



BOOK OF ABSTRACTS

16TH INTERNATIONAL DESIGN CONFERENCE
ONLINE · OCTOBER, 26 - 29 2020 · [DESIGNCONFERENCE.ORG](https://designconference.org)

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*DESIGN 2020 proves the verse of Petar Preradović,
written in the late 19th century:*

*“The only permanent in this world the change is”
in original:*

“Stalna na tom svijetu samo miena jest”

The changes that drive and stimulate us all challenged again. Challenges are part of the design in every aspect, practice and research.

For the DESIGN 2020 organising team, the pandemic required a new approach, organising the Online event, quite ad hoc. The DESIGN 2020 is now online!

Although DESIGN 2020 Online can not provide an experience of being on-site in Cavtat or Dubrovnik, we hope it will meet the expectations of the participants, authors, presenters, reviewers and the Programme Chairs.

The design research presented at the DESIGN 2020 conference reflects predominantly the interests and experiences of design researchers and practitioners connected with academia. The papers presented epitomise the current state-of-the-art in design research. In places, they also re-examine questions that have been discussed before but in new contexts.

The papers presented at DESIGN 2020 Online were published with open access in June 2020, in the Proceedings of the Design Society: DESIGN Conference, ISSN: 2732-527X by Cambridge University Press.

The challenge is now on you, the participants. Your research and presentations form just a platform that might turn the DESIGN 2020 into a successful event. With proactive discussions, you may achieve the goal – to share the knowledge with colleagues, evaluate your work and, build your network on the sessions.

In behalf of the DESIGN 2020 organising team, thank you for your support, thank you for staying with the conference, postponed and turned by circumstances and, thank you for your participation.

**CONFERENCE VENUE**

The DESIGN 2020 Online conference will take place at the hopin.to virtual event service.

GENERAL SCHEDULE**DESIGN 2020 WORKSHOPS**

Monday, October 26th, 2020 12:45 – 16:00

DESIGN 2020 MAIN EVENT

Tuesday, October 27th – Thursday, October 29th, 2020 12:45 – 16:15

SPECIAL EVENTS

with recorded video messages on disposal

PRE-WORKSHOP SESSION

Monday, October 26th, 2020
12:45-13:00

Dean's Message
Dubravko Majetić, Faculty of Mechanical Engineering and
Naval Architecture, University of Zagreb, Croatia

OPENING SESSION

Tuesday, October 27th, 2020
12:45 – 13:00

The Design Society Welcome Address:
Tim McAlloone, President of the Design Society, Denmark
A Word Before:
Dorian Marjanović, University of Zagreb, Croatia

PRE-SESSION GATHERING

Wednesday, October 28th, 2020
12:45-13:00

Message from the Programme Chair:
P. John Clarkson, University of Cambridge, United Kingdom

PRE-SESSION GATHERING

Thursday, October 29th, 2020
12:45-13:00

Message from the Programme Chair:
Julie Stal-Le Cardinal, CentraleSupélec, France

CLOSING

Thursday 16:15-16:30

Message from the Programme Chair:
Christian Weber, Technische Universität Ilmenau, Germany
A Word After:
Dorian Marjanović, University of Zagreb, Croatia

SOCIAL EVENTS

Virtual social events will take place Tuesday - Thursday, 16:15-18:00 in gather.town
Time zone: Zagreb local time - CET!

PROGRAMME

MONDAY, OCTOBER, 26TH 2020

12:45	D1-O: PRE-WORKSHOP GET-TOGETHER <i>Dean's Message: Dubravko Majetić, Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Croatia</i>										12:45
13:00											13:00
14:30	D111 AFRICA-DESIGN: DESIGN FOR GLOBAL SUSTAINABLE DEVELOPMENT VR 1	D112 CREATIVITY-ENHANCING PHYSICAL WORK ENVIRONMENTS VR 2	D113 DECISION MAKING AND DATA DRIVEN DESIGN	D114 EXPLOITING MATERIAL POTENTIAL IN DESIGN FOR ADDITIVE MANUFACTURING VR 4	D115 HEALTH SYSTEMS DESIGN SIG LAUNCH VR 5	D116 INNOVATIVE BUSINESS MODELS FOR ADDITIVE MANUFACTURING (AM) VR 6	D117 MANAGING THE COMPLEXITY OF SOCIO-TECHNICAL SYSTEMS - A CONTRIBUTION TO ADVANCED SYSTEMS ENGINEERING FOR THE ADDED VALUE OF TOMORROW VR 7	D118 PROTOTYPING PERSPECTIVES IN PRODUCT SERVICE SYSTEM (PSS) DESIGN VR 8	D119 SUPPORTING DECISIONS IN SUSTAINABILITY-RELATED TRADE-OFF SITUATIONS VR 9	D120 THE RELATIONSHIP BETWEEN ANALOG TOOLBOX AND DIGITAL TOOLS VR 10	14:30
16:00											16:00

TUESDAY, OCTOBER, 27TH 2020

D2-O: OPENING - VIRTUAL STAGE <i>The Design Society Welcome Address: Tim McAloane, President of the Design Society, Denmark A Word Before: Dorian Marjanović, University of Zagreb, Croatia</i>							
D211 DATA-DRIVEN DESIGN VR 1	D212 MODEL-BASED SYSTEMS ENGINEERING VR2	D213 CIRCULAR ECONOMY VR 3	D214 DESIGN TEAMS VR 4	D215 HEALTHCARE SOLUTIONS VR5	D216 ADDITIVE MANUFACTURING I VR6	D217 KNOWLEDGE-BASED ENGINEERING VR7	D218 ROBUST DESIGN AND OPTIMISATION VR8
REFRESHMENT BREAK							
D2-P: PLENARY SESSION I – VIRTUAL STAGE <i>Keynote: Mary Lou Maher - AI Models for Creative Design: Curiosity, Novelty, and Surprise; Chair: Christian Weber</i>							
REFRESHMENT BREAK							
D221 AI IN DESIGN VR 1	D222 TOOLS FOR SYSTEMS ENGINEERING VR2	D223 PRODUCT-SERVICE SYSTEMS VR 3	D224 IDEATION STUDIES VR 4	D225 HEALTHCARE DESIGN METHODS VR5	D226 ADDITIVE MANUFACTURING II VR6	D227 ENHANCED AND NEW CAD VR7	D228 AFRICA-DESIGN: DESIGN FOR GLOBAL SUSTAINABLE DEVELOPMENT VR8
SOCIAL EVENT - SOCIAL EVENT ROOM							

WEDNESDAY, OCTOBER, 28TH 2020

D3-O: PRE-SESSION GET-TOGETHER – VIRTUAL STAGE Message from the Programme Chair: John.P Clarkson, University of Cambridge, United Kingdom							
D311 AGILE DEVELOPMENT VR1	D312 REQUIREMENTS ENGINEERING VR2	D313 SUSTAINABLE DESIGN METHODS VR 3	D314 CO-DESIGN VR 4	D315 VIRTUAL, AUGMENTED AND MIXED REALITY VR5	D316 DESIGN EDUCATION METHODS I VR6	D317 USER EXPERIENCE VR7	D318 APPLICATION OF METHODS IN DESIGN PRACTICE I VR8
REFRESHMENT BREAK							
D3-P: PLENARY SESSION II – VIRTUAL STAGE Keynote: Zehavit Reisin – What's New with Materials?, Chair: P. John Clarkson							
REFRESHMENT BREAK							
D321 INDUSTRY 4.0 VR 1	D322 ARCHITECTING ENGINEERING SYSTEMS VR2	D323 QUANTITATIVE SUSTAINABILITY ASSESSMENT VR 3	D324 COLLABORATIVE DESIGN VR 4	D325 ADVANCED VISUALISATION VR5	D326 DESIGN EDUCATION CONCEPTS & COMPARISONS VR6	D327 USER BEHAVIOUR VR7	D328 APPLICATION OF METHODS IN DESIGN PRACTICE II VR8
SOCIAL EVENT - SOCIAL EVENT ROOM							

THURSDAY, OCTOBER, 29TH 2020

D4-O: PRE-SESSION GET-TOGETHER Message from the Programme Chair: Julie Stal-Le Cardinal, Centrale Supélec, France							
D411 IMPROVING DESIGN PROCESSES VR 1	D412 ANALYSING INNOVATIVE TECHNOLOGIES VR 2	D413 CONCEPTUALISATION AND EMBODIMENT VR 3	D414 DESIGNERS' ACTIVITY ANALYSIS VR 4	D415 LIGHTWEIGHT DESIGN VR 5	D416 TEACHING SUSTAINABLE DESIGN VR 6	D417 USER CONTEXT VR 7	D418 METHODS FOR DESIGNING AUTONOMOUS VEHICLES VR 8
REFRESHMENT BREAK							
D4-P: PLENARY SESSION III – VIRTUAL STAGE Keynote: Tobias Larsson – AI; the end for the designer as we know it?; Chair: Julie Stal-Le Cardinal							
REFRESHMENT BREAK							
D421 CHANGE MANAGEMENT VR 1	D422 RISK MANAGEMENT VR 2	D423 DESIGN KNOWLEDGE VR 3	D424 SEMANTIC APPROACHES IN DESIGN STUDIES VR 4	D425 DECISION-MAKING SUPPORT TOOLS VR 5	D426 DESIGN EDUCATION METHODS II VR 6	D427 SUSTAINABILITY AWARENESS VR 7	D428 SUPPORTING LATER LIFECYCLE PHASES VR 8
D4-C: CLOSING - VIRTUAL STAGE Message from the Programme Chair: Christian Weber, Technische Universität Ilmenau, Germany; A Word After: Dorian Marjanović, University of Zagreb, Croatia							
D4-S SOCIAL EVENT III: SOCIAL EVENT ROOM							

VR = Virtual Room

PROGRAMME

12:45	D1-O: PRE-WORKSHOP GET-TOGETHER <i>Dean's Message Dubravko Majetić, Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Croatia</i>										12:45
13:00	VIRTUAL STAGE										13:00
14:30	D111 AFRICA-DESIGN: DESIGN FOR GLOBAL SUSTAINABLE DEVELOPMENT VR 1	D112 CREATIVITY- ENHANCING PHYSICAL WORK ENVIRONMENTS VR 2	D113 DECISION MAKING AND DATA DRIVEN DESIGN VR 3	D114 EXPLOITING MATERIAL POTENTIAL IN DESIGN FOR ADDITIVE MANUFACTURING VR 4	D115 HEALTH SYSTEMS DESIGN SIG LAUNCH VR 5	D116 INNOVATIVE BUSINESS MODELS FOR ADDITIVE MANUFACTURING (AM) VR 6	D117 MANAGING THE COMPLEXITY OF SOCIO-TECHNICAL SYSTEMS - A CONTRIBUTION TO ADVANCED SYSTEMS ENGINEERING FOR THE ADDED VALUE OF TOMORROW VR 7	D118 PROTOTYPING PERSPECTIVES IN PRODUCT SERVICE SYSTEM (PSS) DESIGN VR 8	D119 SUPPORTING DECISIONS IN SUSTAINABILITY- RELATED TRADE-OFF SITUATIONS VR 9	D120 THE RELATIONSHIP BETWEEN ANALOG TOOLBOX AND DIGITAL TOOLS VR 10	14:30
	<i>Chairs: Margareta Norell Bergendahl Susanne Carin Nilsson Panos Y. Papalambros</i>	<i>Chairs: Katja Thoring Petra Badke-Schaub Roland M. Mueller Alejandro Lecuna Aguerrevere</i>	<i>Chairs: Julie Stal-Le Cardinal Camille Jean</i>	<i>Chairs: Tino Stanković Nicholas Alexander Meisel Serena Graziosi</i>	<i>Chairs: P. John Clarkson Anja Maier Maaïke Kleinsmann</i>	<i>Chairs: Busayawan Lam Eujin Pei Israt Rumana Kabir Damir Godec</i>	<i>Chairs: Albert Albers Roman Dumitrescu</i>	<i>Chairs: Alessandro Bertoni Ryan Ruvald</i>	<i>Chairs: Mariia Kravchenko Daniela C. A. Pigosso Tim C. McAlloone</i>	<i>Chairs: Yvonne Eriksson Kristin Paetzold</i>	
16:00											16:00

VR = Virtual Room



D111: WORKSHOP 1

AFRICA-DESIGN: DESIGN FOR GLOBAL SUSTAINABLE DEVELOPMENT

Hosted by The Design Society

Chairs: *Margareta Norell Bergendahl (KTH Royal Institute of Technology, Sweden)*
Susanne Carin Nilsson (KTH Royal Institute of Technology, Sweden)
Panos Y. Papalambros (University of Michigan, USA)

AFRICA-DESIGN is a Design Society initiative to build a network of design researchers, educators, and practitioners based in African countries with particular emphasis on design for sustainable development; and to link them with colleagues in the worldwide design community. The initiative builds on the perception of mutual learning opportunities in the challenges that we all share.

