DESIGN 2016

Excellence in Design

PROGRAMME & BOOK OF ABSTRACTS

14TH INTERNATIONAL DESIGN CONFERENCE
May 16 - 19 2016 Cavtat, Dubrovnik, Croatia

Programme chairs
Stephen J. Culley
Udo Lindemann
Tim McAloone
Christian Weber
Dorian Marjanović

FSB

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DORIAN MARJANOVIĆ
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Editors:
Dorian Marjanović
Mario Štorga
Neven Pavković
Nenad Bojčetić
Stanko Škec

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Tomislav Martinec, Marija Majda Perišić, Jasmin Juranić, Lucijan Stamać, Ida Midžić, Vlasta Klaić
University of Zagreb Faculty of Mechanical Engineering & Naval Architecture

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DESIGN 2016
Excellence in Design

In June 1981, the first "Simposium on Design - Scientific and Professional Meeting" took place at the University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture. The proceedings of this event encompassed four themes: "The Science of Design, Computer Aided Design, Ergonomic and Design, and The Situation in the Field of Designing in our Science and Industry". Motivation for the Meeting was emphasised in the Foreword:

> "The development of new technologies in many fields of human activities imposed necessity of scientific approach to the process of designing. This need emerged, demanding qualitative changes in approach, development and application of the methods of design.
> Based on modern scientific achievements and modern information processing, these methods create a new technical scientific field "The Science of Design". Comparatively fresh, this scientific discipline analyses the process of design development with the aim of discovering the rules governing deisgn processes."

Looking at the proceedings of this event it is hard to imagine that this conference would continue to gather interest for the next 35 years. After three events in Zagreb, the conference first took place in Dubrovnik, in the year 1998 and since y. 2000 Cavtat has provided an inspiring environment for discussion amongst researchers and practitioners that think and practice design in all its multifaceted manifestations. The founding of Design Society and the effort of the DESIGN programme chairs provide a synergy that has brought DESIGN conference to its 14th event, celebrating its 35th anniversary.

The design research presented at the 14th DESIGN conference reflects predominantly the interests of design researchers and practitioners connected with academia, epitomising the current situation in design research, readdressing questions that have been discussed through the last four decades or more. Although the answers offered are in some cases similar to previously published research there is clear development, reminding us that science provides only partial truths.

The truly thought provoking essence of design lies in its complexity that cannot be modelled or formally designated within autonomous theory or models. Noticable variation in approaches, proposed design theories and models recently became a research theme tending to consolidation and convergence. Since the first "Meeting" the progress has been made: for design and for design research, or to be more precise, in research about design and implementation in design practice. These advances have led to methodological stability and autonomy of the design discipline.

Discussion and further development of all aspects of design knowledge from cognition and philosophy, to methods and tools, from research theory to practice is the reason for gathering at DESIGN conferences. In the papers selected for the DESIGN 2016 conference the authors strive to improve design projects and processes that will require new methods, processes, competencies, information and communication technologies. How this influences engineering design methodologies and tools in practice and what impact it will have on design practice should became focal points of this discussion.

The programme of DESIGN 2016 is the result of a joint effort of Programme chairs and Organising team who have been working together for a long time. We would like to express our gratitude to all the authors who have submitted their papers and all the reviewers who have helped to select papers, ensuring an outstanding conference experience for all. A special thank you goes to all the authors and Session Chairs, who will make this experience possible.

Dorian Marjanović
Steve Culley
Udo Lindemann
Tim McAloone
Christian Weber


DESIGN 2016
Excellence in Design

CONFERENCE VENUE

The conference will take place at the Hotel Croatia CAVTAT.

REGISTRATION DESK WORKING HOURS

Sunday, 15th May:	18:00 - 20:00
Monday to Thursday, 16th – 19th May:	08:00 - 18:30

SPECIAL EVENTS

MONDAY, 16th May	
09:00 - 17:15	CONFERENCE WORKSHOPS
09:00 - 12:15	PHD FORUM
WEDNESDAY, 18th May	
11:30 - 12:45	DESIGN DEBATE
14:15 - 18:15	REMANUFACTURING WORKSHOP
16:45 - 18:15	SPECIAL INTEREST GROUPS AND EU PROJECT MEETINGS

OPENING SESSION

Congress Hall Ragusa

MONDAY, 16th May

17:15 - 18:00

UNIVERSITY OF ZAGREB, FSB WELCOME ADDRESS
Zvonimir Guzović – Dean UNIZG FSB (HRV)

THE DESIGN SOCIETY WELCOME ADDRESS
Panos Papalambros – Vice President of the Design Society (USA)

A WORD BEFORE
Dorian Marjanović – Conference Chair (HRV)

CLOSING SESSION

Congress Hall Ragusa

THURSDAY, 19th May

17:00 - 17:45

REFLECTION ON RESULTS OF THE "DESIGN RESEARCH – 10 YEARS ON" WORKSHOP
Steve J. Culley – University of Bath (GBR)
Christian Weber – Technical University of Ilmenau (DEU)

CONFERENCE REFLECTION AND CLOSING
Udo Lindemann – Technical University of Munich (DEU)

REFRESHMENTS AND LUNCHES

Refreshments and lunches will be served in the Hotel Croatia from 16th – 19th May

SOCIAL EVENTS

MONDAY, 16th May	18:45 - 19:45	WELCOME COCKTAIL – HOTEL CROATIA
WEDNESDAY, 18th May	19:00 - 23:00	CONFERENCE GALA DINNER
THURSDAY, 19th May	19:00 - 21:00	FAREWELL PARTY – HOTEL CROATIA
FRIDAY, 20th May	10:00	OPTIONAL FULL DAY EXCURSION

This excursion is NOT included in the conference fee.
Further information on conference reception desk.

GUEST PROGRAMME

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

DESIGN 2016 *Excellence in Design*

Ragusa *Bobara* *Orlando* *Konavle* *Šipun* *Quiet Salon* *Salon 5*

MONDAY, MAY 16

8:00 – 8:45 REGISTRATION

9:00 – 12:15

- D111 WORKSHOP — UNDERSTANDING THE TRANSITION FROM ECO-DESIGN TO SUSTAINABLE DESIGN — DS SIG
- D112 WORKSHOP — DESIGN BY USAGE AND EXPERIMENTATION
- D113 WORKSHOP — NEW APPROACHES TO SUPPORT DECISION MAKING IN ENGINEERING PRACTICE — DS SIG
- D114 WORKSHOP — HUMAN BEHAVIOUR IN DESIGN — DS SIG
- D115 PHD FORUM

12:30 – 13:45 LUNCH

14:00 – 17:00

- D131 WORKSHOP — DESIGN RESEARCH – 10 YEARS ON
- D132 WORKSHOP — EMOTION IN THE ERA OF CREATING EXPERIENCE — DS SIG
- D133 WORKSHOP — DESIGN FOR ADDITIVE MANUFACTURING — DS SIG
- D134 WORKSHOP — EXPLORING SUSTAINABLE DESIGN THROUGH SYSTEMS THINKING
- D135 WORKSHOP — DESIGNING THE NEXT GENERATION OF PROJECT MANAGEMENT DASHBOARDS FOR GLOBAL ENGINEERING PROJECTS

17:30 – 17:45 D1-O OPENING

18:00 – 18:45 D1-P PLENARY SESSION I

19:00 – 19:30 WELCOME COCKTAIL

TUESDAY, MAY 17

8:00 – 8:45 REGISTRATION

9:00 – 10:45

- D211 EARLY-STAGE DESIGN AND INNOVATION METHODS
- D212 PRODUCT ARCHITECTURE - IMPLEMENTATION ISSUES
- D213 DESIGN RESEARCH METHODS AND THEIR APPLICATION
- D214 MODELLING SOCIO-TECHNICAL SYSTEMS
- D215 SYSTEMS ENGINEERING AND DESIGN

11:00 – 11:15 REFRESHMENT BREAK

11:30 – 12:15 D2-P PLENARY SESSION II

12:30 – 13:45 LUNCH

14:00 – 15:45

- D231 PRODUCT/SERVICE SYSTEMS
- D232 PRODUCT ARCHITECTURE - MODELS AND METHODS
- D233 INNOVATION - COMPLEX SYSTEMS AND ENTERPRISES
- D234 KBE AND CAD SYSTEMS
- D235 PROCESS PLANNING AND SUCCESS FACTORS

16:00 – 16:15 REFRESHMENT BREAK

16:30 – 17:45

- D241 REQUIREMENTS ENGINEERING
- D242 PROCESS MODELS AND FRAMEWORKS
- D243 EARLY PHASES OF INNOVATION
- D244 COLLABORATION AND VISUALISATION TOOLS
- D245 COLLABORATION MANAGEMENT

DESIGN 2016 *Excellence in Design*

WEDNESDAY, MAY 18

REGISTRATION

- D311 UNCERTAINTY AND ROBUSTNESS
- D312 INFLUENCING FACTORS
- D313 COLLABORATION BASED INNOVATION
- D314 TOOLS FOR EARLY PHASES
- D315 CHANGE MANAGEMENT

REFRESHMENT BREAK

- D3-P PLENARY SESSION III
- D3-D DESIGN DEBATE

LUNCH

- D331 COMPUTATIONAL DESIGN SYNTHESIS
- D332 NEW APPROACHES IN SPECIALISED FIELDS
- D333 PROBLEM SOLVING AND DESIGN THINKING
- D334 HEALTHCARE AND MEDICAL SUPPORT
- D335 WORKSHOP EUROPEAN REMANUFACTURING NETWORK - PART 1

REFRESHMENT BREAK

- D340 DESIGN MANAGEMENT DS SIG MEETING
- D342 MODELLING AND MANAGEMENT OF ENGINEERING PROCESSES DS SIG MEETING
- D343 DESIGN CYBER PHYSICAL SYSTEMS DS SIG MEETING
- D344 NETWORK ACTIVITIES FOR REALISATION OF INNOVATIVE PRODUCTS
- D345 WORKSHOP - EUROPEAN REMANUFACTU-RING NETWORK - PART 2

CONFERENCE DINNER

THURSDAY, MAY 19

REGISTRATION

- D411 ADDITIVE MANUFACTURING
- D412 USER EXPERIENCE AND INTERACTION MODELLING
- D413 PRODUCT FUNCTIONALITY AND CUSTOMER INTEGRATION
- D414 INDUSTRIAL DESIGN
- D415 NEW PRODUCTS

REFRESHMENT BREAK

- D421 SUSTAINABILITY MEASUREMENT AND ASSESSMENT
- D422 UNDERSTANDING USER EXPERIENCE
- D423 METHODS SUPPORTING INNOVATION
- D424 KNOWLEDGE TRANSFER AND KBE
- D425 DESIGN EDUCATION

LUNCH

- D432 ECO-DESIGN
- D433 CREATIVITY SUPPORT AND EVALUATION
- D434 CASE STUDIES ON DESIGN METHODS
- D435 CASE STUDIES ON DESIGN PRACTICE

REFRESHMENT BREAK

- D4-P PLENARY SESSION IV
- D4-C CLOSING

FAREWELL PARTY

8:00 8:15 8:30 8:45 9:00 9:15 9:30 9:45 10:00 10:15 10:30 10:45 11:00 11:15 11:30 11:45 12:00 12:15 12:30 12:45 13:00 13:15 13:30 13:45 14:00 14:15 14:30 14:45 15:00 15:15 15:30 15:45 16:00 16:15 16:30 16:45 17:00 17:15 17:30 17:45 18:00 18:15 18:30 18:45 19:00 19:15 19:30


DESIGN 2016
Excellence in Design

MONDAY, MAY 16

Ragusa · Bobara · Orlando · Konavle · Šipun · Quiet Salon · Salon 5

	Ragusa	Bobara	Orlando	Konavle	Šipun	Quiet Salon	Salon 5
8:00–9:00	REGISTRATION						
9:00–12:15	D111 WORKSHOP UNDERSTANDING THE TRANSITION FROM ECO-DESIGN TO SUSTAINABLE DESIGN DS SIG		D112 WORKSHOP DESIGN BY USAGE AND EXPERIMENTATION		D113 WORKSHOP NEW APPROACHES TO SUPPORT DECISION MAKING IN ENGINEERING PRACTICE DS SIG	D114 WORKSHOP HUMAN BEHAVIOUR IN DESIGN DS SIG	D115 PHD FORUM
12:15–13:45	LUNCH						
13:45–17:00	D131 WORKSHOP DESIGN RESEARCH – 10 YEARS ON		D132 WORKSHOP EMOTION IN THE ERA OF CREATING EXPERIENCE DS SIG		D133 WORKSHOP DESIGN FOR ADDITIVE MANUFACTURING DS SIG	D134 WORKSHOP EXPLORING SUSTAINABLE DESIGN THROUGH SYSTEMS THINKING	D135 WORKSHOP DESIGNING THE NEXT GENERATION OF PROJECT MANAGEMENT DASHBOARDS FOR GLOBAL ENGINEERING PROJECTS
17:15–17:45	D1-O OPENING						
18:00–18:45	D1-P PLENARY SESSION I						
19:00–19:30	WELCOME COCKTAIL						

D111 WORKSHOP

Congress Hall Bobara

UNDERSTANDING THE TRANSITION FROM ECO-DESIGN TO SUSTAINABLE DESIGN

Hosted by DS SIG ECODESIGN

Chairs: Daniela A. C. Pigosso (DNK), Tim C. McAloone (DNK), Sophie Hallstedt (SWE), Yann Leroy (FRA)

In this workshop, the main trends, concepts and approaches leading the transition from eco-design to sustainable design will be discussed based on recent research and industrial cases, to enable a reflection of the benefits and challenges of the transition, from theoretical and empirical points of view. The participants will engage in active discussions on how the social dimension of Sustainable Design can be integrated into the strategic, tactical and operational levels of an organization, based on the concepts of social LCA and social innovation.

D112 WORKSHOP

Congress Hall Orlando

DESIGN BY USAGE AND EXPERIMENTATION

Chair: Bernard Yannou (FRA)

This workshop aims at inventorying, deepening, exploring concepts such as Usage, Activities, user/customer Behaviors, user/customer Preferences, Experience, Agents/stakeholders collaborations and corresponding emerging design methods and industrial issues. For considering these new user/customer dimensions within the design process, new forms of experimentations must also be considered. The workshop is open to researchers having started exploration in this domain as well as to those willing to debate.

D113 WORKSHOP

Congress Hall Konavle

NEW APPROACHES TO SUPPORT DECISION MAKING IN ENGINEERING PRACTICE

Hosted by DS SIG DECISION MAKING

Chairs: Julie Le Cardinal (FRA), Sandro Wartzack (DEU)

With increasing complexity Decision situations are characterised by complex steps and consequences are getting harder to anticipate. Tthis leads to the need to support decision-making processes methodically. On the previous DM SIG workshops a need for a computer assistance tool (e.g. an app) has been highlighted. The development of an iDecide App for a computer-aided evaluation and decision-making process should be further discussed on the workshop.

A BUSINESS MODEL CANVAS FOR IDECIDE – HOW TO DESIGN A NEW DECISION MAKING APP?

Luft T., Lamé G., Ponn J., Le Cardinal J., Wartzack S.
Friedrich-Alexander-Universität Erlangen-Nürnberg (DEU)

As products become increasingly complex, product developers have to make decisions effectively and efficiently. Therefore, the long term goal of the SIG DM is to develop an iDecide App. This app should support developers in complex decision making situations during the development process. The aim of this paper is to describe possible business models for an iDecide App with the Business Model Canvas. Some business models and one industrial case study for an iDecide App are described. This should initiate an in-depth discussion on a detailed business model for an iDecide App.

D114 WORKSHOP

Congress Hall Šipun

HUMAN BEHAVIOUR IN DESIGN

Hosted by DS SIG HUMAN BEHAVIOUR IN DESIGN

Chair: Kristin Paetzold (DEU)

The subject's relevance to product development is reflected in the increasing researching and developing of methods and concepts, which also increasingly refer to approaches from other human-oriented research disciplines. The aim of the workshop is to identify typical methods and, furthermore, to develop a framework for methods of user participation and user integration. Such a framework is intended not only to reflect the state of the art but also helping to identify research needs and to initialize research collaborations.

D115 PHD FORUM

Tihi salon (Quiet Salon)

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

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 specifi c needs of PhD students. Therefore, the DESIGN 2016 conference offers a PhD Forum.

The aims of the PhD Forum are:

- To foster the exchange of ideas and research approaches between younger researchers
- To provide opportunities for discussing personal research topics, methodologies and potential problems with experts
- To enhance networking and collaboration

The forum will be an opportunity for PhD students to discuss their research questions and ideas with their peers and experienced researchers in order to support their research. 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. 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.

D131: WORKSHOP

Congress Hall Bobara

DESIGN RESEARCH – 10 YEARS ON

Chairs: Steve J. Culley (GBR), Christian Weber (DEU)

At DESIGN 2016, 10 years after the first workshop, we want to investigate which goals were achieved, which were not achieved and which were overlooked and what are the topics for 2026? After short statements about past results and various perspectives on design research, we expect – formalised as well as unformalised – contributions of the next generation of researchers and thought leaders about their view on future directions.

D132: WORKSHOP

Congress Hall Orlando

EMOTION IN THE ERA OF CREATING EXPERIENCE

Hosted by DS SIG EMOTIONAL ENGINEERING

Chairs: Monica Bordegoni (ITA), Shuichi Fukuda (JPN), Robert Wendrich (NLD)

Intro short talks on Emotion in the Era of Creating Experience, will be followed by extensive discussion on product experience metrics. Participants are invited to present showcase products and experiences through sketches, storyboards, videos and tangible prototypes. Participants are invited to contribute with short talks on the: Experience design, Multisensory experience, Methods for design and experience evaluation, Experience prototyping and any other related to real emotions, virtual emoticons, and tangible experiences.

D133: WORKSHOP

Congress Hall Konavle

DESIGN FOR ADDITIVE MANUFACTURING

Hosted by DS SIG ADDITIVE MANUFACTURING

Chairs: Georges Fadel (USA), Kristina Shea (CHE)

Design for AM extends this focus to include new design models, methods, guidelines, processes and tools focused on the link between designing for AM and understanding and characterizing AM processes and materials such that they can be better exploited. The workshop provides a forum to bring interested researchers, practitioners and educators together internationally to discuss these goals, share experience and push the state-of-art forward. The workshop will include keynote talks and discussion to determine the current priorities in this area focusing on DfAM guidelines, methods and tools.

D134: WORKSHOP

Congress Hall Šipun

EXPLORING SUSTAINABLE DESIGN THROUGH SYSTEMS THINKING

Chairs: Steven Hoffenson (USA), Cecilia Berlin (SWE)

This workshop explores the state-of-the-art in systems thinking and sustainability assessment, drawing from the experiences of the participants and organizers to better understand how to integrate these areas into the design research community and design practice. The agenda includes interactive exercises designed to provoke fun, thoughtful discussions and examine the roles of stakeholders in sustainable design, interspersed with short presentations by the facilitators on the state-of-the-art and their personal experiences in systems thinking, environmental sustainability, and social sustainability.

D135: WORKSHOP

Salon 5

DESIGNING THE NEXT GENERATION OF PROJECT MANAGEMENT DASHBOARDS FOR GLOBAL ENGINEERING PROJECTS

Chairs: Chris Snider (GBR), Lia Emanuel (GBR), Hamish McAlpine (GBR)

Innovative analysis methods, visualisations and dashboards are needed to provide specific and timely information essential to a project manager's tasks and objectives. This workshop comprises two activities through which researchers and practitioners can begin to explore these challenges. First, drawing on the insights of the participants and organisers, we will evaluate and discuss the factors within projects that have the biggest effect on eventual performance, success and failure. Second, from this common understanding, participants will engage in a hands-on participatory design session to create prototype dashboard tools that would support and improve the management, control and performance of engineering projects; with the best designs (as voted by workshop participants) winning special prizes.


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D1-O: OPENING SESSION

17:15 - 18:00

UNIVERSITY OF ZAGREB, FSB WELCOME ADDRESS

Zvonimir Guzović
Dean UNIZG FSB (HRV)

THE DESIGN SOCIETY WELCOME ADDRESS

Panos Papalambros
Vice President of the Design Society (USA)

A WORD BEFORE

Dorian Marjanović
Conference Chair (HRV)

D1-P: PLENARY SESSION I

Chair: Lindemann, Udo (DEU)

18:00 - 18:45

DESIGN AND TECHNOSCIENCE – WHAT'S UP WITH RESPONSIBILITY?

Klaus Kornwachs
Humboldt Study Center for Humanities, University of Ulm (DEU)

"Quia parvus error in principio magnus est in fine, secundum philosophum ..."
"A small error at the outset can lead to great errors in the final conclusions as the Philosopher says ..."
Thomas de Aquinas 1255

Today, nearly every discipline has been converted into a science. The borderlines between the pure or epistemic sciences on the one hand, and the action sciences or applied science on the other hand have become fuzzy. Thus all disciplines have more or less theoretical, empirical and practical issues as well. Any given science can act as an ancillary discipline to any other science. Whilst practical design seems to be only a matter of technology, the study of possibly alternative design is a task for the technological sciences. Yet today, design is done in a scientific and computer aided way as never before. The thinking in alternatives requires that the practical design has become also a scientific, not only a practical task.

"The technological sciences establish the cognitive requirements for technological innovation and the application of technological knowledge, and provide us with a basis for considering the impact and repercussions of technology." Here we call the set of technological sciences Technoscience. We speak about Engineering and Technology as multi-faceted disciplines. With this definition of Acatech (2012) in mind, we take a look to Design Thinking and the Modus 2 of science, according to Helga Novotny (2003).

