can be used to introduce distinct design skills. In the paper students undertook the design of a cordless handtool by addressing a wide range of functional attributes and design rationale. Experience with this project suggests that case studies provides a suitable activity for students to explore and understand product functions and other design activities. The analysis has indicated paucity in understanding the significance of product design specifications and design rationale among students and therefore suggest more intensive training.

Congress Hall Šipun

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## CLOSING

Chair: Marjanović Dorian (HRV)

### EUROPEAN DESIGN INNOVATION PLATFORM - DRIVING INNOVATION THROUGH DESIGN

**Fennelov C. / *Design Council (GBR)***

On behalf of the European Commission, the Design Council and the consortium of 13 other partners, are delivering the European Design Innovation Platform (EDIP) for three years from January 2014. The aim of the EDIP is to raise awareness and build capacity for design among SMEs, the public sector and policy-makers through a programme of engagement as well as an online platform. One of the sub-themes of the platform is to promote the economic value of design to a range of different sectors. The project will raise awareness of examples that show how design-driven innovation is being used to drive business growth and boost job creation across Europe. Design Council's recent evaluation report, *Design Delivers for Business*, shows that every pound invested in design by SMEs translates into over 4 GBP net operating profit, over 20 GBP net turnover and over 5 GBP net exports. Businesses that invest in design have about 50% better long-term financial performance than their peers. 21% of European companies are already using design as a strategic means to encourage innovation and the EU's design sector has an annual turnover of €36 billion. The EDIP aims to increase this by promoting the adoption of design as a driver for competitiveness, prosperity and well-being across the EU. The platform will act as a one-stop-shop for anyone interested in finding the latest tools and techniques for applying design, making connections with peers, and finding the latest research. By developing a digital platform that will bring together knowledge and examples of innovation design from across the EU, EDIP aims to create a space where those wanting to know more can connect with each other. It will also work alongside a programme of events for European business people, public service managers, and policymakers. This will increase their awareness of design's role in innovation and growth, and enable them to put what they learn into practice. All parties who are interested to be part of this project can register their interest on [www.designplatform.eu](http://www.designplatform.eu).

### CONFERENCE REFLECTION

**Lindemann U. / *Technical University Munich (DEU)***

SESSION D4-C

Congress Hall Ragusa

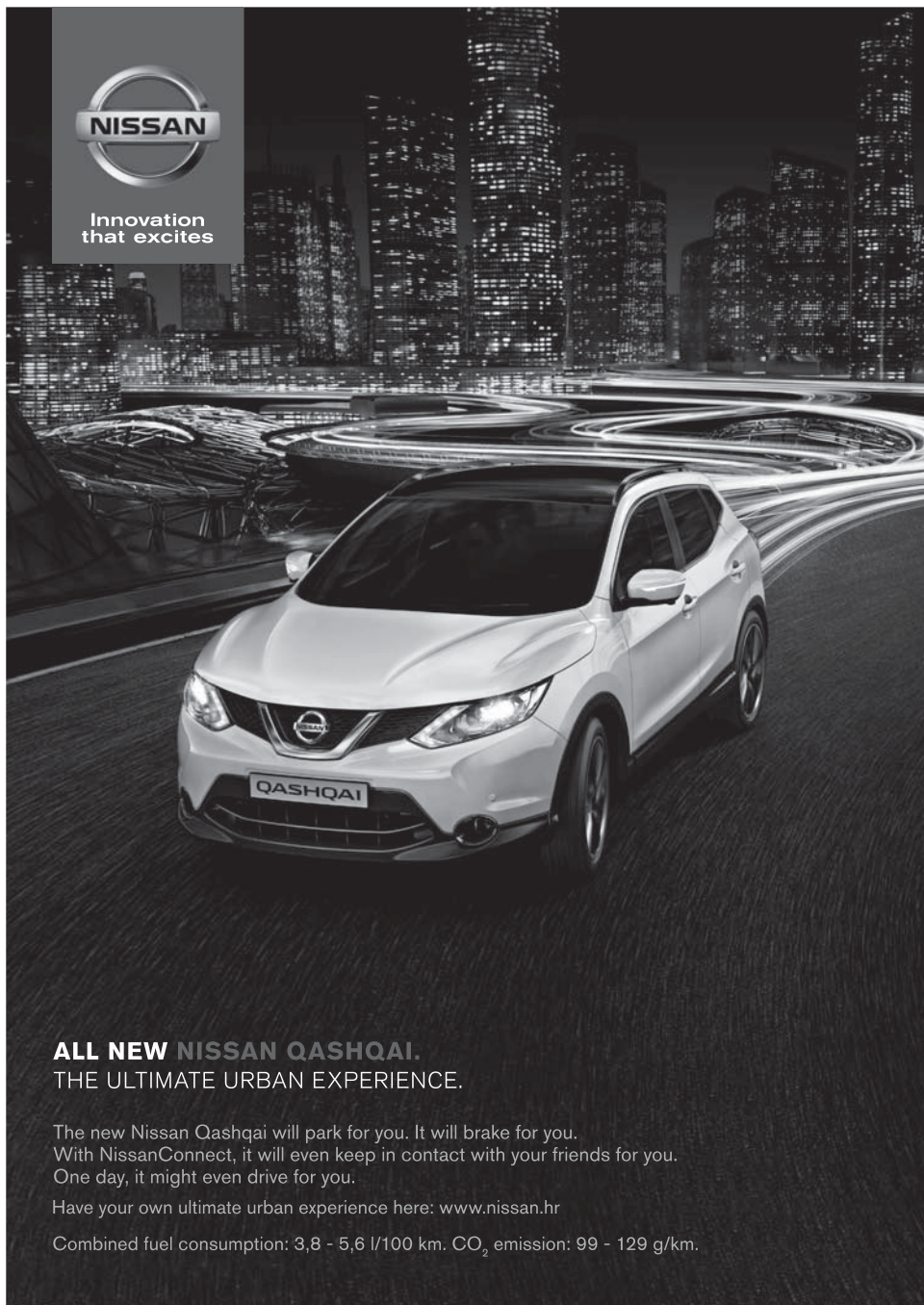
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16:30 - 17:45

A black and white advertisement for the Nissan Qashqai. The top left features the Nissan logo and the slogan "Innovation that excites". The main image shows a white Nissan Qashqai driving on a road at night, with a city skyline in the background. The car's headlights are on, and there are light trails behind it, suggesting motion. The license plate area says "QASHQAI".

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## NOTES

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