The continent of Africa presents a great challenge and opportunity for sustainable development in the coming decades as described in the UN Sustainable Development Goals (SDGs). The Design Society and its members have a strong commitment to sustainable design but Society membership from African countries is very limited.

The Society aims to serve as a community builder leveraging a number of existing relationships between its members and colleagues in African countries, as well as cultivating new ones with academic, government, and other organizations.

Workshop will consist of three parts:

- Brief presentations by African colleagues from Africa re. their current activities and interests with follow-up information
- Breakout Rooms discussion per topics:
 - Research Themes: Complex Systems Design, Design Education Co-design, Efficient Resource Usage, Product-Service Systems Design
 - Application Domains: Agriculture, Energy, Health Care, Water
- Breakout goal: Initiate collaborations on planning for ICED2021 Workshop; co-authoring papers (e.g., ICED2021, Design Science Journal Thematic Collection on Global Sustainable Development); joint research projects; and joint education projects.
- Reassemble for report-out and next steps

Session
D111

Virtual
Room
1

14:30
16:00

26 Oct

MON



D112: WORKSHOP 2

CREATIVITY-ENHANCING PHYSICAL WORK ENVIRONMENTS

Hosted by The Design Society DESIGN CREATIVITY SIG

Chairs: *Katja Thoring (Delft University of Technology, The Netherlands & Anhalt University of Applied Sciences, Germany)*
Petra Badke-Schaub, (Delft University of Technology, The Netherlands)
Roland M. Mueller (Berlin School of Economics and Law, Germany)
Alejandro Lecuna Aguerrevere (HTW Berlin, Germany & Anhalt University of Applied Sciences, German)

Work environments that facilitate creative activities and stimulate creativity are becoming more and more important in the creative industries and other innovation-related contexts. Early research on the topic was mostly focusing on organizational and cultural aspects of a work environment, such as freedom, encouragement by superiors, available time and resources, etc. Only recently, the impact of the physical work environment (PWE) became a research focus. This workshop explores elements of a physical work environment that are considered to be conducive to creativity and how their impact could be explained theoretically.

RQ: What theoretical concepts can explain an influence of a physical work environment on creativity?

This research workshop will consist of three parts:

- Theoretical input
 - Introduction of a creative space assessment tool
 - Input on creativity concepts that may help to explain working mechanisms of spatial designs)
- Hands-on activities
 - Creative Space Clinic: Assessing the creativity potential of given workspaces (presented as photographs)
 - Theory-Blooming Exercise: Playing with initial hypotheses of causal relationships between workspace elements and creativity)
- Discussion
 - How can we further develop and validate a theory of creative spaces?
 - What could be the next steps in the research on the topic of creative spaces?
 - How can we build a community of scholars who are interested in the topic of creativity-enhancing workspaces?

As the result of the workshop, participants will have gained a better understanding of creativity concepts and the possible causal relationships of creativity and physical work environments.

Target audience:

- Researchers with a general interest in design creativity,
- Researchers with a particular interest in creative space.
- Practitioners and educators who want to improve their work environments to increase creativity.

Session
D112

Virtual
Room
2

13:00
16:00

26 Oct

MON



D113: WORKSHOP 3

DECISION MAKING AND DATA DRIVEN DESIGN*Hosted by The Design Society DECISION MAKING SIG*

Chairs: *Julie Stal-Le Cardinal (CentraleSupélec, France)*
Camille Jean (Arts et Métiers ParisTech, France)

Data-Driven Design is a design technique based on collecting and exploiting data for the optimization of the design process. It is in the digital sector that data is most commonly used to identify new opportunities, to optimize decision-making and to reduce development time.

In some sectors, such as the automobile industry, little use is made of data in this context. In the manner of the web, it would be particularly interesting to exploit data in the early phases of product design.

The purpose of the workshop is to determine the relevant data that could be used for a specific decision-making need in the early design process. Decision Making & Data-Driven Design will be studied from the point of view of each profession of the design process to understand how they can exploit properly data and how data can improve their communications.

The structure of the workshop is as following:

- Introduction on Data-Driven Design
- Workshop on several examples
- Discussions

Targeted audience: All participants of the DESIGN Conference.

Session
D113Virtual
Room
313:00
16:00

26 Oct

MON



D114: WORKSHOP 4

EXPLOITING MATERIAL POTENTIAL IN DESIGN FOR ADDITIVE MANUFACTURING*Hosted by The Design Society DESIGN FOR ADDITIVE MANUFACTURING SIG*

Chairs: *Tino Stanković (ETH Zürich, Switzerland)*
Nicholas Alexander Meisel (The Pennsylvania State University, USA)
Serena Graziosi (Politecnico di Milano, Italy)

The range of materials that can be processed via Additive Manufacturing (AM) technologies is expanding rapidly, from polymers to metals, as well as advanced composites and bio-based materials. AM's "free" material complexity enables two or more materials to be simultaneously processed and varied locally within a single structure. This enables designs to leverage the concepts of functionally graded materials and architected materials, which have already gained significant attention in many research communities and fields of application. Breakthrough solutions to technical problems can be achieved by exploiting the unconventional properties and functionalities of such materials produced via AM. The design engineer can now not only select a material but also contribute to the design of new material properties. However a range of questions remain:

- How is this evolution of AM materials influencing the design process of new products and systems?
- How can design engineers be supported in exploiting the possibility of designing new materials' properties and functionalities?
- Do we need to re-think the design of technical products and systems in terms of the design of materials for additive manufacturing?
- How should the education of next-generation design engineers evolve in light of these new material design possibilities?

By discussing the answers to these questions, the workshop will investigate how the innovation of AM materials influences the design process, as well as how it changes the way design engineers should consider DfAM. Through a series of design talks and exercises, participants will explore the latest advancements in material availability, processability issues, methods and tools for designing functionally graded and architected materials. They will also be invited to share their experiences on the use of AM materials and processes and to reflect on how these advancements will influence the engineering design field in the future.

Session
D114Virtual
Room
413:00
16:00

26 Oct

MON



D115: WORKSHOP 5

HEALTH SYSTEMS DESIGN SIG LAUNCH

Hosted by The Design Society HEALTH SYSTEMS DESIGN SIG

Chairs: *P. John Clarkson (University of Cambridge, UK)*

Anja Maier (DTU-Technical University of Denmark, Denmark)

Maaïke Kleinsmann (Delft University of Technology, The Netherlands)

This workshop is planned in anticipation of the proposed Health Systems Design SIG within the Design Society (DS). The SIG is motivated by the fact that healthcare is a major industrial sector that faces important challenges across the globe. The United Nations Sustainable Development Goals (SDGs) which the DS has recently embraced highlight the important role of healthcare. SDG3 is about ensuring healthy lives and promoting well-being, which is what we intend to achieve with the proposed SIG, drawing on the abundance of design knowledge and expertise within the DS. Yet, as a complex system dealing with human behavior, healthcare poses specific challenges to designers, in terms of engaging and collaborating with different healthcare stakeholders, interfacing with current research methods in health sciences, defining value, all while dealing with ethical challenges.

Recent years have seen gradually increasing contributions on health systems design research at Design Society conferences. It is our hope that the newly proposed SIG will further drive increases in this field of research and extend the impact of the DS on global health and care issues.

This workshop will be the culmination of work we have done in the background over the past two years. It will be the opportunity to introduce the SIG to the wider membership of the Design Society and begin to engage with those interested, to identify and recruit members, and to shape collaboratively the agenda and the roadmap for the SIG.

The tentative agenda for the workshop is as follows:

- Background (rationale for creating a SIG).
- Introduction of SIG's steering committee
- Presentation of vision of health systems design
- Baseline assessment of health system design research in the DS
- Co-creating a four year roadmap
- Next steps

All conference participants are welcome, whether they are already working in health systems design or not. We take a broad view on health systems design, including wellbeing and medical technologies, drug development, the organization of healthcare delivery and the design of healthcare environments.

Expected outcome of the workshop:

- A roadmap for the Health Systems Design SIG

Session
D115

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Room
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13:00
16:00

26 Oct

MON



D116: WORKSHOP 6

INNOVATIVE BUSINESS MODELS FOR ADDITIVE MANUFACTURING (AM)

Chairs: *Busayawan Lam (Brunel University London, UK)*

Eujin Pei (Brunel University London, UK)

Israt Rumana Kabir (Brunel University London, UK)

Damir Godec (University of Zagreb, Croatia)

The workshop is a combination of a short talk and hands-on activities designed to introduce participants to:

- 1) Additive Manufacturing (AM) technologies and current applications;
- 2) the concept of Business Model development and the planning tool called Business Model Canvas developed by Osterwalder and Pigneur (2010); and
- 3) examples of innovative business models from other sectors. The hands-on activities will offer participants an opportunity to apply the business model canvas to create new business ideas for the AM applications and share their ideas with others.

Target audience: 30 participants who are interested in business model development and AM.

The activities include:

- Participants are given a 30-minutes talk about AM and its current applications, followed by a 30-minutes talk about Business Model Development and examples of innovative business models from other sectors
- Participants are asked to work as a team (5 people per group) to apply the Business Model Canvas to come up with new business ideas for AM applications (max 1 hour).
- Participants will be asked to present their outcomes to other teams (10 minutes per team).
- The wrap-up (max 15 minutes) will provide participants an opportunity to discuss what they have gained from this workshop.

Expected outcomes:

1. A presentation summarising the outcomes of each group
2. A workshop report based on notes taken by all facilitators
3. Publication – workshop outcomes will be published on the INEX-ADAM project website

Israt Rumana Kabir, Giselle Hsiang Loh, Eujin Pei

Brunel University London, United Kingdom

FUNCTIONALLY GRADED ADDITIVE MANUFACTURING: A TEACHING CASE STUDY OF INEX-ADAM

The multidisciplinary nature and lack of comprehensive 'materials-product-manufacturing' knowledge of Functionally Graded Additive Manufacturing (FGAM) require training to support the future Additive Manufacturing experts. INEX-ADAM, an EU funded project is building a transnational platform to promote FGAM. Brunel University London conducted two-day workshop on FGAM at the University of Zagreb in Croatia with academics and industry professionals. The workshop will strengthen the research capabilities to harness the potential of the FGAM and mitigate the constraints to industrial applications.