The Modus 2 of science integrates knowledge about theoretical and empirical conditions, knowledge about phenomena and facts as well as knowledge about norms, values, and goals. Together with knowledge about technical practice and knowledge how to shape and design, we have knowledge that we cannot formalize and model completely.


DESIGN 2016
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TUESDAY, MAY 17

	Ragusa	Bobara	Orlando	Konavle	Šipun	Quiet Salon	Salon 5
8:00–8:15	REGISTRATION						
8:15–10:15	D211 EARLY-STAGE DESIGN AND INNOVATION METHODS	D212 PRODUCT ARCHITECTURE - IMPLEMENTATION ISSUES	D213 DESIGN RESEARCH METHODS AND THEIR APPLICATION	D214 MODELLING SOCIO-TECHNICAL SYSTEMS	D215 SYSTEMS ENGINEERING AND DESIGN		
10:15–10:30	REFRESHMENT BREAK						
10:30–12:15	D2-P PLENARY SESSION II						
12:15–13:45	LUNCH						
13:45–15:45	D231 PRODUCT/SERVICE SYSTEMS	D232 PRODUCT ARCHITECTURE - MODELS AND METHODS	D233 INNOVATION - COMPLEX SYSTEMS AND ENTERPRISES	D234 KBE AND CAD SYSTEMS	D235 PROCESS PLANNING AND SUCCESS FACTORS		
15:45–16:15	REFRESHMENT BREAK						
16:15–18:15	D241 REQUIREMENTS ENGINEERING	D242 ROCESS MODELS AND FRAMEWORKS	D243 EARLY PHASES OF INNOVATION	D244 COLLABORATION AND VISUALISATION TOOLS	D245 COLLABORATION MANAGEMENT		
18:15–19:30							

LEAN INNOVATION METHODS: INSIGHTS ABOUT ITS APPLICATION & EVALUATION DURING A STUDENT PROJECT

Rötzer S., Wilberg J., Lindemann U.
Technical University of Munich (DEU)

Lean Innovation is an approach that supports companies in developing more innovative products with a lower resource consumption. The available methods help to incorporate the abstract Lean Innovation principles in processes. However, many case studies discuss the overall implementation of Lean without focusing on the methods in particular. The paper provides empirical insights by applying and evaluating two Lean Innovation Methods during a student project. The results show that the project benefited from the application but it also required effort to overcome the resistance of the people.

RE-DESIGN THE DESIGN TASK THROUGH TRIZ TOOLS

Frillici F. S., Rotini F., Fiorineschi L.
University of Florence (ITA)

Among the different activities that a designer has to perform during the design process, the clarification of the design objectives is a crucial task. Several factors make the recalled activities very difficult to accomplish. The TRIZ body of knowledge is rich of tools characterized by a great flexibility that makes possible their application to different design tasks. According to this evidence, this paper presents how Functional Analysis (FA) and System Operator (SO) can help the designer in the identification of the right design task to be accomplished.

DEVELOPMENT OF A METHODOLOGY TO IMPLEMENT SET-BASED DESIGN IN A DAY

Ström M., Raudberget D., Gustafsson G.
Swerea IVF AB (SWE)

A simplified variant of Set-Based Design (SBD) was created and combined with creative methods such as the 6-3-5 method and the gallery method. This made it easy to introduce in one day, which has been verified by tests in industrial firms. In total 45 experienced designers have tested the method on real mechanical design problems. The method was perceived easy to understand and was well received by the designers. The introduction of it was less cumbersome compared to the full version of SBD. The conclusion is that the developed method makes it easier to introduce parts of SBD with good results.

TECHNOLOGY-PULL AND BIOLOGY-PUSH APPROACHES IN BIO-INSPIRED DESIGN - COMPARING RESULTS FROM EMPIRICAL STUDIES ON STUDENT TEAMS

Farzaneh H., Helms M. K., Muenzberg C., Lindemann U.
Technical University of Munich (DEU)

Bio-inspired design focusses on analogical transfer from the large pool of biological solutions to develop innovative products. Different approaches to bio-inspired design exist, namely the technology-pull or problem-driven approach and the biology-push or solution-driven approach. The two approaches have only been compared in few empirical studies with design teams. In this work, we analyse a technology-pull and a biology-push team's procedure throughout the design project. The results are compared to past studies and provide starting points for better supporting bio-inspired design .

A LENS ON FUTURE PRODUCTS: AN EXPANDED NOTION OF PROTOTYPING PRACTICE

Camere S., Bordegoni M.
Politecnico di Milano (ITA)

Designers engage with prototyping already at the early phases of design process, implying a variety of techniques and with diversity of scopes. The classic definition of prototyping is currently debated in the design research community, to achieve one more inclusive of emerging approaches. With this paper, we propose a definition of prototypes as lenses through which designers can frame the product-to-be, raising design questions and construct answers to them. A model and a framework for prototyping decisions are also discussed in the context of other scholars' perspectives.

A METHOD TO EXPLICATE SAFETY FUNCTIONS

Roth M., Muenzberg C., Lindemann U.
Technical University of Munich (DEU)

In current markets efforts for safety analyses and approval increase. Instead of review-based methods, recent publications demand for a shift of safety considerations to early stages and to bridge the gap between designers and safety experts. This paper develops a modelling method which helps to explicit safety knowledge and model safety functions. It unites existing methods of functional and structural modelling and extends the concept of safety functions. The resulting method, thus contributes to the requested shift and helps to bridge the gap between safety experts and product designers.

ASSESSING IMPACTS OF MODULAR PRODUCT ARCHITECTURES ON THE FIRM: A CASE STUDY

Windheim M., Hackl J., Gebhardt N., Krause D.
Hamburg University of Technology (DEU)

Product modularization is difficult and has far-reaching impacts for the company. It requires a sound understanding of cause and effect chains, which start with product structure decisions, such as module boundary definitions or interface specifications, and lead to essential target values consisting of cost, quality and time categories for each product and the product portfolio. This paper investigates effects of modularity on product development and the challenges to assess them, and gives a further hint research on support for decision makers in the context of modular product definition.

DESIGN PLATFORM - SETTING THE SCOPE AND INTRODUCING THE CONCEPT

Elgh F., André S. E., Johansson J., Stolt R.
Jönköping University (SWE)

Product platforms has been a successful enabler for efficient mass customization. However, they cannot fully support suppliers working in an engineer-to-order business environment. This work identifies the need and scope of a different platform model that supports customization and management of fluctuating requirements. A novel plaform model is introduced entitled Design Platform. The model is based on the current state and future target condition at four companies. The model provides a coherent environment for heterogeneous design assets to be used in product development.

PROCESS INTEGRATED DESIGN GUIDELINES - SYSTEMATICALLY LINKING MANUFACTURING PROCESSES TO PRODUCT DESIGN

Wagner C., Roos M., Gramlich S., Kloberdanz H.
Technical University Darmstadt (DEU)

The comprehensive consideration of manufacturing potentials during product design is a challenging task for designers, which has been discussed within manifold design approaches like DfM and DfMA. Expanding the idea of design guidelines and design patterns, property-based process integrated design guidelines (PIDG) provide design solutions, which comprise of manufacturing insights, desired product functions, and use processes equally and simultaneously. Easily applicable, standardised PIDG support decision making, resulting in a more efficient design process and product innovations.

FUNCTIONAL SPECIFICATION METHODOLOGY FOR AN ARCHITECTURAL MODELER SUPPORTING A MODULAR CONSTRUCTIVE SYSTEM

Boulanger C., Rahhal A., Delfosse V., Lorquet C., Leclercq P.
University of Liege (BEL)

This article presents a methodological approach which helped the software development of an architectural modeler that aims to support the life cycle of buildings with a modular construction system. Conducted within a multidisciplinary team of architects engineers, computer engineers and ergonomists, this methodology is based on the analysis of three fields of functions (composition - production and evaluation) which are considered simultaneously through a theoretical framework stemming from ergonomics: Activity Theory.

RECONFIGURABILITY AND MODULARIZATION FOR INTEGRATED MACHINE TOOLS BASED ON FUNCTIONAL ANALYSIS: A SYSTEMATIC APPROACH

Schmid A., Katzwinkel T., Schmidt W., Siebrecht J., Löwer M., Feldhusen J.
RWTH Aachen University (DEU)

The development of machine tools integrating multiple production technologies is challenging. To minimize the effort for implementation, a systematic conceptual design for hybrid machine tools is initiated already in early phases of product development. Reference product architectures are addressed. The main emphasis is on technology and system integration. A technological similarity assessment forms the basis to assure potential for synergies. The reference architecture introduced is validated by a Multi-Technology-Platform combining a milling spindle and two laser processing units.

CHALLENGES IN IMPLEMENTING MODULE AND PLATFORM STRATEGIES IN PLANT ENGINEERING COMPANIES

Weidmann D., Chucholowski N., Lindemann U.
Technical University of Munich (DEU)

Modularization and platform strategies are a more and more important aspect in plant engineering. In contrast to series product engineering, plant engineering is characterized by individual customer requirements for each particular sold product. The implementation of such a strategy is a big challenge itself. Exemplary reasons are extensive restructuring activities in organization and processes. This contribution focuses on challenges during the implementation of a module and platform strategy derived from observations in a German medium-sized plant engineering company.

DISCRIMINATING ENGINEERING INFORMATION INTERACTION USING EYE TRACKING AND AN INFORMATION OPERATIONS MODEL

Boa D. R., Hicks B.
University of Bristol (GBR)

A set of fundamental operations used to manipulate the information space during a design problem are described and discriminated. It has been demonstrated that Information Operations are distinguishable through eye movements. However, eye movements are inherently variable and the size of the observed Information Operation-gaze effect is non-uniform, indicating a complex interrelation between operations. The findings and model afford important knowledge that can be used to improve the training and support of engineers, interface design, and offer novel means for managing compliance.

PROBLEM OR SOLUTION FOCUSED? ILL-DEFINED DESIGN PROBLEMS AND THE INFLUENCE OF DESIGN ABILITY

Self J. A.
UNIST (Ulsan National Institute of Science and Technology) (KOR)

A comparative analysis examines responses to an ill-defined design problem between industrial design students and those with no design ability. Distributions of and transitions between naming, framing, moving and reflecting were compared. Design student protocols were characterised by significantly increased moving activity. Non-design student activity indicated increased naming. Results indicate design ability as providing opportunities for appositional reasoning between problem and solution ideation. Implications for engagement with ill-defined design problems are discussed.

WHAT'S THE BENEFIT OF PROBLEM EXPLORATION?

Vasconcelos L. A., Crilly N., Chen C. C., Campos F., Kelner J.
University of Cambridge (GBR)

Models of the design process often start with activities of problem exploration before generating ideas, but the benefits of exploration have not been properly investigated. We did an experiment with undergraduate industrial designers during a design course. Except for the exploration methods, all teams had to follow the same design process. We observed that exploration methods increased the design teams' perceived knowledge about the problem, but no impact on the quality of their final designs was seen. This challenges a widely held assumption about the value of problem exploration in design.

TOWARD A COMMON PROCEDURE USING LIKERT AND LIKERT-TYPE SCALES IN SMALL GROUPS COMPARATIVE DESIGN OBSERVATIONS

Guerra A. L., Gidel T., Vezzetti E.
Sorbonne Universités, Université de Technologie de Compiègne (FRA)

Often, users' opinions in small groups comparative observations are measured through Likert and Likert-type items-based questionnaires. Resulting data are analyzed in order to find any statistical difference whether positive or negative among the two conditions. Due to the confusion around Likert scales ordinal or interval nature, how to statistically analyze them, is still an open matter of discussion. Should it be a parametric or non-parametric approach? This article analyze the existing literature and propose an approach which aim is to avoid fragmentation in this type of research.

A REVIEW OF DESIGN SUPPORT PROGRAMMES IN THE EUROPEAN UNION COUNTRIES

Swiatek P., Whicher A.
Cardiff Metropolitan University (GBR)

This paper explores how European Union member states are supporting the supply and demand of design to enhance their Design Innovation Ecosystems. Design is increasingly being recognised by governments in Europe as a factor of innovation. Acknowledging the major contribution of research on National Innovation System, this research proposes Design Innovation Ecosystem concept to inform policy-making in the field of design-driven innovation. It presents an overview of design support programmes to draw conclusion on possible future developments in design policy implementation instruments.

CLASSIFICATION OF DESIGN METHODS FROM THE VIEWPOINT OF DESIGN SCIENCE

Sakae Y., Kato T., Sato K., Matsuoka Y.
Keio University (JPN)

This paper describes the characteristics of design methods necessary for facilitating the design process of sharing and accumulating design information by classifying existing methods based on several frameworks proposed in the field of design science: "design thinking", "design methodology", and "form of data". As a result, we classify 174 design methods into 13 categories. Along this classification, it is revealed that the expansion and proposition of design methods deemed appropriate to use in basic design are necessary for information sharing and accumulation.

AN EMPIRICAL INVESTIGATION ON MODELLING OF SOCIO-TECHNICAL UNCERTAINTY LEVELS TO SUPPORT DESIGN PROCESS PLANNING

Hassannezhad M., Montagna F.
University of Cambridge (GBR)

Planning of design processes concerns multiple aspects related to the whole product, process, and organizational characteristics. The major limitation to the most of existing tools is that the social and technical aspects of uncertainties are considered separately. This paper describes the application of "Actor-Based Signposting" (ABS) in providing predictive process planning during the DP of an automotive engine component and concludes that there is no absolute way to manage uncertainty of complex projects, so there should be a balance between degree of uncertainty and goodness of product.

A METHOD TO IMPROVE DESIGN PROCESS RESOURCE MANAGEMENT

Xin Chen H. L., Moullec M.-L., Clarkson P. J.
University of Cambridge (GBR)

The paper presents a new method to model different resource types (designers, computational, testing) and study the impact of using different options of those resources by simulating and analysing the results in a PD context. Thus, activity behaviour is shaped depending on the chosen resource option to perform the activity. The approach enhances the capability to explore all the variations of resource combination design space. It was applied to an aerospace case study to identify insights such as the best performing resource combinations, critical resources and resource sensitive activities.

A SIMULATION-BASED ANALYSIS ON THE INTEGRATION OF PROGRAM MANAGEMENT AND SYSTEMS ENGINEERING

Becerril L., Rebentisch E., Chucholowski N., Conforto E., Lindemann U.
Technical University of Munich (DEU)

Poor performance in engineering programs has been partly associated with a growing cultural barrier between Program Management (PM) and Systems Engineering (SE). However, an understanding on how the integration of these two disciplines affects program performance is still missing. This study examines the relationship between the integration of PM and SE and program performance by relating factors that contribute to 'integration' and program behavior. For this purpose, a System Dynamics model is developed. Overall, the model simulations results improve the understanding of PM and SE integration.

AGENT-BASED SIMULATION FRAMEWORK TO SUPPORT MANAGEMENT OF TEAMS PERFORMING DEVELOPMENT ACTIVITIES

Perišić M. M., Martinec T., Štorga M., Kanduč T.
University of Zagreb, FSB (HRV)

An agent-based approach to modelling and simulation of design teams executing development activities is presented. Based on literature review and the need for a research and managerial planning tool, a simulation framework is developed. Different framework aspects are briefly described with indications on the supporting literature. An initial version of the agent-based model is developed based on the proposed framework. In this initial model, it is possible to simulate agents of different characteristics working by a predefined workflow of activities.

A KNOWLEDGE MANAGEMENT FRAMEWORK FOR IDENTIFYING INNOVATION POTENTIALS FROM USE PHASE INFORMATION

Omer M., Venkataraman S., Wilberg J., Hollauer C.
Technical University of Munich (DEU)

Effective knowledge management of the use-phase can be a catalyst for driving innovations. In this paper, we propose a knowledge management framework that offers a systematic approach for driving innovation from the use phase. To start, an information acquisition architecture is developed. The system KPI's are derived and agent-based models are used to evaluate the KPIs under various analysis scenarios. The insight gained is used to identify innovation potentials, and finally, the knowledge gained is shared with relevant stakeholders. The framework is applied to an ebike sharing system.

DETERMINING WORK FOCUS, COMMON LANGUAGE, AND ISSUES IN ENGINEERING PROJECTS THROUGH TOPIC PERSISTANCE

REVIEWERS FAVOURITE

Snider C., Škec S., Gopsill J., Hicks B.
University of Bristol (GBR)

Large-scale engineering projects are challenging to monitor, manage, and improve. This paper presents an approach to addressing part of this challenge - the automatic detection of engineering activity through the project lifecycle. By monitoring the focus of work in real-time, this aims to enable managers to build a detailed understanding of the activity that occurs at different stages, work that deviates from that expected, and issues as they arise. The approach is applied to a long-term email dataset, and extracts key themes, issue occurrence, and activity focus through time.

SYSTEMATIC FOR FUNCTION-ORIENTED DEVELOPMENT OF SPATIAL CIRCUIT CARRIERS AND PROTOTYPES

Jürgenhake C., Dumitrescu R.
Fraunhofer Mechatronic Systems Design (DEU)

Innovative technologies like MID (Molded Interconnect Device) are necessary to meet the rising requirements within the development and production of integrated mechatronic devices. Due to their domain-spanning nature and occurring interactions between product and production system, a consistent and systematic use of prototypes within the product development is indispensable. We developed a function-oriented systematic that assists determining the ideal manufacturing process for a prototype at any stage of the product development process taking into account process afflicted solution elements.

A TOOL FOR VISUALISATION OF COMPLEX CAD MODELS USING DSM

Zubić A., Bojčetić N., Žeželj D., Flegarić S.
University of Zagreb, FSB (HRV)

With today's increased level of product complexity during the product development, traceability is an approach which naturally fits into an environment where future decisions need to be made fast and precise with the broad spectrum of context surrounding the product. Knowing the decision making process and how conflicts inside issues were resolved helps with future versioning and product variants. Knowledge gathered during the development process can be reused and it helps to achieve better efficiency while shortening the time for finalizing similar future projects. The existing tools and methods for product development are not able to deal with today's complex dependencies in product development. In the paper a method for automatic recognition of relations between the components of a mechanical assembly was described. Captured relations are analyzed using DSM and used to support traceability during product development.

AN INTERDISCIPLINARY MODEL-BASED DESIGN APPROACH FOR DEVELOPING CYBERTRONIC SYSTEMS

Eigner M., Dickopf T., Huwig C.
Technical University Kaiserslautern (DEU)

Innovative and interdisciplinary engineering of consumer products and their production systems, like cybertronic systems, requires a rethinking of current design methodologies, processes, IT solutions, and the entire enterprise organization. In order to define a design process suited for cybertronic systems, design methodologies of all involved disciplines need to be analysed with respect to their support of an interdisciplinary design process. This paper shows an interdisciplinary model-based design approach for developing cybertronic systems based on these analysis.

TOWARDS IMPLEMENTING SYSTEMS ENGINEERING AS PART OF COMMERCIAL VEHICLE DESIGN

Karrer-Müller E., Fuss T., Schiffer M., Kreimeyer M., Schuh G.
MAN Truck & Bus AG (DEU)

Existing processes for the development of complex products in the commercial vehicle industry are often variant-based and the components and their individual diversity have priority. Most product innovations in automotive industry are realized less and less as a single innovation but as a system innovation in the field of mechatronics.The paper describes an ongoing research approach to embed systems engineering design into an existing environment of the concept design phase at a commercial vehicle manufacturer to increase the concept quality.

FOSTERING URBAN-CENTERED INNOVATION

Bekhradi A., Yannou B., Cluzel F., Chabbert F.
Ecole Centrale Paris (FRA)

This paper aims at investigating, through several examples of innovative startups, different categories of Urban-Centered Innovative (UrCI) design solutions as well as the necessity to conduct real life experimentations supported by public and private stakeholders. This research will also shed light on the reasons why some urban-centered innovations are not efficient, and provides as well decision-making elements intended for startups and public administrations in order to improve the efficiency of UrCIs.

MANAGEMENT OF VEHICLE ARCHITECTURE PARAMETERS

Toepfer F., Naumann T.
Daimler AG (DEU)

This paper describes a novel approach for modeling qualitative dependencies. The presented low-effort modeling approach facilitates the management of functional and geometric parameters in a database application. Qualitative dependencies are modeled by defining active chains. A first application of the modeling approach is the modeling of vehicle architectures. Therefore, the significance and use of vehicle architectures is described in the following.


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D2-P: PLENARY SESSION II

Chairman: Weber, Christian (DEU) **10:45 - 12:15**

MULTIDIMENSIONAL NETWORK ANALYSIS OF CUSTOMER PREFERENCES IN ENGINEERING DESIGN

Wei Chen
Wilson-Cook Professor in Engineering Design, McCormick School of Engineering, Northwestern University (USA)

Using network analysis for investigating complex social systems has gained increasing scientific support in many research disciplines. In this talk, we present a conceptual framework of multidimensional network analysis (MNA) for modeling customer preferences in supporting engineering design decisions. In the proposed Multidimensional Customer-Product Network (MCPN), customer-product interactions are viewed as a socio-technical system where separate entities of "customers" and "products" are simultaneously modeled, and multiple types of relations, such as consideration and purchase, product associations, and customer social connections are considered. Beyond the traditional descriptive analysis that examines the network structure characteristics, we employ the Exponential Random Graph Model (ERGM) as a unified statistical inference framework to interpret complex preference decisions. Our approach broadens the traditional utility-based logit models by considering dependency among complex customer-product relations, including the similarity of associated products, "irrationality" of customers induced by social influence, nested multi-choice decisions, and correlated attributes of customers and products. Examples on customer vehicle preferences are presented to illustrate the benefits of network approach.

INDUSTRY ADOPTION OF DESIGN METHODS: WHERE IS THE CRISIS?