<https://doi.org/10.1017/dsd.2020.262>

Session
D116

Virtual
Room
6

13:00
16:00

26 Oct

MON



D117: WORKSHOP 7

MANAGING THE COMPLEXITY OF SOCIO-TECHNICAL SYSTEMS - A CONTRIBUTION TO ADVANCED SYSTEMS ENGINEERING FOR THE ADDED VALUE OF TOMORROW

Chairs: *Albert Albers (Karlsruhe Institute of Technology (KIT), Germany)*
Roman Dumitrescu (Paderborn University, Germany)

"Managing the complexity of socio-technical systems - A contribution to advanced systems engineering for tomorrow's value creation" - under this title the German Federal Ministry of Education and Research has launched an initiative that deals with the current status and future of systems engineering in theory and practice. The aim is to sustainably strengthen the ability to innovate against the background of digitalization in companies and to ensure that the next generation of engineers is properly prepared in their training (curricula). The results of a large study with national and international expert interviews to assess the status quo and identify potential for further improvements will be published in summer.

At the beginning of the workshop we will present the main research needs identified in said study. Subsequently, we intend to proceed in several steps:

- Locate existing frameworks and models of the Design Research Community along the identified needs as possible starting points for addressing these needs
- Analyze the specific potentials, strengths and challenges of these approaches in relation to research needs
- Derive and discuss partial research questions for addressing research needs based on the individual approaches
- Identify individual linking points for your own research and possible cooperation partners.

Session
D117

Virtual
Room
7

13:00
16:00

26 Oct

MON



D118: WORKSHOP 8

PROTOTYPING PERSPECTIVES IN PRODUCT SERVICE SYSTEM (PSS) DESIGN

Hosted by The Design Society DESIGN PRACTICE SIG

Chairs: *Alessandro Bertoni (Blekinge Institute of Technology, Sweden)*
Ryan Ruvald (Blekinge Institute of Technology, Sweden)

Many methods, tools and frameworks exist to design and develop each component of a product-service system (PSS) individually or in parallel. However; many of these are aimed at an iterative improvement or restructuring of established elements and concepts. In the workshop we will focus on the design practices concerning the development of radical or transformative PSS' that leverage new technologies to realize 10x increases in productivity or efficiency.

Goals:

The panacea of opportunity comes with the challenge of ambiguity in design. Established methods of managing early ambiguity pay particular attention to prototypes' ability to explore and communicate across the disciplinary domains which is required to design a PSS. Building off recent explorative research into how traditional manufacturing industry approaches prototyping within different domains, this workshop aims to further illuminate how practitioners and academics of different experience levels approach the prototyping process within the design and development of a transformative PSS solution.

It further aims to foster the discussion between academics and practitioners about the impact on prototypes in the design practice, to capture, share, and exchange design experience.

Activities:

After an introduction to the SIG interest and activities, the participant will be invited to participate to a workshop session in which they will receive a challenge that will reflect a global sustainability goal. Teams of participants will develop an ambitious future ideal solution state, apply a backcasting-forecasting approach to identify the prototype milestones which would be needed to realize. Each milestone will be explained in depth utilizing a "prototyping canvas" to enable the participants to wrestle with their views on the key drivers behind "successful" prototyping. The presentation of the results of the workshop will kick off the group discussion about the use of prototypes for the design of radically new product-service systems.

Workshop Format:

The workshop will be moderated and facilitated by Design Practice SIG members. We expect that three or four challenges will be available for the workshop attendees to address. The attendees will be in groups mixed by profession (i.e. academics, practitioners, students, other).

Planned timeline:

Problem statement presentation and questions

- Design Activities – Groups of academics and practitioners design PSS timelines by engaging with canvases
- Recap by table including recommendations generated and a summary of design strategy, methods, tools used and their effectiveness
- Recap by session moderator(s)
- Participant survey

We are investigating a new SIG sub-theme to capture design activity in-situ (industry and practice contexts) or in-vitro (laboratory or non-practice contexts), using video protocol data, and to bring these videos into the Design Practice SIG as reference cases.

Session
D118

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Room
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13:00
16:00

26 Oct

MON



D119: WORKSHOP 9

SUPPORTING DECISIONS IN SUSTAINABILITY-RELATED TRADE-OFF SITUATIONS

Hosted by The Design Society SUSTAINABLE DESIGN SIG

Chairs: *Mariia Kravchenko (DTU-Technical University of Denmark, Denmark)*
Daniela C. A. Pigosso (DTU-Technical University of Denmark, Denmark)
Tim C. McAloone (DTU-Technical University of Denmark, Denmark)

Decision making for sustainability can be a challenging task. Firstly, the challenge can occur when selecting a suitable assessment approach to understand sustainability performance of, for instance, a new product. Secondly, the challenge can occur when navigating the complexity of the data needed to calculate this performance. Once both are overcome, the result is there waiting for the actions to be taken. However, the results may not always conform the desired directions. The challenge is, there are trade-offs, which impede taking actions, because the decision between whether to minimize energy use or reduce waste generation is not straightforward once only one of them can be achieved.

The scope of the workshop is to introduce a decision support tool to assist industrial practitioners (e.g. product developers) in navigating situations when trade-offs within and across sustainability aspects occur. The support tool is based on the empirical learnings from the case studies conducted under the present research as well as on the literature recommendations. As a result, several criteria have been consolidated (these learnings are the focus of the paper which is submitted to the Design Conference) and used as a foundation for developing the support tool.

This goal of the workshop is to test the support tool within the Design Society community and to discuss it as an opportunity to support companies during sustainability-oriented decision-making processes.

The structure of the workshop is as following:

- introduce the support tool
- introduce several examples of sustainability trade-off situations
- apply the tools and facilitate open discussion about to what extent can the developed tool support decisions in trade-off situations.

Discussions and opinions from different perspectives (e.g. business modeling, product development) will be welcomed. Target/expected audience are researchers from the field of sustainable design, and decision making for sustainability.

Session
D119

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13:00
16:00

26 Oct

MON



D120: WORKSHOP 10

THE RELATIONSHIP BETWEEN ANALOG TOOLBOX AND DIGITAL TOOLS

Hosted by The Design Society HUMAN BEHAVIOR IN DESIGN SIG

Chairs: *Yvonne Eriksson (Mälardalen University, Sweden)*
Kristin Paetzold (Bundeswehr University Munich, Germany)

Every kind of prototyping supports the communication process between user and designer. Prototypes not only will be used to verify functionalities or properties but also to validate the functionality from user's perspective. Conversely, everyday solutions from users can provide valuable help in identifying their needs and desires. Prototypes become more and more important as means of communication. They help to transfer information between developers and users. Then the question arises which medium can transfer this information best, i.e. as undistorted as possible.

The motivation of the workshop is to discuss and explore how various tools could be useful and especially how different steps and situations requires different kinds of input in order to be graspable for the different stakeholders, but also to be able to involve different stakeholders.

Session
D120

Virtual
Room
10

13:00
16:00

26 Oct

MON

12:45	<div>D2-O: OPENING</div> <div>The Design Society Welcome Address:Tim McAlloone, President of the Design Society, Denmark</div> <div>A Word Before: Dorian Marjanović, University of Zagreb, Croatia</div> <div>VIRTUAL STAGE</div>								12:45
13:00	<div>D211</div> <div>DATA-DRIVEN DESIGN</div> <div>VR 1</div> <div>Chair: Mario Štorga</div>	<div>D212</div> <div>MODEL-BASED</div> <div>SYSTEMS</div> <div>ENGINEERING</div> <div>VR2</div> <div>Chair: Ola Isaksson</div>	<div>D213</div> <div>CIRCULAR ECONOMY</div> <div>VR 3</div> <div>Chair: Jeremy Faludi</div>	<div>D214</div> <div>DESIGN TEAMS</div> <div>VR 4</div> <div>Chair: Georgi V. Georgiev</div>	<div>D215</div> <div>HEALTHCARE</div> <div>SOLUTIONS</div> <div>VR5</div> <div>Chair: Alexander Komashie</div>	<div>D216</div> <div>ADDITIVE</div> <div>MANUFACTURING I</div> <div>VR6</div> <div>Chair: Tino Stanković</div>	<div>D217</div> <div>KNOWLEDGE-BASED</div> <div>ENGINEERING</div> <div>VR7</div> <div>Chair: Kristin Paetzold</div>	<div>D218</div> <div>ROBUST DESIGN AND</div> <div>OPTIMISATION</div> <div>VR8</div> <div>Chair: Dorian Marjanović</div>	13:00
14:00	REFRESHMENT BREAK								14:00
14:15	<div>D2-P: PLENARY SESSION I</div> <div>KEYNOTE: MARY LOU MAHER - AI MODELS FOR CREATIVE DESIGN: CURIOSITY, NOVELTY, AND SURPRISE</div> <div>VIRTUAL STAGE</div> <div>Chair: Christian Weber</div>								14:15
15:00	REFRESHMENT BREAK								15:00
15:15	<div>D221</div> <div>AI IN DESIGN</div> <div>VR 1</div> <div>Chair: John Gero</div>	<div>D222</div> <div>TOOLS FOR SYSTEMS</div> <div>ENGINEERING</div> <div>VR2</div> <div>Chair: Felician Campean</div>	<div>D223</div> <div>PRODUCT-SERVICE</div> <div>SYSTEMS</div> <div>VR 3</div> <div>Chair: Tobias Larsson</div>	<div>D224</div> <div>IDEATION STUDIES</div> <div>VR 4</div> <div>Chair: Ji Han</div>	<div>D225</div> <div>HEALTHCARE DESIGN</div> <div>METHODS</div> <div>VR5</div> <div>Chair: P. John Clarkson</div>	<div>D226</div> <div>ADDITIVE</div> <div>MANUFACTURING II</div> <div>VR6</div> <div>Chair: Damir Godec</div>	<div>D227</div> <div>ENHANCED AND</div> <div>NEW CAD</div> <div>VR7</div> <div>Chair: Kristina Shea</div>	<div>D228</div> <div>AFRICA-DESIGN:</div> <div>DESIGN FOR GLOBAL</div> <div>SUSTAINABLE</div> <div>DEVELOPMENT</div> <div>VR8</div> <div>Chair: Margareta Norell Bergendahl</div>	15:15
16:15	<div>D2-S: SOCIAL EVENT I</div> <div>SOCIAL EVENT ROOM</div>								16:15
18:00									18:00



Bertoni, Alessandro

Blekinge Institute of Technology, Sweden

DATA-DRIVEN DESIGN IN CONCEPT DEVELOPMENT: SYSTEMATIC REVIEW AND MISSED OPPORTUNITIES

The paper presents a systematic literature review investigating definitions, uses, and application of data-driven design in the concept development process. The analysis shows a predominance of the use of text mining techniques on social media and online reviews to identify customers' needs, not exploiting the opportunity granted by the increased accessibility of IoT in cyber-physical systems. The paper argues that such a gap limits the potential of capturing tacit customers' needs and highlights the need to proactively plan and design for a transition toward data-driven design.

<https://doi.org/10.1017/dsd.2020.4>

Sigsgaard, Kristoffer Vandrup; Agergaard, Julie Krogh; Bertram, Christian Alexander; Mortensen, Niels Henrik; Soleymani, Iman; Khalid, Waqas; Hansen, Kasper Barslund; Mueller, Georg Otto

DTU-Technical University of Denmark, Denmark

STRUCTURING AND CONTEXTUALIZING HISTORICAL DATA FOR DECISION MAKING IN EARLY DEVELOPMENT

It is important to be able to compare and evaluate different solutions early in development. This paper proposes a method for structuring historical data into a data model that can support the evaluation of new design concepts. The data is contextualized by linking it to a hierarchical decomposition of existing products. Two case studies were conducted to evaluate the value of using historical data when evaluating new concepts. The cases confirm that the proposed method is useful for evaluation of new concepts.

<https://doi.org/10.1017/dsd.2020.113>

Han, Ji⁽¹⁾; Forbes, Hannah⁽¹⁾; Shi, Feng⁽²⁾; Hao, Jia⁽³⁾; Schaefer, Dirk⁽¹⁾

¹University of Liverpool, United Kingdom; ²Amazon Web Services, United Kingdom; ³Beijing Institute of Technology, China

A DATA-DRIVEN APPROACH FOR CREATIVE CONCEPT GENERATION AND EVALUATION

Conceptual design, as an early phase of the design process, is known to have the highest impact on determining the innovation level of design results. Although many tools exist to support designers in conceptual design, additional knowledge, especially knowledge related to emerging technologies, is still often needed. In this paper the authors aim to propose a data-driven creative concept generation and evaluation approach to support designers in incorporating emerging technologies in the new product early development stage. The approach is demonstrated by means of an illustrated example.

<https://doi.org/10.1017/dsd.2020.5>



Tan, Xinyang⁽¹⁾; Chen, Wei⁽²⁾; Cao, Jiangang⁽²⁾; Ahmed-Kristensen, Saeema⁽³⁾

¹Imperial College London, United Kingdom; ²Xuzhou Central Hospital, China; ³Royal College of Art, United Kingdom

IDENTIFY CRITICAL DATA DURING PRODUCT CUSTOMISATION – A CASE STUDY OF ORTHOSES FABRICATION

Big data provides high volume of data to inform product customisation. Understanding which data is relevant remains a challenge. A method is proposed to identify relevant data to inform data-driven customisation. A case study regarding customisation of orthoses was conducted. Verbal protocol analysis was employed to extract time spent on major fabrication phases. Data related to patients, therapists and fabrication time was analysed. Results showed that the number of stabilised joints, experience of therapists and whether the design is for in- or out-patient are key factors for customisation.

<https://doi.org/10.1017/dsd.2020.105>

Wall, Johan; Aeddula, Omsri Kumar; Larsson, Tobias

Blekinge Institute of Technology, Sweden

DATA ANALYSIS METHOD SUPPORTING CAUSE AND EFFECT STUDIES IN PRODUCT-SERVICE SYSTEM DEVELOPMENT

A data analysis method aiming to support cause and effect analysis in design exploration studies is presented. The method clusters and aggregates effects of multiple design variables based on the structural hierarchy of the evaluated system. The resulting dataset is intended as input to a visualization construct based on colour-coding CAD models. The proposed method is exemplified in a case study showing that the predictive capability of the created, clustered, dataset is comparable to the original, unmodified, one.

<https://doi.org/10.1017/dsd.2020.123>



Heihoff-Schwede, Jörg; Kaiser, Lydia; Dumitrescu, Roman
Fraunhofer IEM, Germany

AN MBSE-BASED APPROACH FOR THE DEFINITION AND EVALUATION OF ENGINEERING IT ARCHITECTURES

As the complexity of the systems increases, so does the complexity of designing a suitable engineering IT architecture. Challenges reach from the definition of required and consistent functionalities and interfaces to the evaluation, which combination of IT tools fulfils the required functionality, usability and interoperability in the best way. Thus, we provide a procedure, methodology and modelling support for the definition of functional and logical engineering IT architectures and their holistic evaluation. The approach is part of an overall procedure and demonstrated in an example.

<https://doi.org/10.1017/dsd.2020.37>

Schöberl, Maximilian⁽¹⁾; Rebentisch, Eric⁽²⁾; Trauer, Jakob⁽¹⁾; Mörtl, Markus⁽¹⁾; Fottner, Johannes⁽¹⁾

¹Technical University of Munich, Germany; ²Massachusetts Institute of Technology, United States of America

EVALUATING MBSE POTENTIAL USING PRODUCT AND DEVELOPMENT CHARACTERISTICS – A STATISTICAL INVESTIGATION

As model-based systems engineering (MBSE) is evolving, the need for evaluating MBSE approaches grows. Literature shows that there is an untested assertion in the MBSE community that complexity drives the adoption of MBSE. To assess this assertion and support the evaluation of MBSE, a principal component analysis was carried out on eight product and development characteristics using data collected in an MBSE course, resulting in organizational complexity, product complexity and inertia. To conclude, the method developed in this paper enables organisations to evaluate their MBSE adoption potential.

<https://doi.org/10.1017/dsd.2020.277>

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¹Skolkovo Institute of Science and Technology, Russia; ²ISAE-SUPAERO, University of Toulouse, France



CONCURRENT CONCEPTUAL DESIGN SEQUENCING FOR MBSE OF COMPLEX SYSTEMS THROUGH DESIGN STRUCTURE MATRICES

Whilst Concurrent Conceptual Design (CCD) has been performed for many years at facilities such as: the Concurrent Design Facility at ESA and the Project Design Center at JPL-NASA, the sequencing know-how resides in their communities of practice. This paper strives to explain how a sequencing algorithm based on Design Structure Matrices can be used as an instrument to facilitate the interaction between disciplines during CCD studies for Model-Based systems exemplified with two case studies.

<https://doi.org/10.1017/dsd.2020.96>



Wyrwich, Christian; Jacobs, Georg; Siebrecht, Justus; Konrad, Christian
RWTH Aachen University, Germany

MODEL-BASED PRODUCT CONFIGURATION OF HIGH VARIETY PRODUCT PORTFOLIOS

Facing a rising competitive pressure, manufactures create advantages when they are able to offer customer-specific products to the conditions of a mass production article. Traditional configurators support the creation of personalized products from the elements of a modular product system, but are based on a pre-defined set of rules. The model based approach changes the environment of configuration from static configuration rules to the dependencies defined within the product's system model. So, by regarding target quantities of the user, the configurator identifies the optimal variant.

<https://doi.org/10.1017/dsd.2020.287>

Wäschle, Moritz⁽¹⁾; Martin, Alex⁽¹⁾; Radimersky, Aline⁽²⁾; Behrendt, Matthias⁽¹⁾; Albers, Albert⁽¹⁾

¹Karlsruhe Institute of Technology, Germany; ²Robert Bosch GmbH, Germany

SUPPORTING THE MODELLING IN MBSE BY APPLYING PRODUCT GENERATION ENGINEERING USING ELECTRONIC COMPACT ACTUATORS AS AN EXAMPLE

The development of a new motor can be a high effort. In this paper, Model-based Systems Engineering (MBSE) is applied to model the second generation of an electronic compact actuator (ECA). This paper focuses on the traceability between model elements from previous product generations. By integrating the approach of the PGE - Product Generation Engineering in MBSE, developers can store more relevant information in the model; they can accomplish automatic calculations of derived factors and build models more efficiently in further product developments.

<https://doi.org/10.1017/dsd.2020.293>



Pieroni, Marina P. P.; McAloone, Tim C.; Pigosso, Daniela C. A.
DTU-Technical University of Denmark, Denmark

DEFINING THE REQUIREMENTS FOR A TOOL TO SUPPORT CIRCULAR ECONOMY BUSINESS MODEL INNOVATION WITHIN MANUFACTURING COMPANIES

To implement circular economy, manufacturers will need to develop new business models. Available approaches are granular, generic, infrequently focusing on advice or implementation, and lacking practical demonstration. This article presents how a tool was proposed to cover these gaps. Based on design research methodology, twenty-two conceptual and practical requirements were identified and translated in functions for the development of the Circular Economy Business Model Configurator, a tool that supports manufacturers in strengthening proposals of business models for circular economy.

<https://doi.org/10.1017/dsd.2020.28>

<https://doi.org/10.1017/dsd.2020.339>

Kohl, Jonas Laurenz; van der Schoor, Michel Joop; Syré, Anne Magdalene; Göhlich, Dietmar
Technische Universität Berlin, Germany

SOCIAL SUSTAINABILITY IN THE DEVELOPMENT OF SERVICE ROBOTS

We introduce the concept of social sustainability, intertwined with ecological and economic aspects, to the field of service robots and comparable automation technology. It takes a first step towards a comprehensive guideline that operationalizes and applies social sustainability. By applying this guideline to the project MURMEL we offer a concept that collects and rates social key issues to visualize their individual importance. Social sustainability is an important and often overlooked aspect of sustainable technology development which should be considered in the early development phase.

<https://doi.org/10.1017/dsd.2020.59>

Saidani, Michael^(1,2); Kim, Harrison⁽¹⁾; Cluzel, François⁽²⁾; Leroy, Yann⁽²⁾; Yannou, Bernard⁽²⁾

¹University of Illinois at Urbana-Champaign, United States of America; ²CentraleSupélec, France

PRODUCT CIRCULARITY INDICATORS: WHAT CONTRIBUTIONS IN DESIGNING FOR A CIRCULAR ECONOMY?

This paper investigates and questions the relevance of product-centric circularity indicators in a product design context. To do so, reviews of eco-design tools and critical analyses of circularity indicators at the micro level of circular economy implementation are combined with a new workshop experimenting four of these indicators with the aim to improve the circularity performance of an industrial product. On this basis, the four tool-based circularity indicators tested are mapped on the engineering design and development process, and are positioned among the pool of main eco-design tools.

<https://doi.org/10.1017/dsd.2020.76>

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Villamil Velasquez, Carolina⁽¹⁾; Salehi, Niloufar⁽²⁾; Hallstedt, Sophie I.⁽¹⁾

¹Blekinge Institute of Technology, Sweden; ²KTH Royal Institute of Technology, Sweden

HOW CAN INFORMATION AND COMMUNICATIONS TECHNOLOGY SUPPORT THE LINK BETWEEN CIRCULAR ECONOMY AND PRODUCT LIFE CYCLE MANAGEMENT? – A REVIEW

Linear production is related to resource scarcity and negative environmental impacts. Circular Economy (CE) emerged for society transition towards sustainability, based on regenerative systems and multiple life cycle products. Product Life cycle Management (PLM) supports the whole life cycle with the aid of Information and Communication Technology (ICT). A literature review analyzed the role of ICT enabling CE based on PLM, identifying challenges and opportunities, active and passive PLM, system perspective, stakeholder's role, and sustainability. Concluding that ICT enables the CE transition.

<https://doi.org/10.1017/dsd.2020.299>

Huang, Siyuan^(1,2); Carulli, Marina⁽¹⁾; Hekkert, Paul⁽²⁾; Schifferstein, Rick N. J.⁽²⁾; Bordegoni, Monica⁽¹⁾

¹Politecnico di Milano, Italy; ²Delft University of Technology, The Netherlands

DESIGNING PRODUCT METAPHOR TO PROMOTE SUSTAINABLE BEHAVIOUR: A PROPOSED METHOD

Within the scope of Design for Sustainable Behaviour, the connection between behavioural change strategies and design idea generation has received limited attention. This paper highlights metaphorical thinking in product design to stimulate sustainable behaviour. In particular, the current study proposes a metaphor-based design method to guide designers on how to associate product features with behavioural and experiential cues through metaphors. We next report two design cases to evaluate this method. In the end, the shortcomings of current research and future developments are also discussed.