Kevin N. Otto
Adjunct Professor of Mechanical Engineering, Aalto University (FIN)

As design researchers, one service that our community provides is to develop new methods and tools that are better in some scientific sense. Given that, how do you get companies to change what they are doing and use your better method? Prof. Otto has had years of experience working with companies large and small on product design and engineering opportunities and has ample success and failures at deploying design research methods.
Overall, design research transfer into practice follows the standard theory on technology adoption, an S-curve in time from incubation to trials to crossing the chasm into widespread adoption. This leaves open the question on how to accelerate this process. What are useful channels, papers, books, software, speaking events, web pages, etc.? A theory of design research adoption will be progressively presented, underscoring that the efficacy of your research as better or worse is irrelevant, as are the communication channels used. Instead, companies ought to be viewed as learning organizations subject to competitive pressure as periodic impulses of difficulties. Crises. Each of these crisis events are opportunities for design researchers to insert new and better methods into practice. Crises and only crises drive corporate adoption of design research. Prof. Otto will share experiences and offer recommendations.

ORGANIZING END USER REQUIREMENTS FOR PRODUCT-SERVICE ENGINEERING PLATFORM

Karvonen I., Ryynänen T., Jansson K., Korhonen H.
VTT (FIN)

A H2020 project Manutelligence aims to develop a collaborative Product/Service Engineering Platform. The development is based on end user requirements elicited from four use cases in different industrial fields. This paper focuses on the phase after elicitation: the organization of the heterogeneous requirements. Based on top-down and bottom-up analysis, a common structure is defined, the requirements are organized in the structure and turned to 20 aggregated requirements. The approach for the organization is described and the main observations from the organization and aggregation are given.

MODEL-BASED SUPPORT FOR PRODUCT-SERVICE SYSTEM PLANNING

Kammerl D., Winkler S., Schmidt D., Mörtl M.
Technical University of Munich (DEU)

The presented planning model and its implementation in a visualization tool help the Product-Service System (PSS) planner to maintain an overview of the system, the relations between its elements and further necessary information. In that manner, it is possible for the PSS-planner to modularize the portfolio, depict variants and derive structured PSS from the entire portfolio. Finally, short-, middle- and long-term planning horizons can be depicted within the model. For evaluation of the model, it was used to support the planning phase of the development of a pedelec sharing concept.

INTERDISCIPLINARY INSIGHTS FOUND FOR PRODUCT/SERVICE SYSTEM DESIGN

Brambila-Macias S. A., Sakao T., Kowalkowski C.
Linköping University (SWE)

Product/Service System (PSS) is a different way of fulfilling customer needs by providing a bundle of products and services. PSS is by nature an interdisciplinary field of research that needs collaboration across disciplines. This research paper investigates how much interdisciplinary research has been carried in terms of insights used between two important disciplines, namely, Engineering Design and Industrial Marketing. The results show that few insights have been used across disciplines which shows a gap for further research.

USER-CENTRED APPROACH FOR PRODUCT-SERVICE DESIGN USING VIRTUAL MOCK-UPS

Peruzzini M., Marilungo E.
University of Modena and Reggio Emilia (ITA)

Product-Service System (PSS) allows creating new business opportunities for companies, but also new challenges. The research defines a user-centred design methodology for PSS, which includes user-centred practices to investigate the users' needs and virtual prototyping to create immersive and interactive virtual mock-ups able to simulate the product-service behaviours for the evaluation of the user experience. An industrial case study is presented and the benefits in respect to traditional methods are demonstrated.

CONCEPTUAL DESIGN FRAMEWORK FOR ICT SERVICE SYSTEM DEVELOPMENT AND DELIVERY

Numata E., Hosono S., Shimomura Y.
NEC Corporation (JPN)

This paper propose conceptual design framework for ICT service system development and delivery. To provide ICT service systems with high value-in-use, ICT service providers explore clients' business needs and design sustainable them at the early development phase. However, this work has been relied on by certain experts and consultants.To assist such skilled work, it is necessary to urgently establish high-level service modelling methods and procedures of conceptual ICT service system design for inexperienced engineers of ICT service providers.

FRAMEWORK OF A VARIANT MANAGEMENT FOR MODULAR PRODUCT ARCHITECTURES

Weiser A.-K., Baasner B., Hosch M., Schlueter M., Ovtcharova J.
Karlsruhe Institute of Technology/Bosch Thermotechnik GmbH (DEU)

Nowadays companies are facing the threat of an increasing complexity by a modular product architecture. The implementation of a modular structure comes with high efforts, yet during the application phase these expenditures are compensated by an efficient complexity handling. However, the modular structure is not permanent. Decisions on a refinement of the modular product family have to be made, while simultaneously ensuring commonalities within the modular structure. Therefore, a framework for a modular variant management has been designed and verified at Bosch Thermotechnik.

PRODUCT ARCHITECTURE DESIGN AS A KEY TASK WITHIN CONCEPTUAL DESIGN

Richter T., Inkermann D., Vietor T.
Technische Universität Braunschweig (DEU)

Product architecture design is a key challenge of conceptualisation and has to be considered explicitly in each stage of concretisation. This paper introduces an integrated approach for product architecture design exploiting potentials of different existing methods from functional modelling to the composition of the physical product. Especially, apparently contradictory principles of functional integration and modularisation are considered collectively, to develop optimal product architectures for individual design tasks.

MODULAR FUNCTION DEPLOYMENT ADAPTED

Sonego M., Echeveste M., Fogliatto F. S., Tonetto L. M., Caten C. S. t.
Universidade do Vale do Rio dos Sinos (BRA)

Modularization strategies should be planned along the life cycle of a product. Modular Function Deployment (MFD) is one of the best known methods, taking into account different stages of the product's life cycle. However, it is not directly linked to particularities of different development projects. We propose an adaptation of MFD that takes into account different levels of complexity and novelty of each project. The adapted method allows to choose the set of stages and tools that best fits different combinations of complexity and novelty levels in a company's project.

EFFECTS OF MODULAR PRODUCT STRUCTURES ON LIFE PHASES AND ECONOMIC FACTORS

Hackl J., Krause D.
Hamburg University of Technology (DEU)

This paper contributes to the lack of an overall understanding of the impact modular product structures have on economic factors. Therefore a literature study is conducted in this paper and an impact model is created, providing cause-effect chains between modularity and economic factors. Effects which have been observed in product life phases are named and if possible related to their cause, being one of the properties of modularity (commonality, seperability, combinability). The life phase effects are then summed up to general strategic and economic factors.

TOWARDS A PLATFORM APPROACH SUPPORTING THE INTERFACE BETWEEN TECHNOLOGY- AND PRODUCT DEVELOPMENT

André S. E.
Jönköping University (SWE)

The separation of technology development (TD) and product development (PD) is adding to the challenge that suppliers face. They are to conduct long term TD and at the same time tailor products when the order arrives. This paper proposes a platform approach in order to describe some conceptual knowledge. An example from the automotive business where early simulations of concepts are performed during TD is presented. The focus is on how these simulations can support the transfer of knowledge from TD to PD and how they are to be described in order to communicate the technology's ability to adapt.

KOPPELSYSTEMS: OBLIGATORY ELEMENTS WITHIN VALIDATION SETUPS

Albers A., Pinner T., Yan S., Hettel R., Behrendt M.
Karlsruhe Institute of Technology (DEU)

Validation is one source for new objectives and new design solutions. Within validation activities, models represent specific properties of the system in development or its user or environment. For the implementation of models on the test bench "Koppelsystems" must be selected and installed. Such Koppelsystems ("koppeln" is a German word for "to interconnect") may be necessary to interconnect models of different fidelity levels or of incompatible input and output flows. The paper analyses the role of Koppelystems within validation activities.

PERFORMANCE ASSESSMENT OF DESIGN DRIVEN NEW ENTREPRENEURIAL VENTURES

Petersen S. I.
ingomar & ingomar (USA)

The investment potential of startups is notoriously difficult to assess and there are no assessments addressing Market, Technology, Design Execution Risk and Design Quality. We examine this issue and offer a risk and design valuation process. Partnering with the INDEX Award, we analyzed 250 applicants, finding 3 key performance indicators. Our analysis shows that investors' assessment of design quality co-varied positively with combined risk. Applying this and other insights and assessments from entrepreneurs, experts and investors can provide a predictor for investment worthiness.

A FRAMEWORK FOR INNOVATION OPPORTUNITY IDENTIFICATION BASED ON BRAND EXPERIENCE

Gonzalez I., Val E., Justel D., Iriarte I.
Mondragon Unibertsitatea (DBZ) (ESP)

Companies need to focus their innovation activities toward the generation of a unique and memorable brand experience to gain sustainable and significant competitive advantage.Hence, there is a growing need for practical guidance on how to transform brand values into relevant customer experience. Existing brands already generate a particular experience in the mind of the consumers. However, inconsistencies exist between what the brand wants to communicate and what the customer perceives. We propose a framework which helps us to identify and understand the reasons behind these inconsistencies.

AN EXAMPLE OF HYBRIDIZATION BETWEEN THE "DISCOVERING MATRIX" AND THE "9 WINDOWS" TOOLS DURING IDEATION PHASES OF INTERCLUSTERING PROJECTS

Ambrosino J., Legardeur J.
ESTIA Research, Bordeaux University (FRA)

In the specific context of coopetition between members of clusters, innovative collaborative projects emergence is a key issue for members and clusters. Given the heterogeneous ecosystems that evolve within the clusters, the interclustering strategy which is conducted to create new types of cross-sectoral projects require new appropriate tools to support creative and new ideas emergence. Strong synergies are highlighted through the use of the discovering matrix and 9 screens tools. These links help facilitators of clusters to optimize the preparation and animation of creative sessions.

AN EXTENDED METHODOLOGY FOR THE ASSESSMENT OF TECHNICAL INVENTION EVOLUTION

Smojver V., Štorga M., Potočki E.
The Vehicle Center of Croatia (HRV)

Within this paper, the authors present the early result of the study focusing on the evolution of the technical invention by using patents as a proxy for technology development. In looking at the dynamics, the presented research focuses on the extension to the existing qualitative approaches by the creation of patents citation network and dynamic network analysis to reveal the nature of technical invention evolution within particular patent class describing the scope and context. In the future steps this will be integrated into a framework for the future technology prediction..

NETWORK INSIGHTS FOR PARTNER SELECTION IN INTER-ORGANISATIONAL NEW PRODUCT DEVELOPMENT PROJECTS

REVIEWERS FAVOURITE

Parraguez P., Maier A.
Technical University of Denmark (DNK)

Selecting partners for inter-organisational new product development (NPD) projects is an important yet under-supported task. This paper provides decision-support for the collaboration stages of partner exploration and search. In particular, we propose a conceptual framework for a data-driven and network-based platform. The framework integrates prior research on factors determining successful NPD collaborations and makes the factors actionable by connecting them to publicly available data and by modelling technological, relational and geographical closeness between firms.

OVERLAY PATENT NETWORK TO ANALYZE THE DESIGN SPACE OF A TECHNOLOGY DOMAIN: THE CASE OF HYBRID ELECTRICAL VEHICLES

Song B., Triulzi G., Alstott J., Yan B., Luo J.
Singapore University of Technology and Design (SGN)

Technology domains are often made of various interactive technologies, which makes technology forecasting difficult. We introduce a method to visualize, analyze and predict the evolution of a technology domain, which is to overlay the design space of a technology domain and its evolution paths on the total technology space. In this way, the structure of the design space of a domain and its evolution paths can be identified and analyzed. One can also analyze the nearby neighborhood of the current positions of a domain on the total map, to explore next innovation and expansion opportunties.

APPLICATION OF VECTORIAL TOLERANCES IN CAD-SYSTEMS DURING THE DESIGN PROCESS

Husung S., Weber C., Kroschel A., Krone K.-H., Credo T., Müller B., Ackermann L.
Technical University of Ilmenau (DEU)

Designers have to consider geometrical deviations during the design process. However, many designers cannot easily imagine the impact of these deviations. Therefore, the use of tolerance representation and analysis software tools is necessary. Besides tolerance description and analysis approaches in CAT-software tools there exist several approaches for direct tolerance representation and analysis in the 3D-CAD-system. The objective of this paper is to show the potential of applying vectorial tolerance representations during product development and the necessary steps to use this potential.

A KNOWLEDGE-BASED SYSTEM FOR NUMERICAL DESIGN OF EXPERIMENTS

Blondet G., Le Duigou J., Boudaoud N.
Sorbonne Universités, Université de Technologie de Compiègne (FRA)

Numerical Designs of Experiments (DoE) can be used in a simulation process for optimization or metamodelling. A DoE may be costly, and methods are used to reduce its computational cost, as adaptive DoE. They are efficient but complex to be configured and controlled. The time saved by using these methods may be lost for the configuration step. A knowledge based-system is proposed to capitalize and reuse each DoE process configuration. An inference methodology, combining bayesian network and artificial neural network, is proposed. This system proposes improved configurations to the designer.

AN INTEGRATED APPROACH FOR AN EXTENDED ASSEMBLY-ORIENTED DESIGN OF AUTOMOTIVE WIRING HARNESS USING 3D MASTER MODELS

Neckenich J., Zielbauer U., Winter R., Vielhaber M.
Daimler AG (DEU)

AOD is state of the art in today's industry. In contrast to most industrial applications, CAD models of automotive wiring harnesses (AWH) don't have a 1:1 hardware replication. Therefore, we firstly describe basics of AOD, regarding product structures, component positioning and design methods. Moreover, we show the differences in AWH DMU models. 3D master models (3DMM) need a defined model structure, which is presented in the paper. An integrated approach for the AOD of AWH with 3DMM is introduced and the resulting product structure, model relations and data transfers are analysed in detail.

INTEGRATING REAL GEOMETRY MODELS INTO PRODUCT SIMULATIONS: AN APPROACH OF A KNOWLEDGE-BASED PROCESS

Katona S., Koch M., Wartzack S.
Technische Hochschule Nürnberg Georg Simon Ohm (DEU)

Simulation driven product development is state of the art to insure that desired characteristics in use behave as requested before performing expensive tests using prototypes. Product simulation is performed with high expense to achieve the aim of precise and reliable results. Despite knowing the fact, that manufactured components show differences to its nominal, ideal CAD-models are used for the analysis. Therefore, an approach of a knowledge-based process to integrate real geometry data into simulations and different methods to prepare the models are represented.

OPERATIONALIZATION OF MANUFACTURING RESTRICTIONS FOR CAD AND KBE-SYSTEMS

Gembarski P. C., Sauthoff B., Brockmöller T., Lachmayer R.
Leibniz Universität Hannover (DEU)

Design guidelines for different manufacturing techniques have already been discussed for decades. Nevertheless, up to date no general framework for the implementation of manufacturing knowledge into 3D-CAD-models can be found. In this article a part of this gap is bridged. After discussing manufacturing restrictions in context of product development, different classification criteria for structuring these restrictions are presented. The resulting design catalogue allows the deduction of methods how to operationalize and model single restrictions in a CAD-system.

AN APPROACH TO CAPTURE ENGINEERING KNOWLEDGE THROUGH VISUAL EVALUATION OF MASS GENERATED DESIGN PROPOSALS

Johansson J., Stolt R., Raudberget D.
Jönköping University (SWE)

This paper explores how to involve human operators in an automated engineering design process. Since humans are superior to interpret geometry they can quickly inspect and evaluate automatically generated design proposals that are presented to them visually. Instead of setting up costly rule engines interpreting the output from the generated design alternatives this paper proposed an approach to visualize the results in a standardized and production like setting enabling the engineers to make quick response to the output of the system. The approach supports set based concurrent engineering.

GLOBAL PRODUCT DEVELOPMENT: KPI SELECTION SUPPORT

Taylor T., Ahmed-Kristensen S.
Technical University of Denmark (DNK)

Selecting key performance indicators in conventional product development is a challenging task for project management and is compound by global product development. Informed from the findings of two in depth case studies conducted with large Danish manufacturing companies, in this paper we develop and test a framework that supports the selection of Leading and Lagging key performance indicators in global product development. The framework provides an alternative approach to design, select and document key performance indicators by incorporating a challenge-oriented approach to selection.

SUCCESS FACTORS FOR THE INDUSTRIALIZATION OF PRODUCTION TECHNOLOGIES IN THE PREDEVELOPMENT STAGE - AN ANALYSIS IN THE AUTOMOTIVE INDUSTRY

Hilt M. J., Wagner D., Ordung M., Kampker A.
BMW Group (DEU)

In e-mobility a rapid transfer of technologies from pre- into series development often fails. Reasons were analysed at a german car manufacturer with projects regarding the electric powertrain. Success factors were quantified conducting an online-survey. Projects fail by technological readiness and financial reasons due to changing requirements and missing definitions of transfer criteria. Success factors are concurrent engineering, transparency about benefits and risks and early testing in hardware. The authors derived requirements for future research on methodological project support.

PLANNING THE PRODUCT DESIGN PROCESS

De Lessio M. P.
New York University (USA)

This papers presents findings from an industry survey targeted toward individuals with responsibilities related to the complex product design process. It specifically considers and profiles the design process planning activity. The survey results confirm that the planning activity associated with complex product design projects is often as complex as the projects being pursued.

ANALYSIS OF SUCCESS FACTORS IN LEAN INNOVATION

Schuh G., Rudolf S., Koch J., Riesener M.
RWTH Aachen University (DEU)

To ensure competitiveness manufacturing companies have to increase both effectiveness and efficiency within their product development. In order to focus on value creation and to eliminate waste the concept of Lean is applied to product development. This paper is based on a survey of 100 companies in the manufacturing industry. It aims at the analysis of the current implementation of Lean Innovation and the effects of success factors practicing Lean Innovation on time, cost and quality. Based on the survey results an approach for the successful implementation of Lean Innovation is presented.

DIGITALIZATION CHALLENGES FOR LEAN VISUAL PLANNING IN DISTRIBUTED PRODUCT DEVELOPMENT TEAMS

Stenholm D., Bergsjö D., Catic A.
Chalmers University of Technology (SWE)

Visual Planning has shown strong benefits for its easy-to-use layout and ability to plan projects with little effort and a low threshold to the method. However, limitations of the physical solution becomes apparent as more development are conducted in distributed teams where information becomes difficult to share and interact with. This paper presents challenges extracted from a literature review, combined with interviews and observations in nine case companies and concludes that there is a great importance, that despite digitalization, maintain a strong emphasis on preserving the meeting.

DIMENSIONS OF PRODUCT DEVELOPMENT SUCCESS

Bender B., Marion S.
Ruhr-University Bochum (DEU)

Successful product development (PD) is indispensable for the competitiveness of a company and of strategic relevance. The contribution focuses PD performance measurement from an interdisciplinary perspective. From an engineering point of view PD can cover a wide range of purposes and activities and accordingly contributes from business administration point of view in fundamentally different ways to a company's success. To improve the hit-rate of existing KPIs a classification matrix is proposed which facilitates appropriate KPI application with regard to specific PD contexts.

DESIGN FOR DYNAMIC REQUIREMENT AND DIVERSE USER EXPERIENCE

Wang Y., Yu S.
Northwestern Polytechnical University (CHN)

In the era of rapid consumption and highly digital,dynamic user requirements and diverse user experiences (DRDUE) influence the forms of the product and the way we understand and use the product. There are influential literatures devoted to the subject of dynamic user requirements or user experience, but there is still a lack of principled and practical frame and methods to support designer and practitioner to deal with (DRDUE) in product design development. In this paper, we present a frame of solution and corresponding interactive design process for designer and decider to deal with DRDUE.

INTEGRATION OF A SYSTEMATIC MATERIAL SELECTION INTO THE DYNAMIC DEVELOPMENT PROCESS OF VEHICLE STRUCTURE PARTS

Kaiser R., Wicht D., Vielhaber M.
Daimler AG (DEU)

Changes in prescribed loads and available space of vehicle structure parts lead to a dynamic requirement profile which changes over the course of the vehicle development. Due to the interdependency of vehicle structure parts, the modification of a single component may simultaneously change the requirements of the surrounding parts. Therefore the development of a methodical approach which can deal with these dynamic requirements can be seen as key function for the integration of a systematical material selection into the vehicle development process and is described in detail in this paper.

APPLICATION OF THE INTERFACE ANALYSIS TEMPLATE FOR DERIVING SYSTEM REQUIREMENTS

Uddin A., Campean F., Khan M. K.
University of Bradford (GBR)

This paper presents a structured approach for systems requirements analysis that integrates use case modelling with a coherent flows based approach for describing interface exchanges based on the Interface Analysis Template. The approach is discussed in the context of current frameworks for requirements elicitation from the engineering design and systems engineering domains, and it is illustrated with an automotive case study. This illustrates the strength of the framework to support structured multi-domain and multi-disciplinary analysis of requirements for complex systems.

DESIGNING IN A UNIVERSITY AND START-UP CONTEXT: A STUDY OF THE DEPENDENCY BETWEEN DESIGN REQUIREMENTS

Duran-Novoa R. A., Koh E. C. Y.
National University of Singapore (SGN)

Design requirements determine any product development, but how they influence each other is a grey area. In this paper we propose two indices to quantify the dependencies between requirements, applying them in a start-up context. On it, the analysis revealed great volatility and polarization, confirming that the initial expectations were distant to the final results. The proposed indices showed that they can be used to visualize tendencies at any time of a project, and thus could support a low-prejudge diagnose able to determine actions that minimize change propagation and rework.

DRIVERS FOR ADAPTIVE SYSTEM DESIGN USING SMART MATERIALS

Inkermann D., Vietor T.
Technische Universität Braunschweig (DEU)

There is an increasing need for products that are able to react to changing operating conditions and user demands to achieve high level performance. Adaptronic solutions are able to adapt system properties during the operation of the system without major effects on system weight and size when they are applied in early phases of the design process. Since adaptive system design often results in higher effort, this contribution points out drivers for goal-oriented application of smart materials. The drivers are derived from a literature study and divided into solution and use-related drivers.