<https://doi.org/10.1017/dsd.2020.310>

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*Singh, Harshika⁽¹⁾; Cascini, Gaetano⁽¹⁾; McComb, Christopher⁽²⁾*¹Politecnico di Milano, Italy; ²The Pennsylvania State University, United States of America**ANALYSING THE EFFECT OF SELF-EFFICACY AND INFLUENCERS ON DESIGN TEAM PERFORMANCE**

Social media influencers (SMI) are gaining interest and many are studying their influence on the online audience, little is known about the role played by them in offline teams. One such attempt to study the effect of influencers in co-design team is presented in this paper, where individuals who are confident in their abilities drive the team process. Thus, self-efficacy is considered for determining influencer behaviour. Results expose the relationship between self-efficacy and influencer status on the design process, besides briefly highlighting the effects on above-average teams.

<https://doi.org/10.1017/dsd.2020.64>
*Lecuna Aguerrevere, Alejandro^(1,6); Alleblas, Joost⁽²⁾; Mueller, Roland M.^(3,4); Graves, Morganne⁽⁵⁾; Thoring, Katja^(2,6)*¹Hochschule für Technik und Wirtschaft Berlin, Germany; ²Delft University of Technology, The Netherlands; ³Berlin School of Economics and Law, Germany; ⁴University of Twente, The Netherlands; ⁵phi360, Germany; ⁶Anhalt University of Applied Sciences, Germany**THE IMPACT OF STATUS ANONYMITY ON TEAM DYNAMICS IN CO-CREATION WORKSHOPS**

This paper looks at the positive effects of partial status anonymity in face-to-face co-creation workshops. Results suggest that especially during the early phases of co-creation, i.e. idea generation, participants experience more freedom to express themselves without self-imposed barriers. We observed positive effects in terms of (1) lowering or even suspending the perceived status among team members, (2) increased motivation, (3) freedom to speak and positive disposition to listen, (4) willingness to consider perspectives from other team members.

<https://doi.org/10.1017/dsd.2020.305>
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*Song, Binyang⁽¹⁾; Soria Zurita, Nicolás F.^(1,2); Zhang, Guanglu⁽³⁾; Stump, Gary⁽¹⁾; Balon, Corey⁽¹⁾; Miller, Simon W.⁽¹⁾; Yukish, Michael⁽¹⁾; Cagan, Jonathan⁽³⁾; McComb, Christopher⁽¹⁾*¹The Pennsylvania State University, United States of America; ²Universidad San Francisco de Quito, Ecuador; ³Carnegie Mellon University, United States of America**TOWARD HYBRID TEAMS: A PLATFORM TO UNDERSTAND HUMAN-COMPUTER COLLABORATION DURING THE DESIGN OF COMPLEX ENGINEERED SYSTEMS**

Human-computer hybrid teams can meet challenges in designing complex engineered systems. However, the understanding of interaction in the hybrid teams is lacking. We review the literature and identify four key attributes to construct design research platforms that support multi-phase design, hybrid teams, multiple design scenarios, and data logging. Then, we introduce a platform for unmanned aerial vehicle (UAV) design embodying these attributes. With the platform, experiments can be conducted to study how designers and intelligent computational agents interact, support, and impact each other.

<https://doi.org/10.1017/dsd.2020.68>
*Knudsen, Line Sand⁽¹⁾; Haase, Louise Møller⁽¹⁾; Goncalves, Milene Guerreiro⁽²⁾*¹Aalborg University, Denmark; ²Delft University of Technology, The Netherlands**DESIGN RATIONALE IN CONCEPTUAL DESIGN: A LONGITUDINAL STUDY OF PROFESSIONAL DESIGN TEAMS' PRACTICE**

A design rationale is a representation of the reasoning behind a design concept, explaining why the solution is designed the way it is. This makes design rationale a critical part of concept development. However, there is little exploration on how to build a design rationale. This study sheds light on professional designers' reasoning in conceptual design, as we examine how design rationales for different concepts are built based on a longitudinal study in the context of two design studios. Particularly the study provides insight into how a design rationale is initiated, matured and finalized.

<https://doi.org/10.1017/dsd.2020.11>
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Lüneburg, Lisa-Marie; Papp, Emese; Krzywinski, Jens
Technische Universität Dresden, Germany

THE POTENTIAL OF WEARABLE DEMONSTRATORS INTRODUCING INNOVATIVE TECHNOLOGIES

With the introduction of '5G' data transfer gets faster and further reaching than ever before. This new communication technology paves the way for an exchange of skills and competencies between humans and machines. This raises the question of how future users can profit and understand the potential brought about by these technologies. This paper elaborates the use of demonstrators in a pilot study as research tools and assesses their potential. It gives first insights why demonstrators are suitable to set a basis for public recognition for body-worn CPS and how to promote innovative visions.

<https://doi.org/10.1017/dsd.2020.306>

Ciccone, Nicholas⁽¹⁾; Patou, François⁽¹⁾; Komashie, Alexander⁽³⁾; Lame, Guillaume⁽²⁾; Clarkson, P. John⁽³⁾; Maier, Anja M.⁽¹⁾

¹DTU-Technical University of Denmark, Denmark; ²University of Cambridge, United Kingdom; ³THIS.Institute, United Kingdom

HEALTHCARE SYSTEMS DESIGN: A SANDBOX OF CURRENT RESEARCH THEMES PRESENTED AT AN INTERNATIONAL MEETING

Healthcare systems are under strain, this creates a challenge for designers to develop solutions for better health and care delivery. This paper presents a sandbox of illustrative design themes used to improve health systems based on state of the art research projects. These were collated from presentations at The Second International Meeting on Healthcare Systems Design Research, held at DTU-Technical University of Denmark. Attending groups were mapped based on their research keywords, target journals and methodologies in order to gain insight on the communities research landscape.

<https://doi.org/10.1017/dsd.2020.24>

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Wilke, Hannes⁽¹⁾; Badke-Schaub, Petra⁽²⁾; Thoring, Katja^(1,2)

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THE HEALTHCARE DESIGN DILEMMA: PERILS OF A TECHNOLOGY-DRIVEN DESIGN PROCESS FOR MEDICAL PRODUCTS

This paper reports an embedded single case study from a globally operating manufacturer for digital healthcare products. Based on nine semi-structured interviews, document analysis, and a diary study among employees, we were able to gain insights on the daily business routines and interactions of the design team, the UX research team, and the product management department. The results revealed several unexpected insights that indicate a practical mismatch between user-centred design processes learned from the textbook and design practice in the healthcare sector that warrant further research.

<https://doi.org/10.1017/dsd.2020.133>

Hein, Andreas Makoto; Lamé, Guillaume

CentraleSupélec, France

EVALUATING ENGINEERING DESIGN METHODS: TAKING INSPIRATION FROM SOFTWARE ENGINEERING AND THE HEALTH SCIENCES

Engineering design methods are typically evaluated via case studies, surveys, and experiments. Meanwhile, domains such as the health sciences as well as software engineering have developed further powerful evaluation approaches. The objective of this paper is to show how evaluation approaches from the health sciences and software engineering might further the evaluation of engineering design methods. We survey these approaches and show which approaches could be transferred to the evaluation of engineering design methods.

<https://doi.org/10.1017/dsd.2020.317>



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Garrelts, Enno; Roth, Daniel; Binz, Hansgeorg
University of Stuttgart, Germany

FUNCTIONAL MODELING IN THE DESIGN OF ADDITIVELY MANUFACTURED COMPONENTS

This contribution investigates how methods for functional modeling support designers with additive manufacturing. Therefore, two methods for functional modeling are examined. In this contribution a study with 32 participants is presented. The participants solved two consecutive design tasks, in which some participants were supported by functional modeling methods in the second task. The study shows that students have the most difficulties in dealing with the geometric restrictions of Laser Beam Melting (LBM). Furthermore, the support value of functional modeling was not able to be assessed.

<https://doi.org/10.1017/dsd.2020.258>

Borgue, Olivia⁽¹⁾; Valjak, Filip⁽²⁾; Panarotto, Massimo⁽¹⁾; Isaksson, Ola⁽¹⁾
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SUPPORTING ADDITIVE MANUFACTURING TECHNOLOGY DEVELOPMENT THROUGH CONSTRAINT MODELLING IN EARLY CONCEPTUAL DESIGN: A SATELLITE PROPULSION CASE STUDY

Function and constraints modelling are implemented to design two gridded ion thrusters for additive manufacturing (AM). One concept takes advantage of AM design freedom, disregarding AM limitations and is not feasible. The other concept considers AM limitations and is manufacturable and feasible. Constraints modelling highlights AM capabilities that can be improved, showing where future investment is needed. Constraints representation can also support the creation of technology development roadmaps able to identify areas of AM technologies that must be improved.

<https://doi.org/10.1017/dsd.2020.289>

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Valjak, Filip⁽¹⁾; Bojčetić, Nenad⁽¹⁾; Nordin, Axel⁽²⁾; Godec, Damir⁽¹⁾
¹University of Zagreb, Croatia; ²Lund University, Sweden

CONCEPTUAL DESIGN FOR ADDITIVE MANUFACTURING: AN EXPLORATIVE STUDY

With the broader industrial application of Additive Manufacturing (AM), designers are facing new challenges in conceptual design for AM. To better understand the problematic, the authors organised a design workshop with six experts in AM. The paper presents the results of the conducted design workshop and discusses the current and future trends in research on the conceptual design for AM.

<https://doi.org/10.1017/dsd.2020.307>

Montero, Joaquin^(1,2); Weber, Sebastian^(1,2); Bleckmann, Matthias⁽²⁾; Paetzold, Kristin⁽¹⁾

¹Bundeswehr University Munich, Germany; ²Bundeswehr Research Institute for Materials, Fuels and Lubricants, Germany

RE-DESIGN OF ADDITIVE MANUFACTURED SPARE PARTS BASED ON FEATURES CLASSIFICATION

Additive Manufacturing is doing its first steps in the production of spare parts. Usually the spares belong to legacy systems, and the tooling to produce them is no longer available. Re-designing spares that are designed for a previous industry mindset can be sometimes challenging. In this study a rather classic design approach is compared to a functional driven approach. Four case studies from different clients are reported, remarking the benefits and drawbacks of using design for additive manufacturing practices in Laser Powder Bed Fusion.

<https://doi.org/10.1017/dsd.2020.168>

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Anacker, Harald; Dumitrescu, Roman; Kharatyan, Aschot; Lipsmeier, Andre
Fraunhofer IEM, Germany

PATTERN BASED SYSTEMS ENGINEERING – APPLICATION OF SOLUTION PATTERNS IN THE DESIGN OF INTELLIGENT TECHNICAL SYSTEMS

For the development of intelligent technical systems, Systems Engineering and Solution Patterns are the guarantee for success. In order to avoid cost-intensive iterations, the documentation and reuse of solution knowledge is addressed during the systems design. Using an interdisciplinary specification technique, a uniform structuring of Solution Patterns as well as the composition in a multidimensional knowledge space takes place. This is the basis of an associated systematics for a solution pattern-based system design of mechatronic systems, which is validated by two cooperating DeltaRobots.

<https://doi.org/10.1017/dsd.2020.107>

Müller, Jakob Ramon; Siiskonen, Maria Daniela Irene; Malmqvist, Johan
Chalmers University of Technology, Sweden

LESSONS LEARNED FROM THE APPLICATION OF ENHANCED FUNCTION-MEANS MODELLING

Although well researched and praised in academic publications, function modelling (FM) does not have gained much traction in industrial application. To investigate into possible reasons for this, this publication researches literature of nine different projects where enhanced function-means modelling has been applied. The projects are analysed for their purpose of FM-use, applied benefits and discovered challenges of the FM approach. From this, the main challenges for FM application are the abstraction level of the modelling language as well as the lack of an interface to CAD modelling.