EMBEDDING MULTIPLE DESIGN STRUCTURES INTO DESIGN DEFINITIONS: A CASE STUDY OF A COLLISION AVOIDANCE ROBOT

Behera A. K., McKay A., Chau H. H., Robinson M. A.
University of Leeds (GBR)

This paper introduces a case study of a robot with associated design structures and uses it to compare and contrast techniques available to manage design information and implement design changes. The case study concerns transforming a robot designed for collision avoidance into a one that can follow a loop path. We illustrate how embedding design structures within design definitions has the potential to support the establishment of relationships between structures and show how this could support the management of change thereby improving time to market and reducing product development costs.

A COMPARISON OF DESIGN PROCESS MODELS FROM ACADEMIC THEORY AND PROFESSIONAL PRACTICE

Bobbe T., Krzywinski J., Woelfel C.
Technical University Dresden (DEU)

Academic design process models from different disciplines have been analysed and compared recently. Additionally, this paper presents an analysis that compares design process models from academia, professional organizations as well as from professional studios and companies. Matching and deviating aspects of the models are described regarding the structure of the processes and the emphases of the graphical notations.

MODEL GRANULARITY AND RELATED CONCEPTS

Maier J. F., Eckert C. M., Clarkson P. J.
University of Cambridge (GBR)

Models are integral to engineering design and basis for many decisions. Therefore, it is necessary to comprehend how a model's properties might influence its behaviour. Model granularity is an important property but has so far only received limited attention. The terminology used to describe granularity and related phenomena varies and pertinent concepts are distributed across communities. This article positions granularity in the theoretical background of models, collects formal definitions for relevant terms from a range of communities and discusses the implications for engineering design.

DESIGN FOR INDUSTRIE 4.0

Schuh G., Rudolf S., Riesener M.
RWTH Aachen University (DEU)

In todays competitive markets companies face different challenges, e.g. shorter product lifecycles, a need for individualized products and the customers' demand for an integration of software in hardware products. There is no holistic approach that considers the challenges in product development concerning the integration of Industrie 4.0. As the title Design for Industrie 4.0 shows, this paper introduces a new design approach. A framework consisting of eight fields is presented that enables an integration of Industrie 4.0 into product development for both researchers and practitioners.

MODELS FOR VALUE-DRIVEN ENGINEERING DESIGN

Bertoni M., Bertoni A.
Blekinge Institute of Technology (SWE)

Nowadays, it is a great challenge to understand what models shall be used to iteratively translate customer desires into terms that are meaningful for engineering design decision-making. This paper proposes a framework illustrating the iterative evolution of model-based enablers for value during conceptual system design. The framework is developed from the analysis of four case studies in the Swedish manufacturing industry. The paper discusses the learning from the cross-case study, and elaborates on how value models may complement existing Systems Engineering practices.

TOWARDS A FRAMEWORK OF CHOICES MADE DURING THE LIFECYCLES OF PROCESS MODELS

Gericke K., Eckert C. M., Wynn D.
University of Luxembourg (LUX)

A variety of process modelling approaches exist. The tools provide visualizations and enable analyses of a process. However, analyses of a process depend fundamentally on the properties of the underlying process model. Choices that modellers make in building process models affect the quality of the created models and have an effect on what the models can be used for and can affect the process that is modelled. This paper reflects over the choices the processes modellers need to make in the course of building processes and proposes a framework to show how the choices are related to each other.

APPROACH OF PARTIALLY AUTOMATED MODELLING OF A PROCESS MODEL

Laukemann A., Binz H., Roth D.
University of Stuttgart (DEU)

This paper describes an approach of partially automated modelling of a process model by means of the modelling language "Knowledge Modeling and Description Language". The presented approach comprises different process steps with working results and is part of a comprehensive product-development-specific knowledge management procedure called WMKMU. The process steps are described in detail and the use of the working results is explained. Finally, the presented approach is critically discussed and the paper ends with a brief conclusion as well as an outlook for subsequent research activities.

ARGUMENTATION AND REASONING IN DESIGN: AN EMPIRICAL ANALYSIS OF THE EFFECTS OF VERBAL REASONING ON IDEA VALUE IN GROUP IDEA GENERATION

Cramer-Petersen C. L., Ahmed-Kristensen S.
Technical University of Denmark (DNK)

Reasoning is argumentative and is at the core of design activity and thinking. Understanding the influence of reasoning on the value of ideas is key to support design practice. The paper aims to show the effect of verbal reasoning on the value of ideas. Protocol analyses of four industry cases doing idea generation shows that framing by certainty and deductive reasoning lead to useful incremental ideas while framing by uncertainty and abductive reasoning lead to radical ideas. The paper concludes that the way of framing ideas is indicative of how ideas add value to on-going design processes.

ENHANCING SCENARIO TECHNIQUE BY TIME-VARIANT IMPACTS

Gräßler I., Scholle P.
Heinz Nixdorf Institute - Paderborn University (DEU)

Within the existing consistency-based approaches of scenario technique, time-variant impacts are not yet considered. This paper proposes an approach based on time-variant impact effect functions (IEFs) to consider time-variant impacts for the selection of the key influence factors. The IEFs are characterized by the parameters impact time and shape. IEFs can depict time-variant impacts as well as delayed impacts. By implementing the IEFs, traceability, transparency and acceptance of the resulting scenarios are improved due to a less heuristic selection of key influence factors.

IDEA-SPACE SYSTEM ANALYSIS: THE STUDY OF AN IDEA-CREATION SYSTEM FOR CATALYZING BREAKTHROUGHS

Kiura T., Konita N., Shirasaka S.
Keio University (JPN)

In this study, we focus on breakthroughs and study the elements that catalyze breakthroughs using idea-space systems analysis (ISSA). ISSA is analytical method, which combines degree of idea divergence and idea systems architecture. Examining the idea creation history, the results using ISSA, it shows that the degree of idea divergence would increase in cases where ideas are generated through more movements of viewpoints. Additionally, the results indicate that the changing of the viewpoints are required to catalyze breakthroughs.

LOOKING FOR FUNDAMENTAL ELEMENTS OF DESIGN THINKING

Rosa M., Rozenfeld H.
University of São Paulo (BRA)

Design thinking (DT) is referred to as a new paradigm to support innovation. Identifying the fundamental elements of DT may help to characterize it and integrate it with design processes. The aim of this research is to be a first step towards identifying the fundamental elements of DT. After determining element categories, a content analysis with DT methodologies was performed. This work is part of a more comprehensive research, which intends to identify when in the design process DT may support innovation and to insert DT elements in the design process to make it more user-centred.

THINK.MAKE.START. - AN AGILE FRAMEWORK

Böhmer A., Richter C., Hostettler R., Schneider P., Plum I., Böhler D., Lindemann U., Conradt J., Knoll A.
Technical University of Munich (DEU)

According to Vetter (2011), there are two main perspectives regarding the innovation processes: object-specific and context-specific. A pure phase and context consideration is no longer appropriate. The approach shifts from purely linear and sequentially to iterative and collaborative. Agility is the capability to react, and adopt to expected and unexpected changes within a dynamic environment constantly and quickly; and to use those changes (if possible) as an advantage. Makerspaces can also be an Open Innovation Ecosystem, boosting the innovation capability of its community.

MANAGING THE PARADOX OF EARLY PRODUCTION INVOLVEMENT AND INNOVATIVENESS – TO INVOLVE OR EVOLVE, IS THAT THE QUESTION?

Karlsson A., Törlind P.
Luleå University of Technology (SWE)

Early involvement of production can on the one hand create products better adapted for realization, but on the other hand introduce the risk that incremental adjustments of existing operations and processes is favoured at the expense of more radical ones. The research reported in this paper aims to explore how innovative project teams manage this paradox of early production involvement and innovativeness. Results show that a number of separation strategies at the micro level in the organization play an important role in practice.

AN INITIAL APPROACH OF A STANDARD BASED FRAMEWORK TO MANAGE REALISTIC PRODUCT REPRESENTATIONS

Ebeling R., Specht R., Eigner M.
Daimler AG (DEU)

The current situation of virtual product data management is characterised by an increasing external and internal complexity of information of all business areas based on different aspects like high volatility of markets, a higher need of mass customisation or a growing competitive intensity. This paper shall point out an initial approach to generating, managing and connecting advanced information regarding the appearance of an entire product and enable new virtual opportunities for collaborations between the involved stakeholders like styling, mechanical engineering or marketing departments.

FROM FMEA AS A PROBLEM SOLVING METHOD TO A DESIGN-ORIENTED PROCESS: TOWARD A DESIGN PERSPECTIVE OF FMEA

REVIEWERS FAVOURITE

Cabanes B., Hubac S., Le Masson P., Weil B.
MINES ParisTech (FRA)

In many high-tech sectors, the Failure Mode and Effect Analysis (FMEA) methodology is now one of the main used tools to identify and reduce risks during product design and manufacturing development. However, practitioners and the literature in engineering design highlight many difficulties to implement and efficiently generate FMEA. By using C-K design theory, this research proposes to revisit the theoretical framework of the FMEA to explain why FMEA cannot be reduced to problem solving. Then, we propose to extend the initial FMEA methodology.

AN INTEGRATED PRODUCT INFORMATION MODEL FOR VARIANT DESIGN IN COMMERCIAL VEHICLE DEVELOPMENT

Kreimeyer M., Baumberger C., Deubzer F., Ziethen D.
MAN Truck & Bus AG (DEU)

This paper details a product data model developed to improve both the design process and serve as a basis for a PLM implementation. It focuses on products with a large variant spectrum both from a market and a technical perspective. The data model was used to implement a product architecture process within a large commercial vehicle manufacturer, and the paper reflects on the result from this implementation.

Session D244

Congress Hall Konavle

16:15 18:15

A METHOD FOR DESIGNING VISUALISATIONS AS PRODUCT DEVELOPMENT TOOLS

Gebhardt N., Krause D.
Hamburg University of Technology (DEU)

Visualisations are very helpfull design support tools in product development. Designing their concepts is a challenging task for everybody who develops methodical design supports. This paper presents a new “Methodical Approach to the Design of Visualisation Concepts as Tools in Product Development” which is based on the needs of visualisation designers and state of art in information visualisation. The approach is presented by an industry case which is analysed for applicability and effectiveness of the methodical approach and the visualisation that was developed in the case as a design tool.

17 May

TUE

DEVELOPING A SUPPORT TOOL FOR GLOBAL PRODUCT DEVELOPMENT DECISIONS

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

This paper investigates how global product development decisions are made through a multiple-case study in three Danish engineering. The paper identifies which information and methods are applied for making decisions and how decision-making can be supported based on previous experience. The paper presents results from 51 decisions made in the three companies, and based on the results of the studies a framework for a decision-support tool is outlined and discussed. The paper rounds off with an identification of future research opportunities in the area of global product development and decision-making.

FEATURE-BASED APPROACH FOR THE AUTOMATED SETUP OF ACCURATE, DESIGN-ACCOMPANYING FINITE ELEMENT ANALYSES

Kestel P., Schneyer T., Wartzack S.
Friedrich-Alexander-Universität Erlangen-Nürnberg (DEU)

Finite element analyses (FEA) gain huge attention in engineering design practice. However, an efficient use of FEA requires early application in the product development process. Furthermore, extensive specialist knowledge is a crucial prerequisite to perform reliable simulations. Due to time constraints, design accompanying FEA are performed too rarely by experienced simulation engineers or, if they are applied by non-expert simulation users, are not sufficiently accurate. Hence, a feature-based approach is presented, to support and automate the setup of design accompanying simulations.

MULTIDISCIPLINARY INTEGRATION DURING CONCEPTUAL DESIGN PROCESS: A SURVEY ON DESIGN METHODS OF CYBER-PHYSICAL SYSTEMS

Zheng C., Le Duigou J., Hehenberger P., Bricogne M., Eynard B.
Sorbonne Universités, Université de Technologie de Compiègne (FRA)

CPS design can be characterised as a multidisciplinary integration topic, which has attracted the attention of both academia and industry for a long time. The paper aims at reviewing the existing design methods by focusing on the multidisciplinary integration during the early design process. In order to assess the design methods, some criteria are proposed and used to evaluate each design methods. According to the assessment results, the directions for the future research will be pointed out finally.

SYNCHRONIZATION IN PRODUCT DEVELOPMENT PROJECTS: A LITERATURE STUDY ON CHALLENGES AND PRACTICES

Chucholowski N., Lehmer K., Rebentisch E., Lindemann U.
Technical University of Munich (DEU)

Product development projects face a high degree of complexity due to e.g. modular product portfolios, ambiguous goals, distributed teams and interdisciplinary work. This creates challenges in aligning and coordinating interdependent activities (synchronization). We present a literature study that summarizes challenges and practices. Further, we describe an approach for the selection of practices for a given set of challenges. The study helps researchers and practitioners to understand synchronization needs in product development projects, and we believe, advances synchronization efforts.

COLLABORATIVE DESIGN MANAGEMENT

Park J.-E., Choi Y., Holt C.
Brunel University London (GBR)

“This paper discusses how best to introduce Design Management to architectural design firms in South Korea to enhance architectural practice efficiency and maximise value for all design project participants and associated businesses. This research suggests that Design Management should be implemented in a collaborative and participative way compatible with the attributes of architectural design activities. The new version of Design Management encourages the development of active participation and co-learning between design teams and multidisciplinary professionals.”

POSITION PAPER: DESIGNING COMPLEX SYSTEMS TO SUPPORT INTERDISCIPLINARY COGNITIVE WORK

Greene M., Papalambros P. Y., McGowan A.-M.
University of Michigan (USA)

The size and complexity of modern engineered systems create grand challenges for designers. Systems- and subsystems-level information is widely distributed, and comprehensive knowledge of the system is not accessible to any single designer, discipline, manager or subsystem expert. Thus, successful design of these systems depends on the effectiveness of the interactions between different discipline experts. This work explores cognitive factors pertinent to such interdisciplinary interactions, and offers suggestions for how these insights could be used to advance systems engineering practice.

ANALYSIS OF INFORMATION BEHAVIOUR IN PRODUCT DEVELOPMENT CONTEXT

Škec S., Štorga M., Antonić I.
University of Zagreb, FSB (HRV)

The aim of this paper is to explore different aspects of information-related activities in product development teams. To enable analysis of information behaviour at lower level of process granularity and to allow longer data collection with several participants, work sampling self-reporting approach was selected as an appropriate one for data collection. After analysis of processes in two case companies, results demonstrated diversity and frequency of information-related activities within different product development contexts, but also indicated differences in individual information behaviour.

METHOD TO CREATE MARKET-SPECIFIC CUSTOMER PROFILES FOR ENHANCING POSITIVE USER EXPERIENCES IN CARS

Michailidou I., Franzen F., Lindemann U.
Technical University of Munich (DEU)

Creating positive driving experiences requires deep understanding of users’ characteristics, needs and behavior. Since direct user inclusion can be time- and cost- effective or even impossible in some stages of design, alternative ways of considering users are valuable. To achieve this goal, we developed a method based on the persona technique. The benefit of the method lies in structuring of data required for the creation of customer profiles, as well as inclusion of experience-related aspects. We applied and evaluated the method in two cases collaborating with a major automobile manufacturer


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WEDNESDAY, MAY 18

	Ragusa	Bobara	Orlando	Konavle	Šipun	Quiet Salon	Salon 5
8:00 – 8:15	REGISTRATION						
8:15 – 8:30	D311 UNCERTAINTY AND ROBUSTNESS	D312 INFLUENCING FACTORS	D313 COLLABORATION BASED INNOVATION	D314 TOOLS FOR EARLY PHASES	D315 CHANGE MANAGEMENT		
10:15 – 10:30	REFRESHMENT BREAK						
10:30 – 12:30	D3-P PLENARY SESSION III						
10:45 – 12:45	D3-D DESIGN DEBATE						
12:45 – 14:15	LUNCH						
14:15 – 16:15	D331 COMPUTATIONAL DESIGN SYNTHESIS	D332 NEW APPROACHES IN SPECIALISED FIELDS	D333 PROBLEM SOLVING AND DESIGN THINKING	D334 HEALTHCARE AND MEDICAL SUPPORT	D335 WORKSHOP EUROPEAN REMANUFACTURING NETWORK - PART 1		
16:15 – 16:30	REFRESHMENT BREAK						
16:30 – 18:15	D340 DESIGN MANAGEMENT DS SIG MEETING	D342 MODELLING AND MANAGEMENT OF ENGINEERING PROCESSES DS SIG MEETING	D343 DESIGN CYBER PHYSICAL SYSTEMS DS SIG MEETING	D344 NETWORK ACTIVITIES FOR REALISATION OF INNOVATIVE PRODUCTS	D345 WORKSHOP - EUROPEAN REMANUFACTURING NETWORK - PART 2		
19:00 – 19:30	CONFERENCE DINNER						

UNCERTAINTY IN SIZE RANGE DEVELOPMENT - AN ANALYSIS OF POTENTIAL FOR A NEW SCALING APPROACH

Lotz J., Freund T., Würtenberger J., Kloberdanz H.
Technical University Darmstadt (DEU)

Scaling uncertainty occurs due to effects that are neglected by purpose or due to ignorance and is related to the product models. It results in insufficient mathematic scaling models. The consequence is a need for iterations to ensure a proper result of the scaling process. Size range development can be improved by anticipation of size dependent effects in early stages of the process, implementing a frontloading strategy in size range development. Improvement potentials are analysed qualitatively and linked to the occurring uncertainty. Basic elements of a scaling integrated PD process are proposed.

EVOLUTION OF ROTOR SPIDER DESIGN FOR VERTICAL HYDRO-GENERATORS

Vukšić M., Triplat I., Marjanović D.
Končar - Generators and Motors Inc. (HRV)

This paper presents evaluation of improved rotor spider design Rotor spider is part of vertical hydro-generator which transfers torque and rotation from shaft to rotor rim and poles. Paper gives complete description of calculation input data and methods. Afterwards case study is presented and end design solution is described. Improved design is compared with designs that are used on similar projects by effectiveness of design ratio which is made up especially for evaluation of this design. In the end, benefits of design improvements are discussed and recommendation for further work are given.

A MODEL OF DESIGNING AS THE INTERSECTION BETWEEN UNCERTAINTY PERCEPTION, INFORMATION PROCESSING, AND COEVOLUTION

Lasso S. V., Cash P., Daalhuizen J., Kreye M.
Technical University of Denmark (DNK)

Problem/solution co-evolution and information processing have been described as two fundamental perspectives on designing in the literature. However, prior works have modelled them separately. This paper proposes a model that links design co-evolution and information processing via uncertainty perception. This joint model contributes to a broader understanding of the designer´s work, as well as how their perception of uncertainty drives their activities and decisions in the design process.

DEVELOPMENT OF A METHODICAL APPROACH TO HANDLE UNCERTAINTY DURING THE PROCESS OF PRODUCT MODELLING

Würtenberger J., Lotz J., Freund T., Kloberdanz H.
Technical University Darmstadt (DEU)

Product models are used for decision making during the development process. They are based on assumptions by the designer, which are made under a lack of information, so the designer has to make assumptions under uncertainty. The problem arise, that decision making is also allocated to uncertainty, whereby variations between the realized and the planned product behaviour may occur. This paper gives an approach to support the designer to handle uncertainty during product modelling by a systematic linkage of information from the product lifecycle to the specific needs of product modelling.

POST-PROBABILISTIC UNCERTAINTY QUANTIFICATION: DISCUSSION OF POTENTIAL USE IN PRODUCT DEVELOPMENT RISK MANAGEMENT

Tegeltija M., Oehmen J., Kozine I., Geraldi J.
Technical University of Denmark (DNK)

Uncertainty represents one of the key challenges in product development (PD) projects. Traditionally, risk management quantification methods have been based on probability theory. Those methods showed reliable results for problems dominated by aleatory, i.e. stochastic, uncertainty. To address epistemic uncertainty, i.e. uncertainty that arises from a lack of knowledge, we need to go beyond this traditional approach. Post-probabilistic methods promise improvements. We discuss three possible approaches: Imprecise Probability, the Dempster-Shafer Theory of Evidence and NUSAP Scheme.

RISKS IN PRODUCT DEVELOPMENT: ADVANCEMENTS IN RECENT YEARS

Juranić J., Marjanović D., Pavković N.
University of Zagreb, FSB (HRV)

Risks in product development appear even in the development of the simplest products. As the product and development process are more complex, risk management is gaining the importance. In the world where success is the key to survival, it is very important to manage the risks and try to reduce their probability and impact. The paper reviews the literature on risk management advancements in product development in recent years. New methods and recommendations, as well as structure of risk management process according to international standard are presented.

A SEMIOTIC INTEGRATED PRODUCT DEVELOPMENT FRAMEWORK FOR INTEGRATING BRANDING IN AUTOMOTIVE PRODUCT DESIGN

Cini M., Farrugia P.
University of Malta (MLT)

In an increasingly saturated automotive market, product design may be the only distinguishing feature in a myriad of similar cars that are technically almost identical. Customers choose a particular brand because they connect with the car emotionally. The role of branding in the product's success is vital. A framework is developed to support designers to integrate branding in automotive design. The distinguishing framework's features are semiotics, IPD principles and branding checkpoints. The framework is based on theory and qualitative data gathered from academics and renowned designers.