<https://doi.org/10.1017/dsd.2020.87>

Gopsill, James ⁽¹⁾; Humphrey, Mark ⁽²⁾; Thompson, Dan ⁽²⁾; Garcia, Enrique ⁽²⁾
¹University of Bath, United Kingdom; ²National Composites Centre, United Kingdom

CO-WORD GRAPHS FOR DESIGN AND MANUFACTURE KNOWLEDGE MAPPING

Design & Manufacture Knowledge Mapping is a critical activity in medium-to-large organisations supporting many organisational activities. However, techniques for effective mapping of knowledge often employ interviews, consultations and appraisals. Although invaluable in providing expert insight, the application of such methods is inherently intrusive and resource intensive. This paper presents word co-occurrence graphs as a means to automatically generate knowledge maps from technical documents and validates against expert generated knowledge maps.

<https://doi.org/10.1017/dsd.2020.94>

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Kolarić, Siniša ⁽¹⁾; Beck, Jordan ⁽²⁾; Stolterman, Erik ⁽³⁾

¹Georgia Institute of Technology, United States of America; ²Milwaukee School of Engineering, United States of America; ³Indiana University, United States of America

ON THE HIERARCHICAL LEVELS OF DESIGN KNOWLEDGE

Hierarchies of knowledge represent a popular formalism for conceptualizing beliefs, justifications, and truth statements. To capitalize on the opportunity for formulating effective maps of design knowledge, this article introduces the hierarchical context–design development–high-level (CDH) model that stratifies different bodies of design-specific knowledge into ranked levels. We compare it with existing hierarchical models of knowledge, and describe its unique uses and benefits for both design research and design practice.

<https://doi.org/10.1017/dsd.2020.330>

Wolniak, Philipp; Sauthoff, Bastian; Kloock-Schreiber, Daniel; Lachmayer, Roland
Leibniz Universität Hannover, Germany

AUTOMATED PRODUCT FUNCTIONALITY AND DESIGN OPTIMIZATION INSTANCING A PRODUCT-SERVICE SYSTEM

When using product-service systems as a business model, new product development challenges and opportunities arise. Due to the possibility of customizing the product fleet depending on the user-scenarios, more product variants are possible and often necessary. Therefore, this paper presents an approach for the automated functionality and design optimization for user scenario specific use cases. The approach combines an optimization framework with a functional simulation model and a generative design approach CAD model. This results in a robust and simultaneously flexible design environment.

<https://doi.org/10.1017/dsd.2020.323>

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Wehlin, Camilla; Persson, Johan Alexander; Ölvander, Johan
Linköping University, Sweden



MULTI-OBJECTIVE OPTIMIZATION OF HOSE ASSEMBLY ROUTING FOR VEHICLES

This paper presents a method for multi-objective optimization of hose assembly routing. Hose routing is a non-trivial task which demand a lot of iterations, especially with the increased complexity in modern vehicles. The proposed method utilizes design automation through multi-objective optimization of routing assemblies containing multiple hoses. The method is intended as a decision support and automation-tool, that reduces the number of iterations needed. The method has been implemented and tested on a case, concerning a set of hoses in an engine compartment, showing credible results.

<https://doi.org/10.1017/dsd.2020.267>

Brahma, Arindam; Wynn, David C.
The University of Auckland, New Zealand

CALCULATING TARGET THRESHOLDS FOR THE MARGIN VALUE METHOD USING COMPUTATIONAL TOOLS

Overspecification or excess margin in a design can enhance its ability to absorb changes and uncertainty, but also deteriorates performance criteria such as weight and cost. This paper shows how the Margin Value Method (article in review) can be applied in conjunction with CAE tools such as FEA to quantify excess margin where a design is too complex for algebraic analysis. This new application context for the MVM is illustrated using a case study of a flange coupling design, in which topology optimisation is used within the MVM to identify opportunities for design improvement.

<https://doi.org/10.1017/dsd.2020.66>

Sanchez, Josefin; Björkman, Zachris; Otto, Kevin N.
Aalto University, Finland

ROBUSTNESS IMPROVEMENT USING OPEN SOURCE CODE LIBRARIES

Computer tools are commonly used to assess designs. We develop a toolchain using open source code libraries in Python to provide an open source, interactive robust design improvement toolchain. A reference folder contains a script that reads an input parameter value file and runs the simulation. The toolchain executes uncertainty quantification steps by replicating the reference folder. This is repeated for design points, and mean and sigma graphs generated versus each design variable. This fits within a workflow of defining variation modes, design variables, and toolchain execution.

<https://doi.org/10.1017/dsd.2020.82>

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Juul-Nyholm, Herle Bagh⁽¹⁾; Eifler, Tobias⁽¹⁾; Ebro, Martin⁽²⁾

¹DTU-Technical University of Denmark, Denmark; ²Novo Nordisk A/S, Denmark

ROBUST DESIGN FOR IOT – ON THE RELEVANCE OF MECHANICAL DESIGN FOR ROBUST SENSOR INTEGRATION IN CONNECTED DEVICES

The terms IoT and Industry 4.0 are promising increasingly sophisticated solutions, but the realisation will depend on the inclusion of robust and reliable sensors. If the gathered data is flawed or inaccurate the performance of the whole system will be compromised. By reviewing research on robustness indicators, mechatronics and sensor properties as well as listing mechanical noise factors and providing an electromechanical trade-off example, the paper highlights the importance of considering both mechanical and electrical noise factors and robustness in early development of connected devices.

<https://doi.org/10.1017/dsd.2020.326>

Campean, Felician⁽¹⁾; Delaux, David⁽²⁾; Sharma, Sanjiv⁽³⁾; Bridges, Jonathan⁽¹⁾

¹University of Bradford, United Kingdom; ²Valeo, France; ³Airbus, United Kingdom

RELIABILITY RESEARCH ROADMAPPING WORKSHOP: IMPLICATIONS FOR ENGINEERING DESIGN

Transportation industries are the centrepiece for some remarkable transformations driven by technology development and innovation. However, we have seen limited advances on methods to address reliability and resilience challenges emerging with increasingly complex systems and environments. This paper presents the outcomes of an European Reliability Research Roadmapping workshop, collating the views of automotive, aerospace and defence industries to identify current reliability challenges and research gaps and to define directions for future research and skills development.

<https://doi.org/10.1017/dsd.2020.337>

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AI MODELS FOR CREATIVE DESIGN: CURIOSITY, NOVELTY, AND SURPRISE

Professor Mary Lou Maher

Chair of Software and Information Systems, Director at the Center for Education Innovation, UNC Charlotte, USA



The development of AI models for creative design has been inspired by psychological and cognitive studies of human creativity. Early AI models included analogical reasoning, emergence, reinforcement learning, and evolution. Recent developments in machine learning from large datasets of words and images has enabled a new approach that is based on operations in a latent space that emerge from deep learning. We can now measure the novelty and surprise in a latent space that can be the basis for encouraging curiosity and creativity in design. This trajectory in artificial intelligence coupled with HCI approaches to supporting human creativity, has led to a new kind of creative system: co-creative design systems. In a co-creative system, the computational system contributes to the design by encouraging curiosity and creativity in the human partner. This presentation will trace the evolution of AI-based creative design and the significance of new deep learning models for curiosity, novelty, and surprise. The implementation and evaluation of the Creative Sketching Partner will be described in which computational conceptual shifts that use word embedding and image models are computed to present the designer with sketches that encourage the designer's creativity. The results of user studies show that such conceptual shifts inspire different kinds of creativity depending on how similar or different the system's sketch is from the designer's sketch.

BIOGRAPHICAL SKETCH

Mary Lou Maher is Professor and Chair of Software and Information Systems at UNC Charlotte. She completed a Bachelor of Engineering at Columbia University and a MS and PhD at Carnegie Mellon University. She has been a Professor at Carnegie Mellon University, MIT, Columbia University, University of Maryland, and University of Sydney in Australia. She was a member of the Senior Executive Service at the National Science Foundation. Dr. Maher's current research interests include AI and cognitive models of curiosity and creative design.

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Wendrich, Robert E.

University of Twente, The Netherlands

CREATIVE THINKING: COMPUTATIONAL TOOLS IMBUED WITH AI

This paper presents a test bed for AI technology on the integration of creative AI (CAI) with hybrid design tools (HDTs). The objective is to build and develop tools and programs for creative people (e.g. designers, engineers) to use, whereby the artificial intelligence (AI) software acts as a creative collaborator rather than a mere tool. The goal is to find a set of guiding principles, metaphors and ideas that inform the development of a CAI praxis imbued with computational support tools, new theories, experiments, and applications. Results and findings are presented of early-stage research.

<https://doi.org/10.1017/dsd.2020.7>

Puentes, Lucas ⁽²⁾; Raina, Ayush ⁽¹⁾; Cagan, Jonathan ⁽¹⁾; McComb, Christopher ⁽²⁾

¹Carnegie Mellon University, United States of America; ²The Pennsylvania State University, United States of America

MODELING A STRATEGIC HUMAN ENGINEERING DESIGN PROCESS: HUMAN-INSPIRED HEURISTIC GUIDANCE THROUGH LEARNED VISUAL DESIGN AGENTS

Human designers often work in a visual design space, projecting step-by-step design progression through evolving mental images. The strategic evolution of that design leverages heuristics based on experience and domain knowledge. The methodology presented in this paper brings together the visual nature of design problem solving and design heuristics in a deep learning computational agent framework that emulates and enables human-mirrored design. When applied to a truss design task, results demonstrate superior results to those of human designers who provided the initial data.

<https://doi.org/10.1017/dsd.2020.42>

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Schleibaum, Sören ⁽¹⁾; Kehl, Stefan ⁽²⁾; Stiefel, Patrick ⁽²⁾; Müller, Jörg P. ⁽¹⁾

¹Technische Universität Clausthal, Germany; ²Volkswagen AG, Germany

TOWARDS AUTOMATED CLASSIFICATION OF PRODUCT DATA BASED ON MACHINE LEARNING

Modern machine learning methods have the potential to supply industrial product lifecycle management (PLM) with automated classification of product components. However, there is only little work in the literature on this topic. We propose to apply supervised machine learning on component meta-data. By analysing an industrial case study, we identify requirements and opportunities for automating classification, e.g. in part numbers and product structures. We validate our novel approach through a classification experiment comparing four machine learning methods on a realistic component dataset.

<https://doi.org/10.1017/dsd.2020.139>

Le, Meile; Jung, Eui-Chul

Seoul National University, Republic of Korea

ANALYSIS OF INTENT-DESIGN RELATIONSHIP FOR ARTIFICIAL INTELLIGENCE DESIGN AGENT MODEL BASED ON PRODUCT PURCHASING PROCESS

This study aims at proposing an AI-agent model that helps designers to understand and interpret clients' intent and create customized design outcomes. We recorded and analysed the purchasing process of collecting product information, selecting alternative products and making decision to understand the influence of artefacts on the client's intent during the purchasing process and collect the basic data for proposing an AI-agent model. We analysed the process by Linkography and found the relationship between the decision-making patterns and the artefacts that presented by the AI-agent.

<https://doi.org/10.1017/dsd.2020.146>

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TUE



Pilz, Fabian; Vajna, Sándor; Schabacker, Michael
Otto von Guericke University Magdeburg, Germany

ACHIEVING SIMPLICITY: A CONSIDERATION OF A SYSTEMATIC APPROACH

Design principles from the field of design engineering require that a product be designed as unambiguous, safe and simple as possible. Simplicity results on the one hand from an objective product-relevant side, on the other hand from the experience and knowledge of the user. A product that is perceived as simple by one person may seem complicated to another. From this, the questions arise, with which attributes simplicity can be described and how these are to be captured. In this paper, an evaluation system for the subjective attributes of simplicity is created using the fuzzy sets approach.

<https://doi.org/10.1017/dsd.2020.291>

El Fassi, Soufiane; Guenov, Marin D.; Riaz, Atif
Cranfield University, United Kingdom

AN ASSUMPTION NETWORK-BASED APPROACH TO SUPPORT MARGIN ALLOCATION AND MANAGEMENT

Presented is an approach to support margin allocation and management via a graph-theoretical network of assumptions. In contrast to the document-centric approach, the network captures assumptions dependencies, and enables an algorithmic process supporting margin allocation and management. Ultimately, this methodology is intended to assist decision-makers in managing assumptions and examining their impact on an architecture. Explicitly linking margins to assumptions allows to support mitigating their risk of invalidity. The approach is demonstrated with a conceptual aircraft design example.

<https://doi.org/10.1017/dsd.2020.25>

Mora, Bartomeu; Retolaza, Iban; Campos, Mikel Alberto; Remirez, Adrian; Cabello, Mario javier; Martinez, Felix
IKERLAN, Spain

DEVELOPMENT OF A NEW DESIGN METHODOLOGY FOR LARGE SIZE PRODUCTS BASED ON DSM AND DFMA

A new design methodology for long life and large size (LI-Ls) products called Design for Installation (DfI) is proposed. LI-Ls products are usually made up of large parts that need to be assembled on field. The proposed methodology, based on adapted Design Structure Matrix (DSM) and Design for Manufacturing and Assembly (DfMA) methods, enables to optimize the design of a LI-Ls product in order to reduce time and cost of the installation process. The new methodology works with a conceptual design of the product and the weight and size restrictions given by logistic factors as inputs.

<https://doi.org/10.1017/dsd.2020.2>

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Idrissov, Agzam ⁽¹⁾; Škec, Stanko ⁽²⁾; Maier, Anja M. ⁽¹⁾

¹DTU-Technical University of Denmark, Denmark; ²University of Zagreb, Croatia

VISUALISING SYSTEMS: MAPPING SYSTEM FEATURES AND INTERACTIVE INFORMATION VISUALISATIONS IN DESIGN

Interactive computer-supported information visualisations are being increasingly used in design. However, while there are frameworks that discuss how traditional representations, such as sketches, CAD models and static diagrams support design tasks, no such mapping exists for interactive visualisations of product-related information. As novel contributions, this paper reviews the design literature for the use of information visualisations. Moreover, using systems theory and Gestalt principles, insights on the applicability of such information visualisations for various design tasks are given.

<https://doi.org/10.1017/dsd.2020.138>

Albers, Albert; Rapp, Simon; Fahl, Joshua; Hirschter, Tobias; Revfi, Sven; Schulz, Micha; Stürmlinger, Tobias; Spadinger, Markus
Karlsruhe Institute of Technology, Germany

PROPOSING A GENERALIZED DESCRIPTION OF VARIATIONS IN DIFFERENT TYPES OF SYSTEMS BY THE MODEL OF PGE – PRODUCT GENERATION ENGINEERING

The model of PGE describes the emergence of new systems based on reference by the activities carryover, embodiment and principle variation - qualitatively different manifestations of a transfer process. We investigate indicators which constitute these different manifestations measurably for different types of systems. We propose generalized variation operators to describe system development with respect to different product elements and system types. We use case studies from automotive, production systems and simulation models.

<https://doi.org/10.1017/dsd.2020.315>

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Fakhfakh, Sarra ^(1,2); Hein, Andreas Makoto ⁽¹⁾; Jankovic, Marija ⁽¹⁾; Chazal, Yann ⁽²⁾
¹CentraleSupélec, France; ²Groupe Renault, France

A META-MODEL FOR PRODUCT SERVICE SYSTEMS OF SYSTEMS

A Product Service System of Systems (PSSoS) is a set of products, services, infrastructure, and a network where its constituent elements exhibit operational and managerial independence. As such, a PSSoS shows PSS characteristics of heterogeneity and evolvability and SoS characteristics of emergence and diversity. Neither existing PSS nor SoS development approaches fully address these characteristics. Thus, PSSoS development raises new challenges. In this paper, we propose a PSSoS meta-model that integrates PSS and SoS key concepts, to provide a basis for future PSSoS development methods.

<https://doi.org/10.1017/dsd.2020.48>

Schneider, Jannik Alexander ⁽¹⁾; Gatzen, Matthias M. ⁽²⁾; Lachmayer, Roland ⁽¹⁾
¹Leibniz Universität Hannover, Germany; ²Baker Hughes, United States of America

THE IMPORTANCE OF CONSIDERING FLEET SIZE IN THE LIFECYCLE COST ANALYSIS OF PRODUCT SERVICE SYSTEMS

The use of product-service systems business models is increasing in today's economy. Because the products that provide the service to the customers incur cost during their lifetime, the method of lifecycle costing finds wide-spread use. However, this paper shows the current methods have some inaccuracies when determining lifecycle costs. The methods do not consider the required number of products necessary to provide the offered service to the customers. This paper describes a new framework for lifecycle costing that includes these cost components.

<https://doi.org/10.1017/dsd.2020.284>

Fernandes, Sania da Costa ^(1,2); Pigosso, Daniela C. A. ⁽²⁾; McAloone, Tim C. ⁽²⁾; Rozenfeld, Henrique ⁽¹⁾

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VALUE PROPOSITION OF PRODUCT-SERVICE SYSTEMS: AN EXPERIMENTAL STUDY TO COMPARE TWO DIFFERENT DESIGN APPROACHES

The development of product-service systems (PSS) requires the design of value propositions, which involves challenging activities. In the context of business model innovation, gamification is presented as a practical mechanism to support the design process. This study aims to create a prototype of a gamified approach to design PSS value propositions and to compare its application to a traditional design approach. Based on a design experiment, the advantages and problems for both approaches were evaluated, providing insights for further development of the new version of the gamified approach.

<https://doi.org/10.1017/dsd.2020.84>

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Mitake, Yuya; Hiramitsu, Kenshiro; Nagayama, Atsuto; Muraoka, Naoki; Sholihah, Mar'atus; Shimomura, Yoshiki
Tokyo Metropolitan University, Japan

A CONCEPTUAL FRAMEWORK OF PRODUCT-SERVICE SYSTEMS DESIGN FOR SUSTAINABILITY TRANSITIONS

Product-service systems (PSSs) are regarded as one of the promising ways to contribute to a sustainable society. Despite the well-developed knowledge, PSS design lack of long-term perspective to treat related changes and uncertainties. To address this issue, this paper proposes a conceptual framework of sustainable PSS design for sustainability transition by integrating insight from design approach for system innovation and transition. Applicability of the proposed framework is illustrated through application to exsample of PSS development project for wildlife nuisance in a suburban city.

<https://doi.org/10.1017/dsd.2020.110>

Ruvald, Ryan; Larsson, Andreas; Johansson Askling, Christian; Bertoni, Alessandro
Blekinge Institute of Technology, Sweden

PSS DESIGN INNOVATION: PROTOTYPING IN PRACTICE

Heavy equipment manufacturers recognise an opportunity to realise customer value gains through offering new Product-Service Systems. Such transition implies a radical shift in how new systems are designed. Based on a set of interviews the paper investigates how radical PSS innovation can be enabled by the use of physical prototypes as boundary object to navigate early PSS design ambiguity. On such basis, suggestions for augmenting existing support tools are made in relation to the existing literature.

<https://doi.org/10.1017/dsd.2020.180>

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Herrmann, Thorsten; Roth, Daniel; Binz, Hansgeorg
University of Stuttgart, Germany

FRAMEWORK OF AN AMBIDEXTROUS PROCESS OF IDEA MANAGEMENT SUPPORTING THE DOWNSTREAM PRODUCT DEVELOPMENT PROCESS

One challenge within idea management of the front end of the design process is the handling of radical ideas, meaning ideas with a high degree of novelty. Companies are approaching radical and incremental ideas frequently with the same methods, although many reasoned claims exist for treating ideas differently according to the degree of novelty. The paper aims to address the fact that ambidexterity does not play any specific role in the front end. Therefore, a framework of an extended idea process model based on the idea of ambidexterity is shown and initial test results are presented.

<https://doi.org/10.1017/dsd.2020.10>

Hu, Xinhui⁽¹⁾; Georgiev, Georgi V.⁽¹⁾; Casakin, Hernan⁽²⁾

¹University of Oulu, Finland; ²Ariel University, Israel

MITIGATING DESIGN FIXATION WITH EVOLVING EXTENDED REALITY TECHNOLOGY: AN EMERGING OPPORTUNITY

Design fixation refers to the designers' inability to avoid becoming stuck with preexisting ideas in order to generate new ones. With the recent fast advancements and developments, XR has emerged as a powerful promising technology that can shed new light on this issue. Consequently, this paper aims at: ⁽¹⁾ investigating the underlying mechanisms of design fixation as reported in literature; ⁽²⁾ exploring the state-of-art in the use of XR technology in design; and ⁽³⁾ identifying ways to mitigate design fixation by employing XR technology.

<https://doi.org/10.1017/dsd.2020.91>

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Singh, Harshika; Becattini, Niccolo; Cascini, Gaetano
Politecnico di Milano, Italy

DO ALL CREATIVE STIMULI WORK THE SAME? INSIGHTS FROM A WORKSHOP WITH PROFESSIONALS

The paper presents a comparative study that explores the effectiveness of creative stimuli to foster the generation of creative ideas in non-trained professionals during a co-creative design session. Solution-related stimuli (e.g. patents or biological strategies) are confronted with problem-based stimuli (e.g. TRIZ contradictions or Ideal Final Result), which are less studied in the literature. The 40 participants to the experimental activity benefited from both kind of stimuli, but the solution-related ones allowed a more comprehensive exploration of the design space.

<https://doi.org/10.1017/dsd.2020.177>

Nielsen, Camilla K. E. B. B.; Daalhuizen, Jaap; Cash, Philip

DTU-Technical University of Denmark, Denmark

EXPLORING HOW EXPERT BEHAVIOURAL DESIGNERS IDEATE IN THE BEHAVIOURAL DESIGN SPACE

Behavioural design is a critical means to address challenges surrounding human behaviour. However, practitioners and researcher face difficulties in synthesising relevant perspectives from across fields as behavioural challenges are complex and multi-dimensional. Taking a theory-building approach, this study explores how expert behavioural designers navigate in this complex design space by examining the creative outcome of their current ideation practice. The findings reveal that the designers favour 'holding' out of the four identified ideation patterns: holding, shifting, pairing, and mixing.

<https://doi.org/10.1017/dsd.2020.97>

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Yoshioka, Kiyomi
Meisei University, Japan

DEVELOPMENT AND CLINICAL STUDY OF A PROJECTION IMAGES PROGRAM TO ENCOURAGE ARM MOVEMENTS FOR REHABILITATION

In a program we developed called "Let's keep wiping to draw pictures!", projected graphic images change according to rehabilitation movements for upper limbs, and the levels of exercise amount and quality of movement achieved by patients are reflected in the outcome of the artwork as feedback. At a rehabilitation hospital, inpatients who used the program to perform rehabilitation exercises showed higher levels of satisfaction and expectation in the exercises, and performed simple and repetitive movements more willingly. The program can expect to maintain motivation towards rehabilitation.