ENHANCEMENT OF COLLABORATION AND COMMUNICATION BETWEEN DESIGN AND SIMULATION DEPARTMENTS BY METHODS OF REQUIREMENTS ENGINEERING

Schweigert S., d'Albert H., Lindemann U.
Technical University of Munich (DEU)

Simulation has become a standard part of design processes. While much reseach has been done on technical aspects, there is little knowledge on the implications on communication and collaboration. This paper proposes a three level approach comprising of organizational aspects, rules and guidelines, and methods and tools. A simulation assignment based on requirement templates is built that includes basic information like simulation type and desired output. All further information is provided by requirement templates, transfering techniques from requirements engineering to simulation management.

ADDED VALUE PROCESS FOR COLLABORATIVE EARLY DESIGN USING SIMULATION MODELS IN AERONAUTICS AND AUTOMOTIVE INDUSTRIES

Roa Castro L., Stal-Le Cardinal J., Gasser L.
IRT SystemX / CentraleSupelec (FRA)

The research presented is focused in the modelling of three main features in collaborative design using simulation models (M&S): Actors, activities and objects. To represent these features, an added value process proposition for a collaborative design in early phases using M&S was suggested. The new process was implemented and evaluated during a project at the IRT SystemX having Renault and Airbus industries as a partners of the project. The results suggest the proposed representation as highly adapted to the problem and point out the actors as the key element on the collaborative design.

X FOR DESIGN, A DESCRIPTIVE FRAMEWORK FOR MODELLING THE COGNITIVE ASPECTS OF DIFFERENT DESIGN ACTIVITIES

Filippi S., Barattin D.
University of Udine (ITA)

Classic design activities start from functions and end defining the product structure. The literature offers tools to model the cognitive aspects of these activities. The analysis of recent design activities highlights inadequacies of these tools because of the variety of starting points and goals. This research develops a descriptive framework, the X for Design - XfD, to model different design activities showing any combination of starting points and goals, by putting the existing FBS framework into relationship with the product experience and human behaviour in design concepts.

SUPPLIER INTEGRATION IN PRODUCT DEVELOPMENT: A SEARCH FOR EXISTING APPORACHES IN OTHER INDUSTRIES

Bock J., Wilberg J., Lindemann U.
Technical University of Munich (DEU)

Supplier integration in product development is important to improve the efficiency and effectivity, but additional support for the operational management is needed. To address this need a search for existing approach in other sectors was conducted and the Integrated Project Delivery (IPD) approach from the construction industry was identified as promising. The paper analyses and transfers the approach into the mechanical engineering domain. The interview based evaluation of the developed concept emphasizes that supplier integration could especially benefit from an integrated incentive system.

MODEL-BASED SUSTAINABLE PRODUCT DEVELOPMENT

Buchert T., Pförtner A., Bonvoisin J., Lindow K., Stark R.
Technical University of Berlin (DEU)

Despite the availability of numerous tools for sustainable product development and ecodesign, there is currently no convincing solution which enables design engineers to consider the complex consequences of their decisions on the triple bottom line in early design phases. Model-based Sustainable Product Development aims at closing this gap by providing enhanced modelling options for decision consequences along the product lifecycle. Based on a framework for specifying causal chains between design decisions and sustainability impact application examples for these models are presented.

HOW TO IDENTIFY SUITABLE COLLABORATION STRATEGIES FOR OPEN INNOVATION?

Guertler M. R., Becerril L., Lindemann U.
Technical University of Munich (DEU)

Open Innovation (OI) allows the utilisation of external expertise. Besides various benefits, OI also bears specific risks. These are often linked to the selection of the "right" partners (e.g. knowledge drain and Not-Invented-Here syndrome) that is often based on specific perspectives, e.g. focussing only on external stakeholders, and only on their technical skills and neglecting the strategic relevance. Thus, we developed an integrated methodology to systematically identify, select and involve partners. This paper focusses on deriving suitable operative and strategic collaboration strategies.

A CATEGORIZATION OF CUSTOMER CONCERNS FOR AN OT FRONT-END OF INNOVATION PROCESS IN IT/OT CONVERGENCE CONTEXT

Bonnetto E., Yannou B., Yannou-Le Bris G., Boly V., Alvarez J.
CentraleSupelec (FRA)

Operational Technologies (OT) are designed to monitor and control plants. OT are increasingly mixed with Information Technologies (IT) in global solutions. A conventional customer inquiry is no more sufficient to get enough data about Customer Concerns (CC). Indeed, an IT OT solution is the nervous system of a company; it intertwines people processes and functions. For specification step, one must now capture negative perceptions in the interrelationships with other actors of the customer company. The paper creates a database of CC describing dissatisfactions between several involved personas.

USING CONTESTS FOR ENGINEERING SYSTEMS DESIGN: A STUDY OF AUCTIONS AND FIXED-PRIZE TOURNAMENTS

Chaudhari A. M., Thekinen J. D., Panchal J. H.
Purdue University (USA)

With the increasing interest in using open innovation and crowdsourcing contests for engineering design, there is a need for understanding how different types of contests affect the outcomes. While contests have been studied in the economics literature, the analytical models are based on various simplifying assumptions. There is a lack of critical analysis of these assumptions, which is necessary before utilizing the insights from the models in a design context. In this paper, we address this gap by critically analyzing contest models for engineering design scenarios.

INTERVENTION FRAMEWORK TO SUPPORT EMPLOYEE-DRIVEN INNOVATION BETWEEN R&D AND MANUFACTURING DEPARTMENT

Jensen C. S., Jensen A. R. V., Broberg O.
Technical University of Denmark (DNK)

In this paper we present the development and application of an intervention framework to initiate focus on Employee-Driven Innovation. EDI has the potential to improve product innovation by involving employees. We examine how the intervention framework can be used to facilitate EDI initiatives between R&D and manufacturing in a case-company. The framework consists of a diagnosis and three workshops and stages the intervention by a) creating common perception of current work practices, b) unfreezing roles and communication and c) creating new future EDI practices.

THE CASE OF AN INNOVATION CONTEST – PARTICIPATORY DESIGN IN A SOCIAL CONTEXT

Ericson A., Wenngren J., Holmqvist J., Hammarberg K.
Luleå University of Technology (SWE)

This paper presents measures for collaborative design in a social context. A number of challenges and implications are identified, and changes done to increase the innovativeness in the outcome are discussed and exemplified. The context is an innovation contest in which students, inhabitants, people in common and so on, freely signs up for participation. The competition's theme comes from a client, e.g. a company, organization or municipality. Besides a research approach originating from 2002, fourteen innovation competitions during 2014-2015 are the specific basis for the empirical data.

COLLABORATION IN OPEN ORGANISATIONS

Kremer S., Muenzberg C., Lindemann U.
Technical University of Munich (DEU)

Influences like demographic change and diversification of employees' lifestyles force companies to include external knowledge carriers, offer flexible concepts for employees and create an organisational open mind set. This concept is called Open Organisation. We developed a guide that enables understanding and situation specific planning of collaboration in Open Organisations. Our approach clusters according requirements, strategies and measures – from company network level to individuals. This paper presents important influencing factors of open collaboration and the concept of our guide.

MORPHIX: AN EVOLUTIONARY WAY TO SUPPORT CONCEPTUAL DESIGN

Wünsch A., Pilz F., Vajna S.
Otto-von-Guericke University Magdeburg (DEU)

In this paper we introduce Morphix, a framework to support the conceptual design by combining the morphological box and the Autogenetic Design Theory using a Genetic Algorithm, to reduce the risk of missing a good solution while using a morphological box. Morphix generates concepts and the designer rates the proposed concepts by predefined or custom evaluation criteria. The framework was applied in different use cases. We found that the application of Morphix supports thinking "out of the box" and getting new insights on the product since the genetic algorithm regards the whole solution space.

THE COMBINATOR: A COMPUTER-BASED TOOL FOR IDEA GENERATION

Han J., Shi F., Childs P. R. N.
Imperial College London (GBR)

Idea generation is important in design, but coming up with new and creative ideas is often challenging. The paper presents a computer-based tool named the Combinator for assisting designers to generate creative ideas. The tool is capable to generate combinational ideas based on combinational creativity theory. The Combinator has been indicated to be beneficial in helping designers generate useful and creative ideas through a case study. The result indicates that the Combinator can increase better ideas occurrence, improve design success rate, expand design space, and enhance design space exploration.

KEEP IT REAL: ON TOOLS, EMOTION, COGNITION AND INTENTIONALITY IN DESIGN

Wendrich R. E., Kruiper R.
University of Twente (NLD)

Keep IT real, create, build, and develop design tools that support designers during the early phases of design processing. This paper investigates how, and whether, current technology can afford real-time interaction and affective computing in a HDT(E) design tool that integrates and blends realities through physical and virtual interaction. Interaction design (IxD) is crucial to the usability (UX) and engagement (UE), concepts and terminology are introduced, after which an interaction framework is set up that takes into account the multi-modal Human Computer Interaction (HCI) with a HDT(E).

APPLICATION OF QUALITATIVE SIMULATION FOR EARLY-STAGE SERVICE DESIGN

REVIEWERS FAVOURITE

Murakami F., Morishita Y., Kimita K., Hosono S., Izukura S., Sakaki H., Numata E., Shimomura Y.
Tokyo Metropolitan University (JPN)

In product and service design generally, designers are required to spend additional money and time when design changes occur in the final stages of the design process. In order to obviate design changes, it is important for designers to evaluate design solutions in the early stages of the design process using simulation methods. However, most information about the design solution is still not defined in the early stages. In this paper we apply qualitative simulation methods to the service design process. In particular, our work focuses on building a valid simulation model.

THE APPLICATION OF CREATIVITY METHODS IN VIRTUAL TEAMS IN PRODUCT DEVELOPMENT

Walter B., Rapp S., Albers A.
Karlsruhe Institute of Technology (DEU)

Working together in globally distributed teams becomes increasingly crucial for product development to occupy the benefits lying in embedding internationally allotted knowledge. In opposite to local teams the work of virtual teams is hardly supported by development methods. This paper presents results of a laboratory study which implements the methods brainstorming and gallery method to different sets of collaboration tools which are available on the market. Our findings contribute to adapting development methods for their application in virtual teams in product development.

VIRTUAL CONTEXTUAL VALIDATION OF TECHNOLOGIES AND METHODS FOR PRODUCT DEVELOPMENT

Isaksson O., Bertoni A., Levandowski C., Müller J., Wiklund D., Johansson P. B. V.
Chalmers University of Technology (SWE)

In this paper the use of virtual demonstrators as means to contextually validate both design methods and novel Technologies in advance of industrial Product development. Since maturity requirements are high, and pure technology and methods development Projects typically result in promising, but not validated, methods and Technologies and full scale hardware demonstration initiatives are costly, there is a gap to fill. Functional Modeling and Value Driven design methods are used with Ceramic Metallic Composites technologies in a virtual demonstrator."

AN EXPLORATORY STUDY OF CRISES IN PRODUCT DEVELOPMENT

Muenzberg C., Gericke K., Oehmen J., Lindemann U.
Technical University of Munich (DEU)

This paper presents the result of an interview study with 15 experts on crises in industrial product development practice. The paper focusses on two research questions. 1. How can crises in product development be characterised? 2. What are success factors for effective crisis solving in product development? The paper contributes 9 context factors to discern crises from regular development situations, 56 success factors for crisis resolution, and describes three example crises.

UNDERSTANDING THE RELATIONSHIP BETWEEN DESIGN MARGINS AND TRADE-OFFS

Lebjioui S., Eckert C. M., Earl C.
The Open University (GBR)

To achieve an objective designers often need to make trade-offs between multiple parameters. In incremental design or during the design process an additional objective is often to minimise the changes they need to make to meet the objective. This is in particular an issue for systems with product platforms, over individual components are over-designed. This paper argues that designers can think about this problem in terms of the margins on the objective parameters as well as the parameters that are traded-off. This is illustrated with the case study of an engineering cooling system.

DESIGNING IN A UNIVERSITY AND START-UP CONTEXT: AN ANALYSIS ON ENGINEERING CHANGE PROPAGATION

Koh E. C. Y., Duran-Novoa R. A., Weigl J. D., Henz M.
National University of Singapore (SGN)

This paper examines the evolution of change dependencies during an electrical motorcycle design project undertaken by a start-up team. It was found that only 33% of the changes made in the project were planned and change propagation accounted for 20% of all changes made. The findings also suggest that an analysis of direct inter-component dependencies at the start of the project could have prevented (or prepared for) 67% of change propagation. Such detection rate may suffice for resource-strapped start-ups who cannot afford more advanced change analysis.

LITERATURE REVIEW OF EXISTING EVALUATION METHODS IN THE CONTEXT OF CHANGEABILITY

Stäbler M., Weber J., Paetzold K.
Daimler AG (DEU)

In recent decades a multiplicity of evaluation methods were developed, nevertheless, those methods are used little or not at all in the automotive industry. Hence, this paper should give a best possible holistic overview about existing methods for determining changeability and to show their strengths and weaknesses. Afterwards research potentialities are pointed out and based on them an approach of a new method for the evaluation of changeability will be introduced This new method based on the approach of multi-criteria evaluation.

A CONCEPT FOR MODELLING AND ANALYSING DESIGN PROCESS CHANGES

Shapiro D., Clarkson P. J.
University of Cambridge (GBR)

Research on changes in design has focused on changes in the product domain. However, because the product's design process may change as well, this article suggests a concept for a comprehensive method to support modelling and analysis of changes in the process domain (DPCs). After deriving a set of functional requirements, different conceptual ideas for such a method are examined and the fundamental elements and relationships of a chosen concept are studied. Furthermore, a set of analyses, which helps designers understand DPC impacts and improve process execution and planning, is introduced.

A KNOWLEDGE FRAMEWORK FOR SAFETY ANALYSIS OF USER-INDUCED CHANGES

Roth M., Mayr L., Lindemann U.
Technical University of Munich (DEU)

To meet demands for individual products, concepts like user-driven customization are followed. They induce changes through users directly applied to the product. This challenges both, engineering change management and connected safety analyses. This paper develops a knowledge framework which to solve these challenges. Its main contribution is an extensive literature review on engineering change management and the identification of involved domains and basic methods. Moreover, it provides similar insights into model-based safety analyses and consolidates the domains into a common framework.


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D3-P: PLENARY SESSION III

Chairman: Culley, Steve J. (GBR) **10:45 - 11:15**

DESIGNING IN LARGE-SCALE: CONSIDERATIONS FOR INCREASED COMPLEXITIES IN LARGE SYSTEMS

Anna-Maria Rivas McGowan
Senior Engineer for Complex Systems Design, NASA Langley Research Center (USA)

Large-Scale Complex Engineered Systems (LaCES) are used by billions of people around the world each day. These systems include aerospace (e.g., aircraft, space systems); large maritime (e.g., submarines, aircraft carriers); nuclear (e.g., power plants); and major civil infrastructure systems (e.g., water supply systems, electric power grids, healthcare systems, and air and ground transportation systems). The design of such systems has enabled capabilities that have transformed the way of life in much of the world. We rely on LaCES to meet many basic local and national needs, such as the provision of essential services, the protection from natural and human dangers, and the advancement of infrastructure capabilities to address population growth and environmental sustainability. At an individual person and family scale, our lives cannot be easily separated from the growing technological systems upon which we rely. How might we advance large- scale design to better address large-scale complex engineered systems?

These systems present several unique challenges for the engineering designer, as well as the systems engineer. Challenges include extraordinary costs and risks, the inability to fully test and evaluate the complete system until it is nearly operational, and a significant magnitude of inherent couplings between engineering and non-engineering disciplines and components. The considerations beyond engineering are extensive: economics, policy, urban planning, education, culture, and many others. Thus, the design and development of very large systems are regularly prone to crippling time and cost overruns, largely due to the unintended consequences arising from unknown or unexpected interactions. The methods, processes, and tools used by practitioners have not kept pace with the growing complexity of LaCES.

D3-D: DESIGN DEBATE

Chair: Culley, Steve J. (GBR) **11:15 - 12:45**

THIS HOUSE BELIEVES THAT DESIGN METHODS CREATED BY DESIGN RESEARCHERS ARE VITAL TO PRACTICING ENGINEERING DESIGNERS

Proposed by John Gero (USA) and Ahmed Kovačević (GBR)
Opposed by Sándor Vajna (DEU) and Iris Graessler (DEU)

Organizers and debaters expect the audience will actively and lively participate in this event that was introduced successfully for the first time during DESIGN 2012 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 the topic of the debate.

The format is listed below:

- The topic will be proposed and then opposed (approx 8 minutes each),
- Supporting statements, seconding the two viewpoints will then be given(4 minutes each)
- The floor(the audience) will then be asked to question the proposers and opposers.
- A single final verbal statement or pitch will be given
- A vote will then be taken to see which side has “won” the debate.

SIMULATION-BASED DEVELOPMENT OF PARETO-OPTIMIZED TAILORED BLANKS FOR THE USE WITHIN SHEET-BULK METAL FORMING

Küstner C., Beyer F., Kumor D., Loderer A., Wartzack S., Willner K., Blum H., Rademacher A., Hausotte T.
Friedrich-Alexander-Universität Erlangen-Nürnberg (DEU)

In the context of lightweight design, the so-called tailored blanks are more frequently used to improve sheet-bulk metal forming process results. In order to meet the requirements of tailored blank designs for subsequent sheet-bulk metal forming process steps, design engineers can influence many process or geometry parameters. A crucial task for design engineers is to find the optimal process and geometry parameter setting that is an optimal design with respect to multiple design requirements. A simulation-based approach to face this challenge is presented in this paper.

INTEGRATED PRODUCT MODELLING THROUGH IFM-CPM/PDD

Eisenbart B., Khan Y. I., Qureshi A. J.
Delft University of Technology (NLD)

Designing complex systems is an iterative process requiring constant updating of models representing related information. To ease consistent modelling, this paper focuses on linking function modelling with quantitative modelling. Therein, the IFM framework is used as vantage point which is to be coupled with the CPM/PDD approach. An extended class structure for the IFM framework is proposed incorporating the data model of CPM to enable the transition of information between them. This is illustrated with an example. Finally, implications and potentials for future research are discussed.

ESTIMATING THE POTENTIAL OF STATE OF THE ART DESIGN AUTOMATION - TASKS, METHODS, AND BENEFITS

REVIEWERS FAVOURITE

Rigger E., Münzer C., Shea K.
V-Research GmbH (AUT)

Industrial application of design automation is rare due to a lack of understanding about what type of tasks can be automated, what methods are available and what potential benefits can be expected. It is often difficult upfront to predict the potential savings and improvements that design automation can yield in comparison to the investment cost of its implementation. To improve this situation, this paper introduces an approach that allows mapping of design tasks characterized by spatial aspects to design automation methods and an implicit mapping of automation methods to potential benefits.

SUPPORTING THE DESIGN OF RECONFIGURABLE CELLULAR MANUFACTURING SYSTEMS BY COMPUTATIONAL DESIGN SYNTHESIS

Unglert J., Hoekstra S., Jauregui Becker J.
University of Twente (NLD)

Decisions on manufacturing system design determine the current and future profitability of manufacturing companies. Reconfigurable Cellular Manufacturing Systems make possible to evolve the design of the system in parallel to an uncertain market demand. This paper proposes a software tool based on Computational Design Synthesis to support the design process with the objective to enable and speed up set-based system design, while complementing current design support approaches. In addition, the industrial context of use and an the plans for evaluating the support are outlined.

MATURITY-MODEL-BASED DESIGN OF STRUCTURAL COMPONENTS

Sauthoff B., Gembarski P. C., Lachmayer R.
Leibniz Universität Hannover (DEU)

In the present article a framework and a development process for the design of structural components is presented. Focus of this process is a maturity model based approach where the product is systematically assessed at maturity gates regarding specified characteristics and properties. The maturity model is introduced from the 3 different viewpoints required properties and boundary conditions, design parameters and finally computer-aided synthesis and analysis Tools. The process was visualized with a front frame of a wheel loader.

A QUANTITATIVE MODEL FOR IDENTIFYING REGIONS OF DESIGN VISUAL ATTRACTION AND APPLICATION TO AUTOMOBILE STYLING

Pan Y., Burnap A., Liu Y., Lee H., Gonzalez R., Papalambros P. Y.
University of Michigan (USA)

Analysis of design regions of visual attention that affect aesthetic appeal is an important topic for both practicing designers and design researchers. The paper introduces a data-driven methodology consisting of four stages: (1) design feature learning, (2) design attribute prediction, (3) salient feature selection, and (4) salient feature visualization. Using this methodology, we making inroads to inverting the nonlinear function from design images and design aesthetic attributes, and give preliminary results for an automotive styling study.

FROM PROTOTYPE TO PRODUCTION: USING PLASTIC 3D PRINTED PARTS IN FURNITURE

Pandolfo B.
University of Technology Sydney (AUS)

The digital revolution is expanding beyond the virtual towards tangible material transformation. Advanced digital technologies are enabling small manufacturers of objects the opportunity to engage with making in new ways. This research-through-design exploration was conducted to better understand how Fused Deposition Modelling could be utilised as a production ready option in furniture design.

DYNAMIC DESIGNING OF DENTAL PROSTHESES

Solaberrieta E., Minguez R., Brizuela A., Etxaniz O., Barrenetxea L., Iturrate M., De Prado I.
University of the Basque Country (ESP)

The novel methodology proposes the integration of mandible dynamics and reverse engineering in dental CAD/CAM. The aim of this methodology is to project the forces registered by the sensors on the occlusal surface. Since these data is of the utmost importance in the design phase, this integration provides individualized, meaningful and more objective information to the dental technician. However, this novel methodology is also useful for the dental diagnosis, planning and treatment.

APPLICATION OF DSM TO MECHANICAL CALCULATIONS OF VERTICAL HYDRO GENERATOR

Triplat I., Vukšić M., Marjanović D.
Končar - Generators and Motors Inc. (HRV)

This article confirms the possibility of DSM implementation in mechanical calculations of vertical hydro generator. Article has a theoretic introduction with all relevant informations used for construction, analysis and interpretation of DSM analysis results. According to results of DSM analysis, foundation loads calculation need to be the last calculation. DSM point to all coupled calculations which should be done at the same time to reduce rework and results show benefits of DSM application in mechanical calculations of vertical hydro generator.

SET-BASED PRODUCT DEVELOPMENT IN THE MANUFACTURING INDUSTRY

Schuh G., Rudolf S., Luedtke B.
RWTH Aachen University (DEU)

Due to predominant effects of globalization, a massive price pressure as well as a high product variety manufacturing companies are facing tremendous challenges. To address these challenges an efficient realization of development projects is necessary. One approach to increase the efficiency and effectiveness of development projects is set-based design.Thus, the objective of the paper is to present an approach for set-based design which focuses on the evaluation of the project specific design solution principles and the interrelations of the solution principles within the design space.

DESIGN MARGINS: IMPACTS ON BUILDING ENERGY PERFORMANCE

Jones D. A., Eckert C. M.
The Open University (GBR)

This paper examines the addition of design margins for building services energy infrastructure during the design process. It argues that care must be taken when applying margins; ensuring cumulative effects do not undermine the ability of systems to be energy efficient. An example of a hospital Trust is provided showing the addition of design margins impacting the energy efficiency of services provided. Tensions are found between delivery of flexibility, adaptability and other change parameters and the need for the system to be bounded, so as to encourage effectiveness.

A PRACTICAL APPROACH TO STRUCTURE THE PRODUCT DEVELOPMENT PROCESS USING NETWORK THEORY

Chahin A., Hoffmeister J., Paetzold K., Noori N., Vilasis Cardona X.
Bundeswehr University Munich (DEU)

This thesis deals with the viability of methods of the network theory for mapping a complete product development process (PDP). The aim is to maintain the information and data flow within a company despite the increasing complexity. As a representative PDP the FORFLOW-Process-Model is used, which is a generic process, developed in a cooperation of universities and the industry. Petri-Nets are used in order to simulate a dynamic process and they are treated as sub networks. These are integrated into the overall network, which in return is separated in three main layers.

SOLUTION PATTERNS – THEIR ROLE IN INNOVATION, PRACTICE AND EDUCATION

Weber C., Husung S.
Technical University of Ilmenau (DEU)

The re-use of components, concepts and related knowledge is an important factor in design. Based on the CPM/PDD approach, this contribution defines the term "solution pattern" as the carrier of the product-related knowledge. From there, the role of solution patterns in innovation is studied as the core issue of this article. Because of their importance, the role of solution patterns in design practice and design education is also briefly studied. Conclusions are drawn for further research topics, and for modifications in design education.

UNDERSTANDING DESIGN THINKING IN DESIGN STUDIES (2006 - 2015): A SYSTEMATIC MAPPING STUDY

Paula D., Cormican K.
National University of Ireland (IRL)

Design Thinking (DT) has been heralded as a well-suited methodology in encouraging innovation and economic growth. Although DT has been studied in many research areas, no systematic research effort has been made on aggregating evidence from the Design Studies Journal to understand the evolution of DT from the last ten years. This study aims to analyse the evolution and benefits of research on Design Thinking in the Design Studies Journal from 2006 to October 2015. The findings provide a deep understanding of past research and uncovered many challenges that might be addressed in the future.

A CORPUS-LED STUDY INTO HOW 'DESIGN' IS REPRESENTED IN DESIGN THINKING RESEARCH

Ghassan A.
Coventry University (GBR)

Language use reflects discourse communities' ideologies and maintains their power and legitimacy (P&L). Corpus-led methods aid analysis into how communities generate P&L. In the first attempt to use such methods to analyse design thinking research (DTR), this study finds the community does not speak on negative aspects of 'design'. Instead 'design' is represented in an honorific context, aiding generation of P&L. The insights may aid critical reflection in the DTR community. The results mirror existing findings in other design research areas, necessitating the need for further studies.

DESIGN THINKING AND THE HYPE CYCLE IN MANAGEMENT EDUCATION AND IN ENGINEERING EDUCATION

Spee J., Basaiawmoit R. V.
University of Redlands (USA)

Design thinking may be old wine in a new bottle or it may be new wine in an old bottle. The essence of the logic of Design is best exemplified by Simon (1988) when he states that while natural sciences are concerned with how things are, design is concerned with how things about to be. From an intuitive perspective, one could easily see that designing of "how things could be" is deeply connected to the engineering disciplines with or without user input (the necessity of user-input being a cornerstone in Design Thinking).

THEORY OF SOCIAL SYSTEMS ENGINEERING

Naumann T.
Daimler AG (DEU)

This article refers to a paper "Meta-Model of Sociotechnical Systems" (MSTS). Initially developed as a phenomenological meta-model, the MSTS were constantly validated and refined, for instance for new systems engineering approaches. The paper expand the meta-model approach to a "Theory of Social Systems Engineering". Basically it is a first draft of such a theory. The theory follows fundamentals of every theory of science and shows direct experience and examples from industrial practice.

MAPPING REQUIREMENTS TO PRODUCT PROPERTIES: THE MAPPING MODEL

Mattmann I., Gramlich S., Kloberdanz H.
Technical University Darmstadt (DEU)

Designers model and describe technical products by product properties that have to meet requirements. The paper presents the Mapping Model that ensures the respresentation of relationships between requirements and product properties within an integrated view of product synthesis. Determined product properties are constantly matched to desired properties. The elements and links between the spaces of the Mapping Model are explained and portrayed by a case study. The Mapping Model provides valuable base for methodological support of the transformation of requirements into product properties.

ORGANIZATIONAL REDESIGN: INSIGHTS FROM ETHNOGRAPHIC STUDY BEFORE SIMULATION

Lamé G., Stal-Le Cardinal J., Jouini O.
CentraleSupelec (FRA)

Increasing efficiency is crucial in healthcare systems. To do so, a classical approach is to redesign organizations using Discrete Event Simulation (DES). However, DES models workersonly as resources producing labour with a certain efficiency. To overcome this limitation, DES can be embedded in a Soft Systems Methodology (SSM) framework. In this article, we show how an ethnographic study is undertaken early in such a framework. Precious insights are gained and these findings call for more frequent use of observation in addition to interviews when redesigning organizations.

THE PROCESS OF PARTICIPATORY ERGONOMICS SIMULATION IN HOSPITAL WORK SYSTEM DESIGN

Andersen S. N.
Technical University of Denmark (DNK)

Participatory ergonomics simulation (PES) is a method to involve workers in simulation and design of their own future work system. Understanding of the process of PES is crucial in order to plan and facilitate the process towards creating an ergonomics work system design supporting both human well-being and overall system performance. With outset in two cases of PES in hospital work system design, this study investigates the elements of the PES process and their interrelations. The aim is to develop a framework describing the PES process in hospital work system design.

GENERATIVE PARTICIPATORY DESIGN FOR INTERACTIVE MEDICAL DEVICES

Hare J., Thomas G., Andrews C., Eggbeer D.
Cardiff Metropolitan University (GBR)

This paper covers the use of a novel, early stage, Participatory Design technique used within a wider User Centred Design process for the generative stage of the design of interactive medical devices. Two commercial projects that concentrate on the interfaces for new medical products are used as case studies to illustrate the participatory design approach. The projects were conducted within a centre for design research and undertaken for two separate companies that intend to launch commercial products. This gives important contextual value to the research aspects of the work presented here.

CAN DIAGRAMS HELP IMPROVE HEALTHCARE SYSTEMS DESIGN AND CARE DELIVERY?

Komashie A., Clarkson P. J.
University of Cambridge (GBR)

There is significant evidence to suggest that healthcare systems even in developed countries do not work as desired, leading to millions of pounds in cost and a growing demand for improvements in care quality and patient safety. Many have advocated increased use of systems engineering as the key to designing and delivering systems that work in healthcare. We review the relevant academic health service design and delivery literature and find the absence of a consistent diagrammatic language in the attempts to design better systems. We argue that a better diagrammatic language is required for healthcare.

NEEDS ELICITATION FOR NOVEL PERVASIVE HEALTHCARE TECHNOLOGY

Thorpe J. R., Forchhammer B. H., Maier A.
Technical University of Denmark (DNK)

Healthcare is moving out of the clinic into our everyday lives with rising trends in eHealth and pervasive technology. One challenge this poses is how to elicit diverse needs from users limited by their condition? We approach this by tapping into healthcare professionals' knowledge and activities to learn about and involve patients without demanding their direct engagement. This is applied in the case of smart wearable technology aids for dementia, yielding substantial, valid information.

WHICH HYGIENIC PRODUCTS FOR WHICH CONTINENT? DESIGN FOR USAGE AND SUSTAINABILITY

Leroy Y., Yannou B., Murthy L., Lallmahomed A., Yannou-Le Bris G.
CentraleSupelec (FRA)

All women have to deal with menstrual cycles.The paper proposes to investigate usage and sustainability performances of four hygienic solutions, i.e. environmental, economic, hygienic, comfort and social performances. Three different geographical contexts are also studied: Europe, United States and India, where product expectations, cultural aspects, production and logistic realities strongly differ and influence the purchasing choice. Products sustainable performances are fanally combined with client's preferences to identify the product that fit the best the clients' expectations.

D335 & D345: WORKSHOP

Congress Hall Šipun

EUROPEAN REMANUFACTURING NETWORK

Chair: Tomohiko Sakao (SWE)

Remanufacturing is an important component of a resource efficient manufacturing industry. Remanufacture involves dismantling a product, restoration and replacement of components and testing of the individual parts and whole product to ensure that it is within its original design specifications. The performance after remanufacture is expected to be the same as the original performance specification and the remanufactured product generally offers a warranty. By keeping components and their embodied material in use for longer, significant environmental benefits can be realised. Remanufacturing also provides opportunities for the creation of highly skilled jobs and economic growth.

Despite these accolades, remanufacturing is an undervalued part of the industrial landscape and an under-recognised industry. In order to encourage greater remanufacturing activities, the European Commission has funded a project to form, coordinate and support a European Remanufacturing Network (ERN).

The purpose of the workshops is to learn more about remanufacturing cases in the areas of business models, remanufacturing processes and product design. Presentations from the ERN-project members describing how different companies work with the business models, remanufacturing processes and product design concerning remanufacturing. Tool-kits and learning materials for the three areas will be presented and discussed during the workshop. The goal of the workshop is that the participants will know more about how to gain more economic and ecological benefits from performing remanufacturing to boost their own business either by improving their existing remanufacturing business or by starting up new remanufacturing businesses. Expected focal theme in this workshop is design related issues of product, process, and business model for remanufacturing.

D340: DESIGN MANAGEMENT

Salon 5

Hosted by DS SIG DESIGN MANAGEMENT

Chairs: Erik Bohemia (GBR), Petra Badke-Schaub (NLD), Lianne Simonse (NLD)

The meeting will be run in two parts. In the first part the chairs will present information about the current state of the SIG and about future plans. In the second part a discussion will be steered about Design Management and the „wishes, wants and musts" of the customer. The focus will be on the question: What can be the role of the designer in the management field?

D342: MODELLING AND MANAGEMENT OF ENGINEERING PROCESSES

Congress Hall Bobara

Hosted by DS SIG MMEP

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

Traditionally many design models and methods have been developed for novel design, but there is an increasing recognition that most products are developed based on existing designs, that are upgraded. This SIG meeting will discuss whether existing methods can be applied in this context and where the need for new method development would be.

D343: DESIGN CYBER PHYSICAL SYSTEMS

Congress Hall Orlando

Hosted by DS SIG DESIGN CPS

Chair: Peter Hehenberger (AUT)

This SIG meeting provides an overview of different kinds of systems and focuses on the transition process from mechatronics to CPS and cloud-based (IoT) systems. Main criteria are the classification of the driving forces and necessary technologies. So a cyber-physical system is a system of collaborating computational elements controlling physical entities. These systems can be found in areas such as aerospace, automotive, energy, healthcare, manufacturing, entertainment, and consumer appliances. With the consideration of several case studies we deal with the main research questions, identifies in the last workshops.

D344: NETWORK ACTIVITIES FOR REALISATION OF INNOVATIVE PRODUCTS

Congress Hall Konavle

Hosted by EU NARIP project

Chairs: Jože Duhovnik (SVN), Ahmed Kovačević (GBR), Neven Pavković (HRV)

The aim of this meeting is to present current state of project based courses that are focused to collaboration of geographically distributed student teams working on new product development tasks. We want to bring together teachers involved in such courses to exchange the experiences and to discuss the common problems and requirements for further developments. We also welcome those who want to start such course as well as people from industry interested in participating as partners who provide and support new product development tasks.

INTRODUCTION OF METHODOLOGY FOR DISTRIBUTED COLLABORATIVE INDUSTRY-ACADEMIA PROJECT BASED LEARNING

Vidovics† B., Vukašinović N., Pavković N., Kovačević A. (HUN)
Budapest University of Technology and Economics (HUN)

Paper describes the CODEVE (COllaborative DEsign in Virtual Environment) methodology, developed in the first year of the educational project NARIP (Networked Activities for Realization of Innovative Products), funded by ERASMUS+. Four European universities launched this project with goal to develop a concept and to produce a physical product prototype within one academic semester in dislocated, virtual environment. In order to expose students to real life situations, the educational process is being conducted in tight collaboration with development focused industrial partner company.

THE INFLUENCE OF PRODUCT COMPLEXITY ON TEAM PERFORMANCE WITHIN NPD

Fain N., Žavbi R., Vukašinović N. (GBR)
University of Strathclyde (GBR)

This paper explores the influence of product complexity on team performance. A longitudinal case study of a Masters course European Global Product Realisation, where 4 universities collaborate on product development projects is used to study the phenomenon. 4 different projects are explored, where in 2 of them teams worked on the full product development process for a particular product and 2 projects where several teams worked on a single product, thus the focus was on developing specific modules of the same product, due to its complexity.


DESIGN 2016
Excellence in Design


THURSDAY, MAY 19
REGISTRATION
D411 ADDITIVE MANUFACTURING
D412 USER EXPERIENCE AND INTERACTION MODELLING
D413 PRODUCT FUNCTIONALITY AND CUSTOMER INTEGRATION
D414 INDUSTRIAL DESIGN
D415 NEW PRODUCTS
REFRESHMENT BREAK
D421 SUSTAINABILITY MEASUREMENT AND ASSESSMENT
D422 UNDERSTANDING USER EXPERIENCE
D423 METHODS SUPPORTING INNOVATION
D424 KNOWLEDGE TRANSFER AND KBE
D425 DESIGN EDUCATION
LUNCH
D432 ECO-DESIGN
D433 CREATIVITY SUPPORT AND EVALUATION
D434 CASE STUDIES ON DESIGN METHODS
D435 CASE STUDIES ON DESIGN PRACTICE
REFRESHMENT BREAK
D4-P PLENARY SESSION IV
D4-C CLOSING
FAREWELL PARTY
Ragusa
Bobara
Orlando
Konavle
Šipun
Quiet Salon
Salon 5

BIONIC INSPIRED INFILL STRUCTURES FOR A LIGHT-WEIGHT DESIGN BY USING SLM

Lippert R. B., Lachmayer R.
Leibniz Universität Hannover (DEU)

Additive Manufacturing enables new potentials for a component design. Due to the high design freedom, the implementation of bionic inspired infill structures can be used to manufacture lightweight components. By defining a design catalog, bionic structure for a suitable production in Additive Manufacturing are analyzed. By using FEM, the impact of isolated load cases of the bionic structures are examined. By comparing the simulation results, suitable structures for the different load cases can be identified. Based on a demonstrator, the adaptation of the bionic structures is described.

A STRUCTURED LOOK AT NEW DESIGN POSSIBILITIES FOR ADDITIVE MANUFACTURING MACHINES

Whitney T. S., Moultrie J.
University of Cambridge (GBR)

Rapid prototyping machines are extremely popular, but in terms of robustness, speed and precision are inherently limited. At a cursory glance, they appear to be designed following the principles of their predecessors. This paper takes a morphological approach to analyze the design of these machines, by breaking them into individual elements to compare their performance and consider the potential for new designs. A novel 'periodic table' of potential designs is proposed. This analysis confirms that a lot of design space isn't being used, indicating a degree of 'fixation' in current products.

INFLUENCES OF ADDITIVE MANUFACTURING ON DESIGN PROCESSES FOR CUSTOMISED PRODUCTS

REVIEWERS FAVOURITE

Spallek J., Sankowski O., Krause D.
Hamburg University of Technology (DEU)

Additive manufacturing (AM) has a high impact on the fabrication of customised components of a product, but has not been sufficiently analysed for the implications of AM for design processes. The paper presents AM-specific influences to customised design processes. A gradual range of product design processes for different levels of customization through AM was derived, from elaborated individualisation processes in standardised individualisation to specific product adaptation. The characteristics of the two types are detailed and applied in a case for personalised vascular replications.

DESIGN FOR ADDITIVE MANUFACTURING: A CREATIVE APPROACH

Rias A.-I., Bouchard C., Segonds F., Abed S.
Arts et Métiers ParisTech and Poly-Shape (FRA)

This paper introduces a new method for early stages of Design For Additive Manufacturing. It aims at supporting designers in the generation of creative concepts in AM. A review of current DFAM methods, shows that some of them already integrate creative approaches based on the use of examples. However, a comparison of these methods highlights that the generated concepts are only partially creative. We then assert that a method based on an association between intra-domain examples and far-domain examples as a source of inspiration could foster the generation of creative concepts.

DATA MANAGEMENT FOR ADDITIVE MANUFACTURING: SURVEY ON REQUIREMENTS AND CURRENT STATE

Gräßler I., Taplick P., Pottebaum J., Scholle P., Reiher T.
Heinz Nixdorf Institute - Paderborn University (DEU)

The paper gives an overview of actually used Additive Manufacturing (AM) data formats and AM data infrastructure. Based on empirical analysis of the actual situation, necessary improvement of data management and exchange formats in context with AM technology is derived. The purpose of this paper is to understand the actual use of data formats and management in the field of AM. The paper draws conclusions based on an empirical analysis of the used data formats dependent on stakeholder groups. The results of the expert survey show a necessity to improve or develop new AM specific data formats.

IMPACT OF COLLABORATIVE SPACE ON TEAM WORK IN ENGINEERING DESIGN EDUCATION

Fechter M., Kett S. G., Luft T., Wartzack S.
Friedrich-Alexander-Universität Erlangen-Nürnberg (DEU)

This paper presents a study investigating the impact of space design on behaviour and creative outcome of team work in learning environments. A dedicated space was especially designed and equipped to facilitate creativity during collaboration. A student course in engineering design was held both in conventional classroom settings and in the newly designed space. The observations and measurements made relating to the two environments are shown and discussed in the paper. The results indicate noteworthy differences that can help to positively influence learning and creativity in future lectures.

APPLYING SIMPLE UX IDEATION TECHNIQUES TO IMPROVE THE USABILITY, DESIGN, AND ADOPTION OF ASSISTIVE TECHNOLOGY

Wilkinson C. R.
University of Cambridge (GBR)

This paper outlines a simple design insight acquisition exercise that effectively captures user feedback to inform the design and development of more user-friendly, usable, and assistive devices. The easily transferable approach provides the design community with an opportunity to understand the workarounds that were devised by actual users to overcome inadequacies in the original designs. Further, it allows us to consider how such ideas might be filtered into mainstream assistive technology development while reducing the stigma often associated with the typical design of assistive devices.

THE INFLUENCE OF USER CHARACTERISTICS IN NEGATIVE USE EXPERIENCE AND THEIR IMPLICATIONS

Ahn Y. K., Kim C. J.
UNIST (Ulsan National Institute of Science and Technology) (KOR)

People use a wide range of electronic products every day. And they go through positive and negative experiences. We think not only enhancing positive experiences, but also, reducing the negative experiences could provide better use experiences. So, in this paper, we studied about negative use experiences in terms of user characteristic such as cultural background, gender and technology familiarity. Through this study, we hope to provide the better way of design for reducing the negative experiences.

INTEGRATION OF THE WELL-BEING IN THE EARLY PHASES OF THE AUTOMOTIVE DESIGN PROCESS: FIRST APPROACH AND CONTRIBUTION OF PHYSIOLOGICAL MEASURES

Bertin M., Bluntzer J.-B., Roger M., Sagot J.-C., Del Fabbro L.
Renault/IRTES (FRA)

In this paper is presented the opportunity to consider the user's Well-being in an automotive context directly from the early phases of the design process by proposing new kinds of tools and methods. After establishing a definition of Well-being, an evaluation method is suggested enabling the car designers to assess how a new system would impact the driver's Well-being. More precisely, a first experiment studying the possibility to use physiological measures in order to quantify the driver's Well-being is presented.

INTRODUCING THE WAYFARING APPROACH FOR THE DEVELOPMENT OF HUMAN EXPERIMENTS IN INTERACTION DESIGN AND ENGINEERING DESIGN SCIENCE

Leikanger K. K., Balters S., Steinert M.
Norwegian University of Science and Technology (NOR)

This paper introduces a wayfaring process, previously deployed at early stage product development projects, in the exploration, design and piloting of experiments. The case example being an interaction experiment in a ship bridge context, targeting stress and affective response. It included a simulation task as primary and a cognitive load task as secondary element as well as various physiology sensors. Rather than being based on long-term planning or conducting meticulous analysis before decision points, the team focused onto: Probing ideas, Merging multidisciplinary, Agility, and Speed.

COMPUTER AIDED DESIGN USER INTERACTION AS A SENSOR FOR MONITORING ENGINEERS AND THE ENGINEERING DESIGN PROCESS

Gopsill J., Snider C., Shi L., Ben H.
University of Bristol (GBR)

Computer Aided Design (CAD) has become an integral tool for many engineering design activities. CAD not only forms the digital embodiment of the products design but also supports communication between engineers as a intermediary object, the analysis of engineering systems, and enables computer-mediated collaborative work on the product. It is argued that the logs of the engineers' user interactions could be a powerful sensor in providing insights into the engineers and engineering design process. This paper presents results from the analysis of CAD logs generated by 45 engineering students.

USING SECONDARY VIDEO MATERIAL FOR USER OBSERVATION IN THE NEEDFINDING PROCESS FOR NEW PRODUCT DEVELOPMENT AND DESIGN

Blindheim J., Wulvik A., Steinert M.
Norwegian University of Science and Technology (NOR)

This paper introduces secondary video observation as a fast, versatile and inexpensive tool for needfinding in the early stage of product development and design. Based on comparing the traditional methods: classical observation, participant observation, classical video observation and drawing from a presented in depth case study on the development of a climbing boot, we introduce secondary video observation as a method. Furthermore we suggest an iterative process for its application as a rough prototyping tool that may also be used to create a video persona.

AN APPROACH TO INCLUDE THE LIFE SITUATION OF ELDERLY PEOPLE IN PRODUCT DEVELOPMENT

Paetzold K., Walter J., Pelizäus-Hoffmeister H.
Bundeswehr University Munich (DEU)

Suitable products are able to support elderly people in daily life. It is crucial to understand the future users and their needs. Interviews with elderly people are conducted by an interdisciplinary team, which asked the interviewees about their daily life, what problems arise and how products could be of help. This led to two results: support is clustered in different kinds of technical support and there are hints how products should be designed, in order to satisfy the future users. It became obvious to know not only the activity, which causes problems, but also the reason for it.

KANO'S METHOD IN PRODUCT DESIGN: A STUDY OF DYNAMIC MODELS' RELIABILITY

Borgianni Y.
Free University of Bozen|Bolzano (ITA)

The present paper intends to contribute to systematize long-lasting product development processes, for which customer information obtained at the beginning of the design task could result invalid at the time of market launch. In particular, the paper explores the reliability of dynamic Kano-oriented methods, by extrapolating and elaborating literature data of customer surveys about akin technical systems taken at different times. The statistical model that has been built elucidates to which extent forecasts of Kano quality attributes are trustworthy for designing future products and services.

WINNING FORMULAS FOR METAPHOR DESIGN: A CASE STUDY OF DESIGN COMPETITIONS

Wang H.-H.
National Taipei University of Technology (TWN)

This paper introduces a set of winning formulas for metaphor-oriented design competitions from one hundred entries. Structure mapping theory is used to describe the similarity-based metaphor quality of the entries in the form of attributes, while rough set theory is used to induce the rules for winning formulas from the vague data. The formulas reveal high prediction accuracy when the inference decisions are compared with thirty award winners.They have been applied to a design prize winner for its metaphor created by analogy, suggesting their advantages.

A NETWORK APPROACH FOR UNDERSTANDING AND ANALYZING PRODUCT CO-CONSIDERATION RELATIONS IN ENGINEERING DESIGN

Wang M., Huang Y., Contractor N., Fu Y., Chen W.
Northwestern University (USA)

This paper presents a product association network to characterize customers' consideration preferences, where both descriptive and quantitative approaches are proposed to interpret the co-consideration relations by the underlying factors of product and customer attributes. The integrated network approach provides an easy-to-understand visual representation as well as quantitative evaluations of the important factors that affect customers' co-consideration decisions.

EXPLORING THE ACTUAL PRACTICE OF USER EXPERIENCE AND SCENARIO-BASED METHODS

Michailidou I., Lindemann U.
Technical University of Munich (DEU)

Supporting user experience design-UXD requires understanding of practitioners' needs. To explore understanding, practices and assessment of UX, we invited practitioners to participate in a survey. The 22 received responses indicate that, although not always clearly defined, UX is associated with innovation and opportunities. However, systematic approaches and clear responsibilities are rare. We also investigated practices of scenario-based methods which are considered helpful tools in UXD. We draw initial requirements on a methodological support for UXD and implications for its future practice

CREATING IMPACT FROM INDUSTRIAL DESIGN RESEARCH: CASE STUDIES FOR APP, EXHIBITION, VIDEO, WEBSITE, CARDS AND AWARD

Evans M.
Loughborough University (GBR)

Journal publication remains central to the dissemination of research and acknowledgement of credibility through peer review. As funding bodies start to require evidence of impact for 'non-academic beneficiaries', this paper presents approaches employed by the author to generate additional outputs from industrial design research. Case studies identify resources to support the commercialisation of technology and collaboration/ communication during product development. Whilst challenges exist, industrial design appears to be well placed to identify, execute and exploit emerging opportunities.

DIFFICULTIES IN TRANSFORMABLE DESIGN AND ITS CAUSES

Lee H., Tufail M., Kim K.
UNIST (Ulsan National Institute of Science and Technology) (KOR)

The design of transformable products is difficult because of the interdependency of various elements involved, and multi-functional requirements before, during and after transformation. The main problem in transformable design is that designers often have little experience in design process. As a result, the design concept often being developed without much thought given to design elements and engineering detail. This study explores difficulties faced by designers in designing transformable products and present the causes of such difficulties to infer an effective transformable design process.

GEAR PAIR GENERATION WITH THE METHOD OF TRANSPOSED LINES OF ACTION

Bendefy A. G., Horák P.
Budapest University of Technology and Economics (HUN)

The most typical way to calculate geometry of changing ratio gears is based on the manufacturing process. This article however describes a different approach. We applied the basic law of gearing, and generated the teeth geometry using the lines of action. These lines are escorted along the pitch curves with the help of different coordinate transformations. The connection points are registered on the gears coordinate system, resulting the curves of the teeth profile. This method is a fast and reliable way to determine general gear geometries.

IMPROVING HAJJ PILGRIMS HEALTH CONDITIONS THROUGH PRODUCT DESIGN

Razi M.
Cardiff Metropolitan University (GBR)

Hajj, the annual greater pilgrimage for Muslims, is a combination of different steps. Health condition of Hajj is of the most important issues related due to high population density and activities. This paper is about to see the condition as a design question analysed and suggested solutions through product design. The outcome of this project was a new tent design to be used in the second day of Hajj to improve overal health condition.

DEVELOPMENT OF THE NEW PROTECTION PROCESSES AND SERVICES FOR SECURE PRINTING

Žiljak Vujić J., Crnjac S., Mitrović O.
Zagreb University of Applied Science (HRV)

This work describes the solution relating to the problem of secure printing of documents by using IRD SPB device. The work explains what IRD SPB device is, how it works, and how to use it in different business environments. Also it emphasizes the benefits of using secure printing technology over traditional printing approach.

DESIGN OF A SELF-OPTIMISING PRODUCTION CONTROL SYSTEM

Koechling D., Gausemeier J., Joppen R., Mittag T.
University of Paderborn (DEU)

Key element of this work is a structural model, which describes the phases of the design by means of self-optimizing-process. It describes which aspects are needed and how they are coherently implemented in order to design a self-optimizing production contol system. The system is described with the help of a laboratory project in which a contract manufacturer produces different types of flashlights and faces disturbances in his production system. This has been realised in a simulation model. With the help of this prototypical implementation the feasibility was validated.

PROTOTYPES IN ENGINEERING DESIGN: DEFINITIONS AND STRATEGIES

Jensen L. S., Özkil A. G., Mortensen N. H.
Technical University of Denmark (DNK)

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

DESIGN OF AN INNOVATIVE NATURAL GAS TWO-STROKE ENGINE

Diwisch P., Dinkel C., Rieg F., Alber-Laukant B.
University of Bayreuth (DEU)

Exhaust emissions are a great challenge for today's application of two-stroke engines. The reason are unburned hydrocarbons, generated by short-circuit currents and misfiring in the partial load range. Its emergence is supposed to be prevented by an injection system combined with an innovative concept developed by the Chair for Engineering Design and CAD at the University of Bayreuth based on the split-single engine. A methodical approach and advanced CAx systems lead to a gradual optimization of this engine. The procedure is demonstrated exemplarily by means of a cylinder head.

DESIGN OF A MODULE FOR CONTINUOUS PASSIVE MOTION TO BE USED IN EQUIPMENT FOR THE REHABILITATION OF ELBOW AND FOREARM

Callegaro A. M., Caten C. S. t., Jung C. F., Fogliatto F. S., Tonetto L. M.
Federal University of Rio Grande do Sul (BRA)

The continuous passive motion (CPM) is a physical therapy resource may be performed using a CPM device. In this paper we present the development of a CPM module required to rehabilitate the human elbow and forearm. The module was developed following recommendations from a classical product development model. A working prototype was designed and constructed, and stakeholders' needs were fully contemplated in the module's design. The new device can be tested on human subjects when connected to an equipment for the rehabilitation of elbow and forearm.

PGE - PRODUCT GENERATION ENGINEERING - CASE STUDY OF THE DUAL MASS FLYWHEEL

Albers A., Bursac N., Rapp S.
Karlsruhe Institute of Technology (DEU)

In this contribution the approach of product generation engineering is further developed. It is presented, how the three types of variation (carryover, embodiment and principle variation) can be distinguished by using the contact and channel approach. As database a more than twenty years lasting case study is used. Therefore the development of the dual mass flywheel in several product generations is considered. Taking the bearing of the system as an example it is analyzed in detail which kind of variation was used and which developmental challenges derived.

THE IMPACT OF USER-DRIVEN CUSTOMIZATION ON THE DEVELOPMENT PROCESS

Roth M., Ulrich C. M., Holle M., Lindemann U.
Technical University of Munich (DEU)

Current markets show an increasing demand for individual products. Therefore, user-driven customization is a new concept which combines early user involvement and self-customization. It has not yet been extensively discussed in research. The implications on current development processes are not known. This paper combines a qualitative exploration (interviews) with a quantitative exploratin (questionnaire survey) and researches the implications of user-driven customization. Thus, it paper contributes to the understanding of user-driven customization and provides a base for consecutive research.

MATERIAL CRITICALITY METHOD - PRODUCT VULNERABILITY FROM A SUSTAINABLE BUSINESS PERSPECTIVE

Hallstedt S., Isaksson O., Wallin J., Zetterlund H.
Blekinge Institute of Technology (SWE)

A novel method is presented, including a material criticality list and sustainability compliance index. The method aims to support an estimation of the vulnerability of a product concept due to material criticality and strategically guide early design decisions. A jet engine component design team evaluated the method. It was understood that the method increased communication and clarification regarding material criticality. Further, it became apparent that the method provided a collaboration link between the design team and the business development team.

COMUNICATION MANAGEMENT MODEL OF ENVIRONMENTAL ISSUES TO ENCOURAGE THE CONSUMPTION OF SUSTAINABLE PRODUCTS IN CHILE

Cereceda G., Vidal M., Betancourt M. C.
University of Bio-Bio (CHL)

This research aims to define a communication management model for environmental issues to encourage a sustainable consumption in Chile. The model was performed in three steps; a survey of the state of the art regarding international use of eco-labels. A field study to identify incentives to acquire a sustainable product among local consumers. An analysis of the environmental laws in Chile. The resulting model must be leaded by the government, has to include certified and believable environmental information and a communication strategy adjusted to the environmental culture of the consumer.

EXPLORING THE DYNAMIC AND COMPLEX INTEGRATION OF SUSTAINABILITY PERFORMANCE MEASUREMENT INTO PRODUCT DEVELOPMENT

Rodrigues V. P., Morioka S., Pigosso D., Carvalho M., McAloone T.
Technical University of Denmark (DNK)

In order to deal with the complex and dynamic nature of sustainability integration into the product development process, this research explore the use of a qualitative System Dynamics approach by using the causal loop diagram (CLD) tool. A literature analysis was followed by a case study, aiming to depict the structure of the used sustainability indicators and their relationships. The results showed the main information feedback loops and were discussed in terms of the CLD's advantages and limitations, and how this exploratory study could lead to a more comprehensive modelling approach.

A STEPWISE METHOD TOWARDS PRODUCTS ADAPTED FOR REMANUFACTURING

Lindkvist L., Sundin E.
Linköping University (SWE)

Currently, products are often not designed for remanufacturing. Further, there is a lack of feedback from remanufacturing to product design. Thus, information from remanufacturing and design for remanufacturing needs to be integrated in a better way into the product development processes. In this paper a stepwise method towards products adapted for remanufacturing is described. The method is directed at OEMs that remanufacture, and specifically supports integration of information from remanufacturing into the design process in order to better adapt products for remanufacturing.

EVALUATION OF LIFE CYCLE ANALYSIS CASE STUDIES: FINDINGS FOR APPLICATION AND FURTHER DEVELOPMENT

Rosner A., Hollauer C., Kammerl D., Omer M., Mörtl M.
Technical University of Munich (DEU)

This paper gives an overview of the current practice of life cycle analyses. The overview can serve as support for practitioners and helps to identify potentials for the further advancement of life cycle analyses. In order to be able to derive the desired findings, case studies concerning life cycle analysis (of the method variants Life Cycle Assessment (LCA), Life Cycle Costing (LCC) and Social LCA (SLCA)) are analyzed. Findings include: A general comparison of the three variants LCA, LCC, and SLCA and a conformity check ISO standards 14040 and 14044.

DESIGNER'S IDENTITY: PERSONAL ATTRIBUTES AND DESIGN SKILLS

Kunrath K., Cash P., Li-Ying J.
Technical University of Denmark (DNK)

A designer's professional identity (DPI) develops through both education and professional experience, building on core personality traits and innate skills. In this paper a systematic literature review and a secondary narrative review were developed in order to map personal attributes and design skills that comprise the DPI. Just a few works in literature dealt with these two elements holistically. Thus, in order to address this gap a holistic understanding of these elements, in context, is proposed as a cohesive framework where a DPI can be described as it evolves over time.

WHAT CAN ENGINEERING DESIGN LEARN FROM GAME DESIGN AND ITS PRACTICE?

Mombeshora M., Dekoninck E.
University of Bath (GBR)

While the context within which engineering design is conducted undoubtedly differs from that of game design, both are design activities similar to each other. By adopting a formal approach to, this paper aims to connect both practices in a stimulating manner and, through interviews and a game design case study, take a critical look at the practice of game design and development to distilling lessons that could be beneficial to engineering design.

CONSIDERING EMOTIONAL IMPRESSIONS IN PRODUCT DESIGN: QUALITY OF LIFE THEORY AND ITS IMPACT ON DESIGN STRATEGY

Kett S. G., Wartzack S.
Friedrich-Alexander-Universität Erlangen-Nürnberg (DEU)

In this paper, the necessity of emotional considerations in the context of Universal Design is treated. To work out an alternative approach how to integrate emotional aspects in product design processes, we look at quality of life models to locate emotional design in Universal Design research. Based on identified challenges such as complexity, interdisciplinarity, vagueness or subjectivity we present a way to consider emotional impressions by integrating resources from other disciplines. Hence we introduce ACADE - an Application for Computer Aided Design of Emotional impressions.

MANAGING USER EXPERIENCE DESIGN: THE ROLE OF A "STORYKEEPER"

Michailidou I., Lindemann U.
Technical University of Munich (DEU)

Particularities of user experience-UX highlight the need for effective management using special skills. A gatekeeper of experience should cope with quality requirements, user-centred methods and multidisciplinary teams, while influencing decision-making. Based on literature, experiences from an industrial project and a small empirical study, we identify the need for establishing the role of storykeeper and make a proposal for its description. A storykeeper´s main task is ensuring successful UX design. Required is a unique combination of manager, requirements enginner and design thinker skills

A PRELIMINARY STUDY OF TRENDS IN PERCEIVED QUALITY DESIGN ATTRIBUTES IN THE AUTOMOTIVE LUXURY MARKET SEGMENT

Stylidis K., Burnap A., Rossi M., Wickman C., Söderberg R., Papalambros P. Y.
Chalmers University of Technology (SWE)

The premium vehicle segment has focused on excellent manufacturing quality, while in contrast the luxury segment has focused on emotional and personalized appeal. We perform qualitative analysis of interviews with Italian, Swedish, and American premium and luxury vehicle manufacturers. Results indicate customers of luxury vehicles now consider quality attributes previously considered only by customers of the premium segment. We quantitatively model this design communication process, and show luxury vehicle manufacturers that neglect benchmarking against the premium segment risk low perceived quality.

SHARING THE DESIGN INTENT BETWEEN INDUSTRIAL DESIGNERS AND ENGINEERING DESIGNERS

Laursen E. S., Møller L.
Aalborg University/University College of Northern Denmark (DNK)

The aim of the paper is to understand the challenges sharing the product frame between industrial designers with the engineering designers. The study is based on six case studies. The analysis showed correspondence between industrial designers and engineering designers in their understanding of the key elements of the context and concept. However the analysis also showed a lack of correspondence between the industrial designers and engineering designers in regards to the product framing and thereby how the different elements of the product frame is connected and interrelated.

APPROACH FOR CREATING A REFINED TASK AS PREPARATION FOR A TARGET-ORIENTED IDEA GENERATION PROCESS

Herrmann T., Binz H., Roth D.
University of Stuttgart (DEU)

Knowledge about a need or a problem is important for the idea generation process which leads into the design of successful products. However, this information is often not provided accurately meaning that an analysis of a need or a problem does not take place properly. An approach on how this information gap can be closed by a problem analysis which prepares the information needed for the following idea generation process is given in this paper. Especially, the necessary for this interface and some first ideas, how that problem analysis can take place, are discussed and presented.

THE ESM APPROACH: 8 MECHANISMS TO EFFICIENTLY SUPPORT ECO-IDEATION

Tyl B., Vallet F., Pialot O., Millet D., Le Duigou J., Graves G.
APESA (FRA)

One of the main challenges of this eco-innovation process is the generation of ideas taking into account both environmental and societal positive impacts through adapted stimulation mechanisms. This paper introduces the concept of Eco-ideation Stimulation Mechanism (ESM) as a 'meso' ideation mechanism offering the designer a compromise between a broad and systemic reflection, and a technical-oriented vision to keep an efficient stimulation. This paper also presents a first toolbox of ESMs to explore the whole eco-innovation dimensions, as well as a detailed example through biomimicry.

MANAGING THE PROCESS OF PREPARATION FOR PRODUCT DEVELOPMENT - IDEAS ASSESSMENT AND EVALUATION

Stevanović M., Marjanović D., Štorga M.
Markot.tel (HRV)

The productivity early stages of NPD play an important role in the process of innovation. Innovative ideas and later concepts are assessed in a situation of high uncertainty. Insufficient assessment results in the execution of too many marginal projects and the improper allocation of resources. It is therefore important to define a systematic method for idea assessment and provide transparent information for decision-making. This paper presents an attempt to define the methodology for the selection of ideas, and defines a set of criteria and attributes to assess the value of ideas.

A DATA MINING APPROACH TO ASSIST DESIGN KNOWLEDGE RETRIEVAL BASED ON KEYWORD ASSOCIATIONS

Shi F., Han J., Childs P. R. N.
Imperial College London (GBR)

Design knowledge retrieval is a key part for creative idea generation in engineering design process, and it highly depends on the inherent associations between knowledge. Existing computer-based knowledge networks such as WordNet and ConceptNet are based on hypernym and hyponym and mainly focus on commonsense. This paper proposed a data mining approach to construct a professional knowledge concepts network by exploring the inherent associations between keywords. A software tool was developed to justify its effects on assisting design knowledge retrieval by using an engineering case study.

FACTORS INFLUENCING KNOWLEDGE APPLICATION: A REVIEW FROM THE KNOWLEDGE MANAGEMENT FIELD

Fernandez Miguel R., Carro Saavedra C., Lindemann U.
Technical University of Munich (DEU)

Engineering companies do not efficiently apply the knowledge they possess and understanding why requires analyzing the factors influencing knowledge application. Few studies address this issue in engineering design; nevertheless, numerous publications address it in knowledge management (KM) literature but without a consensus on the model for analysis. We conducted a literature review to collect factors from KM journals and classify them in one individual-centered model of knowledge processes. We end up with 21 factors classified in a model that describes their impact on knowledge application.

IMPORTANCE OF PROBLEM SETTING BEFORE DEVELOPING A BUSINESS MODEL CANVAS

Bekhradi A., Yannou B., Cluzel F.
Ecole Centrale Paris (FRA)

In this paper, the importance of problem setting in front end of innovation to radically innovate is emphasized prior to the use of the BMC. After discussing the context of the Business Model Canvas usage, the failure reasons of a premature use (in early design stages) of the BMC tool is discussed through some real examples of innovative startups in Paris area. This paper ends with the proposition of three main rules to follow when one wants to use the Business Model Canvas.

TOWARDS KNOWLEDGE BASED ENGINEERING FOR MULTI-MATERIAL-DESIGN

Kleemann S., Türck E., Vietor T.
Technische Universität Braunschweig (DEU)

The "Manual Multi-Material-Design" presented in this paper is a Knowledge Management System (KMS) for the automotive lightweight design, providing design rules. For developing automotive components in multi-material-design extensive expertise for various topics is compulsory. Besides, design expertise regarding steel, knowledge about fibre reinforced plastics (FRP), joining and production technologies are crucial. To accelerate the development of components in multi-material-design and to enhance the engineers expertise, a Knowledge Management System must be developed.

DESIGN CATALOGUES: KNOWLEDGE REPOSITORIES FOR KNOWLEDGE-BASED-ENGINEERING APPLICATIONS

Gembarski P. C., Bibani M., Lachmayer R.
Leibniz Universität Hannover (DEU)

In the 1980ies and 1990ies design catalogues were developed as knowledge repository for engineering knowledge. Until now, approaches to devise computer aided design catalogues did not provide the desired results. In the present article the authors introduce a Framework for a computer-aided design catalogue that is combined with a knowledge-based-engineering-system. This is done based upon a discussion of synthesis tasks in engineering design and the over-all setup of KBE-Systems, Roth's design catalogues are systematically characterized as knowledge bases.

OPTIMIZING THE PROCESS OF PRODUCT DEVELOPMENT BY COLLABORATING & THINKING VISUALLY- CO-CREATION WITHIN HOWDEN

Grant D. A., Russell G., Wagner B., Fain N.
Howden (GBR)

The paper explores the process of creating a bespoke New Product Development Procedure for the heavy engineering firm Howden through a collaborative Knowledge Transfer Partnership with the University of Strathclyde. The act of transferring knowledge was done by using a visual methodology and the paper explores the reasoning behind why using this methodology was so successful.

APPLYING THE ELEMENTAL INTERFACES APPROACH TO KINEMATIC DESIGN

Freund T., Lotz J., Würtenberger J., Kloberdanz H.
Technical University Darmstadt (DEU)

The authors introduce with the elemental interfaces approach an alternative to analyse mobilities of mechanisms up from early design phases based on a matrix representation. The paper compares results obtained with the already established Kutzbach Grübler criterion with results derived with the elemental interfaces approach to show its applicability. Finally, both procedures are discussed with their advantages and disadvantages.

ASSESSMENT OF SIMULATION READY CAD MODELS IN A SET-BASED CONCURRENT ENGINEERING CONTEXT

Heikkinen T., Johansson J., Elgh F.
Jönköping University (SWE)

Set-based concurrent engineering (SBCE) has been pointed out as a means of enabling customisation and easy adaptation to fluctuating requirements. A feature and script based automation method of Finite Element Analysis has been proposed and developed by [Johansson, 2014] to help support SBCE. This article presents an assessment of the purposed method with respect to its industrial need, scientific novelty, and further work required. Outcomes of which include a new CAD-model tagging technique, positive industrial feedback and further work suggestions.

APPROACH TO TRANSFER METHODS FOR DEVELOPING MODULAR PRODUCT FAMILIES INTO PRACTICE

Beckmann G., Gebhardt N., Bahns T., Krause D.
Hamburg University of Technology (DEU)

Various methods are developed in design research, but few are used. To improve the uptake of methods in industry, this paper proposes a methodical method transfer support. It covers the analysis and preparation of design methods with a new developed Method and Process Visualisation (MPV) and gives recommendations for planning their integration in a company by a method integration project. The transfer support is used to integrate a design method for developing modular product families in a medium-size enterprise. The made experience in the project and the achieved integration are discussed.

DISTRIBUTED IPD PROJECT-BASED LEARNING - A PHD SUMMER SCHOOL STUDENT'S PERSPECTIVE

EL Badawi EL Najjar R., Friedl M., Martinec T., Ouamer Ali M.-I., Partie M., Borg J., Vajna S.
Johannes Kepler University (AUT)

A group of 5 international PhD students attended a 2 week Integrated Product Development (IPD) summer school (ipdISS15). The aim of ipdISS15 is to provide a platform through which postgraduates working in IPD related fields can sharpen their understanding of current and emerging research issues in this interdisciplinary field. Objectives of this project were to motivate the students to organize, specify roles, adapt views on the engineering tasks and to prepare for distributed collaboration. Perspectives and findings during IPD, related to project-based learning, are shown as conclusion.

INDIVIDUAL DISPOSITIONS AND THE ADOPTION OF SURFACE LEARNING IN DESIGN

Hamat B., Badke-Schaub P., Schoormans J.
Delft University of Technology (NLD)

In this study, we investigated the inter-relationship between students' mind-sets, tolerance for ambiguity and self-efficacy to the learning approaches that design students adopt. Data was collected using a questionnaire and distributed to industrial design students from two universities in Malaysia. We find significant differences between high and low surface learners. In contrast to low surface learners, high surface learners were associated to a fixed mind-set and views their design capability as unchangable, are highly tolerant of ambiguity and rates themselves highly on self-efficacy.

TEACHING DESIGN METHODS WITH THE INTERACTIVE 'METHODOS' PORTAL

Bavendiek A.-K., Inkermann D., Vietor T.
Technische Universität Braunschweig (DEU)

To handle the challenges of shortened product life cycles and rising global competition, engineers need to innovate. To do so, they can be assisted by design methods which most engineers learned during their studies. The idea of this paper is to motivate the students by applying a web-based portal which suits the students' habits like sharing experiences about methods and their use. Furthermore, different media to teach methods will be introduced. The paper illustrates the concept of the new portal, the exemplary introduction in an engineering design course as well as an evaluation.

CROSS-CULTURAL DESIGN (CCD) LEARNING REFLECTIVE TOOL BASED ON UK AND KOREA'S COLLABORATIVE DESIGN PROJECTS

Lee D. Y., Ha J. Y., Fairfax D.
University of London (GBR)

This paper seeks to outline a new methodology for Cross-Cultural Design (CCD) practice and education. By developing a reflective CCD Learning tool based on Donald Schön's theory of "reflection-in/on-action" it seeks to develop tools for "reflection-for-action" i.e. tools that generate new possibilities, and spaces for, Cross-Cultural-Design practices. In conclusion it discusses the viability and efficacy of these tools as they have been deployed in a number of different CCD contexts.

PROJECT-BASED LEARNING: A NEW WAY TO TEACH ERGONOMICS

Astolfi B. M., Costa D. G., Campese C., Costa J. M. H.
University of São Paulo (BRA)

This article aims to present a framework for ergonomics education to the graduate level in which project-based learning is accomplished through partnerships with companies allowing students to develop a real project. The results are quite encouraging. First, students have been successful in the development of the artifacts of their projects. The company has shown great satisfaction with the results of projects, entering some of the concepts developed in its portfolio. Finally, students' satisfaction evaluation report highlighted the need and their motivation to learning through real projects.

PROTOTYPE OF A NEW LEARNING FACTORY - AN EDUCATIONAL APPROACH TO INTEGRATE PRODUCTION AND PRODUCT DEVELOPMENT

Song Y.-W., Herzog M., Kreimeier D., Bender B.
Ruhr-University Bochum (DEU)

Industry demands graduate engineering students with general competences in context of simultaneous engineering. To prepare students for their future job specification new didactical concepts have to be developed. This paper presents a new learning factory concept designed and tested at the Ruhr-University Bochum which focuses on the improvement of interdisciplinary collaboration between product development and production. The conceptual basis is a multidisciplinary role-play realising the approaches of problem based learning and self-reflection of one's actions in the team.

TIME-EFFICIENT ECO-INNOVATION WORKSHOP PROCESS IN COMPLEX SYSTEM INDUSTRIES

Saidani M., Cluzel F., Leroy Y., Auclaire A.
CentraleSupelec (FRA)

Industrial companies increasingly want to eco-innovate in their project but have to deal with strict constraints in time and resources. Thus, a time-efficient eco-innovation workshop process for complex system industries is proposed. From the selection of a relevant multidisciplinary working group (before the workshop) to the follow-up of environmental projects (after the workshop) through eco-ideation and eco-selection (during the workshop), all stages are considered. The proposed workshop lasts in all three hours and is experienced on an industrial complex system at Liebherr.

UNANSWERED QUESTIONS IN CONCEPTUAL DESIGN TOWARDS CIRCULAR ECONOMY

Widgren M., Sakao T.
Linköping University (SWE)

Manufacturing industry faces challenges in implementing design methods for Circular Economy into practice, since much is unanswered due to its complexity and insufficient research. This conference paper aims to clarify the known and unanswered questions within product and service design for Circular Economy by literature review. The results are presented as hypotheses to be tested to enhance the design towards Circular Economy, insight in collaborations between product designers and service designers and the involvement of customers in conceptual design.

VALIDATION OF THE ECO-TRANSFORMITY METHOD

Midžić I., Štorga M., Marjanović D.
University of Zagreb, FSB (HRV)

This paper presents validation of a method for qualitative environmental evaluation of product concepts. The basis of the Eco-transformity method are five environmental criteria. Criteria outcomes are collected in a decision matrix and the rank-sum rule is used. To demonstrate that the method supports evaluation and comparison of concepts which are preferably original and innovative, a suitable set of example concepts is established. Validation framework is adapted from the Validation Square, a method for establishing theoretical and empirical effectiveness and efficiency of design methods.

PROCESS-ORIENTED PERFORMANCE INDICATORS FOR MEASURING ECODESIGN MANAGEMENT PRACTICES

Rodrigues V. P., Pigosso D., McAloone T.
Technical University of Denmark (DNK)

In order to support ecodesign performance measurement from a business perspective, this paper performs an exploration of available process-oriented indicators to be applied to ecodesign management practices. With the Ecodesign Maturity Model as a background framework, a systematic literature review coupled with a cross-content analysis was carried out to assign proper indicators to the practices. Results show that the currently available indicators do not fully reflect the characteristics of ecodesign and there is significant room for improving the development of tailor-made indicators.

ASSESSING DESIGN CREATIVITY: REFINEMENTS TO THE NOVELTY ASSESSMENT METHOD

Jagtap S.
Lund University (SWE)

Sarkar and chakrabarti (2011) developed a method to assess novelty of ideas and products. Their method has received attention in design research, as indicated by a number of studies referring to or using their method. While their novelty assessment method has received attention, deficiencies were found in it when it was applied in our own studies. It is the purpose of this article to overcome these deficiencies. In total, four modifications have been proposed to their method, and are supported by drawing on examples of products.

HUMOUR PROCESSES FOR CREATIVE ENGINEERING DESIGN

Hatcher G., Ion W., Maclachlan R., Wodehouse A., Sheridan M., Simpson B.
University of Strathclyde (GBR)

Humour has long been associated with creativity, however the link has rarely been applied to engineering design. This paper highlights analogies between humour creation and engineering design, and discusses opportunities to develop new processes and methods that could reinvigorate engineering concept design. Idea generation methods have been explored within the realms of improvised comedy and the visual medium of comic strips. The structures and principles of these creative humour processes present opportunities to view complex engineering problems from new and surprising perspectives.

STIMULATED IDEATION SESSIONS IN PRODUCT PLANNING: ASSESSING QUANTITATIVE RESULTS OF INDIVIDUALS AND GROUPS

Borgianni Y., Rotini F.
Free University of Bozen|Bolzano (ITA)

The paper presents an extensive testing campaign aimed at revealing the factors that mostly influence ideation performance within the Product Planning phase of engineering design. Tailored techniques mirror Brainstorming principles and differ according to the ways analogical thinking is stimulated. By comparing different conditions in ideation sessions, the results remark the relevance of submitting manifold formalised stimuli, at least for what concerns Engineering students. The effect of teamwork is arguable, as individuals working separately are capable of producing larger numbers of ideas.

IMPROVING CREATIVITY TRAINING: A STUDY OF DESIGNER SKILLS

Valgeirsdottir D., Onarheim B., Li-Ying J.
Technical University of Denmark (DNK)

Creativity is widely accepted to be important for design, raising the interest to identify ways to train designers to be more creative. To improve such creativity training this study observed individual creativity skills during team interactions and their influence on the creative process. The key finding is the importance of Process awareness, in which individual designers utilize own knowledge of cognitive processes to manage/advance teamwork. It is thus important to educate designers about such cognitive processes during training and arm them with know-ledge to strategically deploy them.

DEVELOPMENT OF A SUPPORT TOOL TO PREDICT MANUFACTURABILITY OF DEEP-DRAWING PARTS

Goller D., Schreyer S., Alber-Laukant B., Rieg F., Volk W.
University of Bayreuth (DEU)

This paper describes the theoretical considerations and implementation of a support tool to predict manufacturability of deep-drawing parts. The approach is faster than detailed simulation of the process and is based solely on geometrical criteria, so it can be used in very early stages of development process, when detailed process information is not available yet. The process first divides the faces into subfaces which subsequently are rated in terms of manufacturability. The proceeding was implemented using the free geometric modeling kernel OpenCASCADE to provide a good user experience.

METHOD RECOMMENDATION AND APPLICATION IN AGILE PRODUCT DEVELOPMENT PROCESSES

Reiß N., Bursac N., Albers A., Walter B., Gladysz B.
Karlsruhe Institute of Technology (DEU)

This paper presents the results of a research project by introducing the demonstrator InnoFox. To achieve a situation-specific method-recommendation in agile product development process, an application for mobile devices InnoFox was developed. With the help of an interactive questionnaire the situation will be translated into activities of product engineering and the activities of problem solving. It was found that InnoFox is able to cover the empirically determined demand for suitable hands-on development methods.

INTEGRATED VALUE ENGINEERING - IMPLEMENTATION OF VALUE OPTIMIZATION POTENTIALS

Maisenbacher S., Fürtbauer D., Behncke F., Lindemann U.
Technical University of Munich (DEU)

The creation of valuable products requires high functionality and quality for low costs, which results in additional challenges in the design process of products. The relatively new approach of integrated value engineering uses matrices to combine target costing and value engineering in a structural model to deduce value optimization potentials. The objective of this publication is to support the implementation of these potentials and to allow a value optimization by a combination of either increasing the functionality for the customer or reducing the product's costs.

APPLICATION, EVALUATION AND FUTURE RESEARCH POTENTIAL OF THE MATRIX AND GRAPH BASED PRODUCT MODEL

Luft T., Wartzack S.
Friedrich-Alexander-Universität Erlangen-Nürnberg (DEU)

The increasing individualization due to customer-specific requirements as well as the enormous complexity of modern products leads to steadily increasing challenges. To meet these challenges, the overall objective of the authors is to develop a computer aided matrix- and graphbased product modelling tool for the product-oriented process management. The aim of this paper is to give a short description of this methodological and conceptual approach and to apply and to evaluate it in order to show future research potential.

FINDING THE APPROPRIATE TEST CONTEXT FOR MOBILE APPLICATION PROTOTYPES - A DECISION MODEL BASED ON A CASE STUDY

Meyer S., Häger F., Uflacker M.
Hasso Plattner Institute (DEU)

With the rise of mobile devices, the usability and testing of mobile applications has gained enormous importance. However, existing tools and approaches for mobile tests are not standardized. This paper investigates the current state of testing mobile prototypes in the software industry. Based on qualitative interviews, a case study with SAP, Microsoft and Nokia HERE evaluates challenges of mobile testing, and the importance of the environment for such tests. Key findings are discussed and a decision model to find the adequate test context for a mobile prototype test is presented.

HOLISTIC APPROACH TO MATERIALS SELECTION IN PROFESSIONAL APPLIANCES INDUSTRY

Piselli A., Simonato M., Del Curto B.
Politecnico di Milano (ITA)

Materials selection contributes in pre-evaluating product's material performance and impact in the production process. Applied to professional food processing appliances, the research aim is to develop a versatile method for materials selection that could help engineers and designers to evaluate both quantitative and qualitative properties of materials. The challenge of the new method is the correlation between material durability properties with their sensorial perception (visual, tactile and auditory), through the evaluation of user-interaction aspects of products and materials.

METHODOLOGY FOR ENERGY EFFICIENT DESIGN OF COOLING PLANTS

Osman K., Pervan D., Tomaš Ž.
Termo Servis Ltd. (HRV)

The research presented in this paper proposed a methodology for development of cooling plants. Proposed methodology is presented with all steps through all its states. Evaluation of cooling plants has been conducted with regard to energy efficiency with focus on electrical energy saving. With the aim to achieve optimal system architecture of the proposed technical system alternatives, possible feedback to structure reselection is made to perform changes. Verification of the proposed methodology is made on real example like cooling plant in pharmaceutical industry, with several iteration steps.

INTRODUCING SELECTIVE LASER MELTING TO MANUFACTURE MACHINE ELEMENTS

Lachmayer R., Zghair Y. A., Klose C., Nürnberger F.
Hannover University (DEU)

In this analysis, a Selective Laser Melting (SLM) is used to contribute within machine elements manufacturing by using aluminium base alloys. It shows the ability to produce hybrid components which composite of different parts with different materials, and lightweight components with internal structure. An investigation to the mechanical and structural properties of specimens is made. Then a new concept to build one solid, hollow body by using SLM is introduced. Two applications are presented to show the ability to integrate functions within components.


DESIGN 2016
Excellence in Design

D4-P: PLENARY SESSION IV

Chair: McAloone, Tim C. (DNK) **16:15 - 17:00**

NEW ADVENTURES IN COMPUTATIONAL DESIGN AND DIGITAL FABRICATION

Kristina Shea
Engineering Design and Computing Laboratory, ETH Zurich (CHE)

The recent rise in digital fabrication technologies and materials, including Additive Manufacturing (AM), may be the best thing that has ever happened to increase the impact of computational design methods and tools. Designers struggle to design parts by hand that take full advantage of the variety of complex shapes that are now possible and the new and different material combinations. From a computational design point of view, finally we can more readily fabricate the complex, customized parts that we can compute. But it goes further than this and opens new avenues for fabricating novel composite materials and active elements. Design is changing. New challenges need to be addressed including defining representations, searching vast design spaces, and characterizing AM processes, new materials and their combinations. Highlights of our research on novel computational design methods for automatically generating, optimizing and directly fabricating structural and mechanical systems are discussed focusing on multi-material printing and end-use, functional parts rather than prototypes alone. This includes testing and characterization of polymer-based AM processes and integration of resulting models in novel computational design and optimization methods. Cutting-edge applications investigated include lattice structures, customized consumer products, biomedical devices and robotics.

D4-C: CLOSING SESSION **17:00 - 17:45**

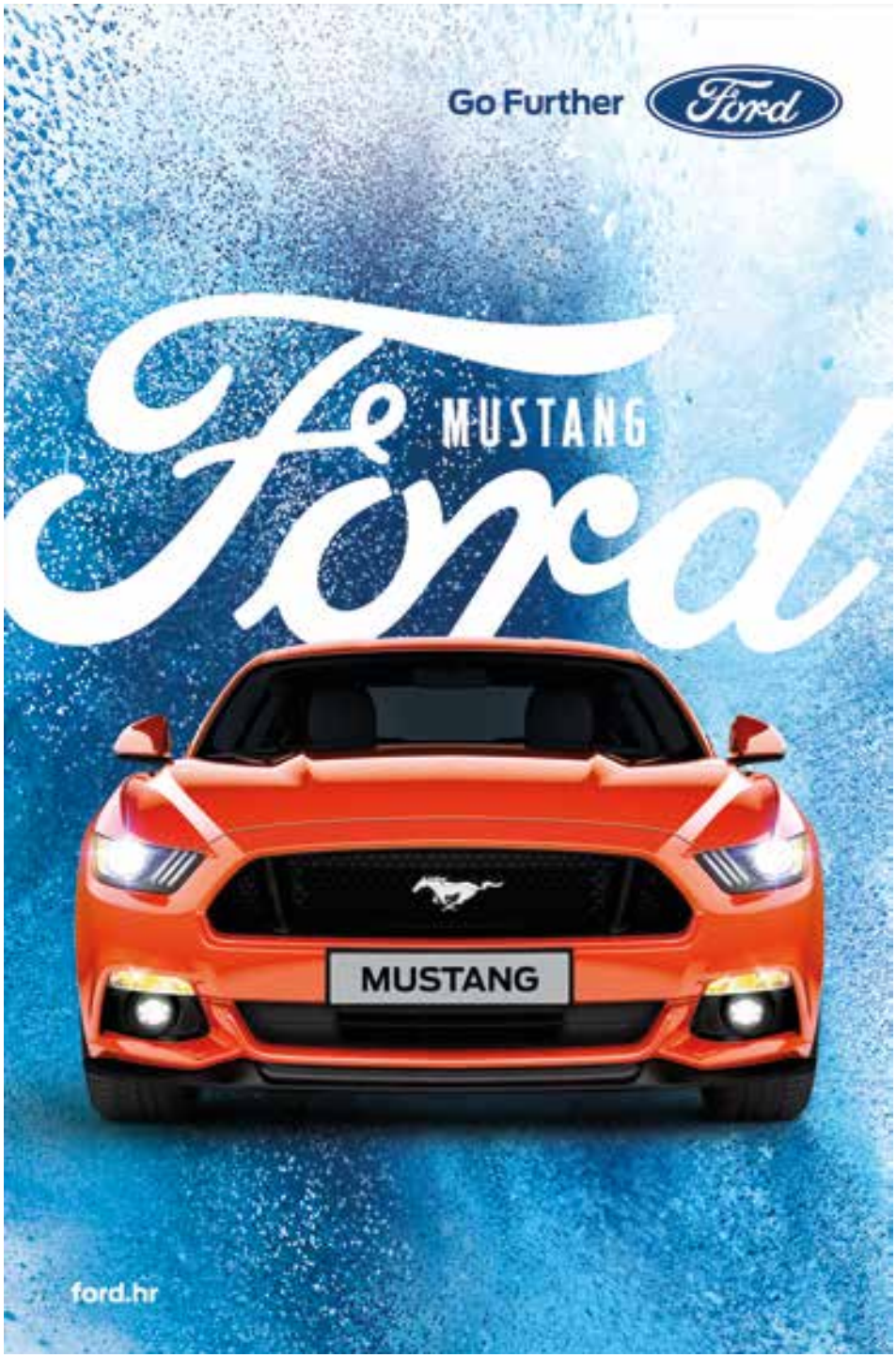
REFLECTION ON RESULTS OF THE "DESIGN RESEARCH – 10 YEARS ON" WORKSHOP

Steve J. Culley
University of Bath (GBR)

Christian Weber
Technical University of Ilmenau (DEU)

CONFERENCE REFLECTION AND CLOSING

Udo Lindemann
Technical University of Munich (DEU)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