<https://doi.org/10.1017/dsd.2020.3>

Feldman, Alix Nessa; Patou, François; Maier, Anja M.
DTU-Technical University of Denmark, Denmark

FROM EVIDENCE TO IMPLEMENTATION: HOW SYSTEMS DESIGN CAN FORESEE COMPLEX HEALTHCARE INTERVENTIONS

How can we design and engineer research that leads to the development and effective implementation of complex healthcare interventions? We advocate for a systems design-based approach when initiating clinical research to anticipate the proposition of complex interventions. Using cognitive care as an example, we investigate how hybrid design-inspired methodologies can promote organisational effectiveness and how strong clinical evidence can support successful conceptualisation and uptake of novel interventions into routine clinical practice.

<https://doi.org/10.1017/dsd.2020.135>

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Komashie, Alexander ^(1,2); Clarkson, P. John ⁽¹⁾

¹University of Cambridge, United Kingdom; ²THIS.Institute, United Kingdom

REQUIREMENTS FOR DIAGRAMING IN THE DESIGN OF MENTAL HEALTH DELIVERY SERVICES

Delivering good quality mental health services remains a top priority in the English National Health Service (NHS). An approach to designing better delivery systems that takes into account the complexities of mental health services is highly desirable. This paper follows previous work that have sought to identify the key components of mental health delivery systems and explored the nature of the relationships between them. The paper presents the results of a qualitative thematic analysis of the requirements for diagrams as tools for describing and representing delivery systems in mental health.

<https://doi.org/10.1017/dsd.2020.166>

Aflatoony, Leila; Lee, Su Jin
Georgia Institute of Technology, United States of America

CODEA: A FRAMEWORK FOR CO-DESIGNING ASSISTIVE TECHNOLOGIES WITH OCCUPATIONAL THERAPISTS, INDUSTRIAL DESIGNERS, AND END-USERS WITH MOBILITY IMPAIRMENTS

There are currently limited guidelines on how to design complex assistive technologies (ATs), which necessitates expertise beyond that possessed by designers, occupational therapists (OTs), or end-users. To address this issue, we conducted a series of four participatory workshops to study various configurations of OT-designer-user collaboration in co-designing do-it-yourself (DIY) ATs for an older adult with mobility impairment. We then proposed a specific co-design framework for such OT-designer-user collaboration.

<https://doi.org/10.1017/dsd.2020.332>

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Weber, Sebastian ^(1,2); Montero, Joaquin ^(1,2); Bleckmann, Matthias ⁽²⁾; Paetzold, Kristin ⁽¹⁾

¹Bundeswehr University Munich, Germany; ²Bundeswehr Research Institute for Materials, Fuels and Lubricants, Germany

PARAMETERS ON SUPPORT STRUCTURE DESIGN FOR METAL ADDITIVE MANUFACTURING

The topic of support structure design in the Design for Additive Manufacturing (DfAM) field is not addressed with the same relevance as the topic of part design. Therefore, this contribution investigates parameters for both the manufacturing and support structure design for the Laser Powder Bed Fusion (L-PBF) process. Matrices for cause-effect-relations of manufacturing and design parameters on build properties as well as correlations of them are presented. Based on these, recommendations for actions for experimental procedures are derived following the Design of Experiments method.

<https://doi.org/10.1017/dsd.2020.14>

Letov, Nikita; Zhao, Yaoyao Fiona

McGill University, Canada

VOLUMETRIC CELLS: A FRAMEWORK FOR A BIO-INSPIRED GEOMETRIC MODELLING METHOD TO SUPPORT HETEROGENEOUS LATTICE STRUCTURES

Current geometrical modelling approaches are unable to handle complex geometrical objects such as heterogeneous lattice structures. In this work, a framework for a novel bio-inspired geometric modelling method is proposed. The method can potentially support geometric modelling of heterogeneous lattice structures. The method utilises discretisation algorithms that are based on cell division processes encountered in nature. The method is verified on two 2D use-cases.

<https://doi.org/10.1017/dsd.2020.164>

Steffan, Kay-Eric Werner Heinz; Fett, Michel; Kirchner, Eckhard

Technische Universität Darmstadt, Germany

EXTENDED APPROACH TO OPTIMIZE MODULAR PRODUCTS THROUGH THE POTENTIALS OF ADDITIVE MANUFACTURING

In modular products conflicting objectives may occur. This leads to characteristics as component-dependent oversizing and undersizing as well as increased complexity of the interfaces. These conflicts can be resolved using the potentials of AM processes. For the best use possible, the potentials are systematically considered in the early design phases as part of an extended procedure. The extended procedure improves the benefit-effort ratio of modular respectively individual products and a further optimization of the product architecture and consideration of synergy effects is achieved.

<https://doi.org/10.1017/dsd.2020.172>



Nordin, Axel

Lund University, Sweden

AN APPROACH FOR TOPOLOGY OPTIMIZATION-DRIVEN DESIGN FOR ADDITIVE MANUFACTURING

This paper describes an approach for designing lightweight components produced through additive manufacturing (AM). Lightweight design is often done through topology optimization (TO). However, the process of manually interpreting mesh-based and imprecise results from a TO into a geometry that fulfils all requirements is complex. To aid in this process, this paper suggest an approach based on combining overhang-constrained TO with lattice-based TO to automate complex tasks, retain parametric control, and to minimize manufacturing cost. The approach is validated through a benchmark part.

<https://doi.org/10.1017/dsd.2020.112>

Orabona, Alessandro; Palazzi, Antonio; Graziosi, Serena; Ferrise, Francesco; Bordegoni, Monica

Politecnico di Milano, Italy

DESIGN OF A SIMPLIFIED 3D-PRINTED ARTIFICIAL UNDERACTUATED HAND

The recent interest in human-robot interaction requires the development of new gripping solutions, compared to those already available and widely used. One of the most advanced solutions in nature is that of the human hand, and several research contributions try to replicate its functionality. Technological advances in manufacturing technologies and design tools are opening possibilities in the design of new solutions. The paper reports the results of the design of an underactuated artificial robotic hand, designed by exploiting the benefits offered by additive manufacturing technologies.

<https://doi.org/10.1017/dsd.2020.311>





Japs, Sergej; Kaiser, Lydia; Kharatyan, Aschot
Fraunhofer IEM, Germany

METHOD FOR 3D-ENVIRONMENT DRIVEN DOMAIN KNOWLEDGE ELICITATION AND SYSTEM MODEL GENERATION

The development of cyber-physical systems requires close cooperation between stakeholders from different disciplines. Model-based systems engineering support this by the design of a system model. Non-identified domain knowledge by the stakeholders is a challenge when creating the system model. The CONSENS 3D-Modeling Method supports the domain-independent elicitation of domain knowledge using a 3D environment and enables the derivation of a SysML system model. We applied the method by implementing a prototype, called 3D Engineer, to an application example from the automotive industry.

<https://doi.org/10.1017/dsd.2020.41>

Pereira, Joao Goncalves; Ellman, Asko
Tampere University, Finland

FROM CAD TO PHYSICS-BASED DIGITAL TWIN: FRAMEWORK FOR REAL-TIME SIMULATION OF VIRTUAL PROTOTYPES

Engineering work is mostly done in 3D CAD software throughout the engineering process from conceptual design and layout of products. Physics-Based Virtual Prototypes are very valuable addition on Computer Aided Engineering enabling product development simulators, training simulators and digital twin concept in product life-cycle process. In this work, we present a framework, how such virtual prototypes can be developed from 3D CAD models with meaningful effort.

<https://doi.org/10.1017/dsd.2020.47>

Gopsill, James; Jennings, Sean
University of Bath, United Kingdom

DEMOCRATISING DESIGN THROUGH SURROGATE MODEL CONVOLUTIONAL NEURAL NETWORKS OF COMPUTER AIDED DESIGN REPOSITORIES

The capability to manufacture at home is continually increasing with technologies, such as 3D printing. However, the ability to design products suitable for manufacture and use remains a highly-skilled and knowledge intensive activity. This has led to 'content creators' providing vast repositories of manufacturable products for society, however challenges remain in the search & retrieval of models. This paper presents the surrogate model convolutional neural networks approach to search and retrieve CAD models by mapping them directly to their real-world photographed counterparts.

<https://doi.org/10.1017/dsd.2020.93>



Poot, Leon Peter; Wehlin, Camilla; Tarkian, Mehdi; Ölvander, Johan
Linköping University, Sweden

INTEGRATING SALES AND DESIGN: APPLYING CAD CONFIGURATORS IN THE PRODUCT DEVELOPMENT PROCESS

With industries striving towards increased customisation of complex products through engineer-to-order, methods are continuously sought to rationalise the product development process. To this end, a framework is proposed using CAD configurators, utilising design automation and knowledge-based engineering to integrate sales and design processes in product development. The application of this framework to the design of spiral staircases is described and analysed, with results showing decreased lead-times and a decreased risk for design errors.

<https://doi.org/10.1017/dsd.2020.129>

Vlah, Daria; Žavbi, Roman[†]; Vukašinović, Nikola
University of Ljubljana, Slovenia

EVALUATION OF TOPOLOGY OPTIMIZATION AND GENERATIVE DESIGN TOOLS AS SUPPORT FOR CONCEPTUAL DESIGN

Nowadays, a large number of different tools that support early phases of design are available to engineers. In the past decade a specialized set of CAD-based tools were developed, that support the ideation process by generating different design alternatives according to the criteria given by the designer. Two types of tools are discussed in this paper: topology optimization and generative design tools. To investigate to what extent these tools are suitable for use in early design phases and what are the main differences between them, a study was conducted on an industrial case.

<https://doi.org/10.1017/dsd.2020.165>



Mitropoulos, Sotirios-Aris; Sicko, Anabel; Frilingos, Stefanos; Aroh, Ngozi; Papalambros, Panos Y.

University of Michigan, United States of America

FUNDING DESIGN AND INNOVATION FOR SUSTAINABLE DEVELOPMENT IN AFRICA: A REVIEW OF SOURCES

Funding for design impacts the practical ability to address relevant problems. Using public sources, we explore funding aimed at design and business innovations for sustainable development in Africa provided by NGOs, governments, and multinational organizations. We focus on agriculture, energy, sanitation, and urban development, with successful or promising project examples. We conclude that country location, population or economic size do not drive government R&D spending; agricultural R&D funding is below targets; and NGOs combine funding with education and skill-building opportunities.

<https://doi.org/10.1017/dsd.2020.73>

Maritz, Minette; Eriksson, Vikki; Barnes, Veronica

Cape Peninsula University of Technology, South Africa

PET PLASTIC IN FOOD AND BEVERAGE PACKAGING DESIGN: A REVIEW OF LEGISLATION, LITERATURE AND INDUSTRY REPORTING COMPARING EUROPEAN AND SOUTH AFRICAN INDUSTRIAL PRACTICE

This article draws inspiration from two concepts, which initially appear to be at odds with each other. The first refers to the impact that plastics use has had on the environment and human health, while the second explores the prevalence and continued increase in the use of plastic materials. The manufacturing of plastic packaging will be reviewed to identify appropriate intervention. This article focuses on the future development of PET packaging in South Africa, exploring current literature and legislation which aid in the holistic development of the plastic packaging value chain.

<https://doi.org/10.1017/dsd.2020.83>

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Van de Zande, Georgia; Amrose, Susan; G. Winter, Amos;

Massachusetts Institute of Technology, United States of America



EVALUATING THE POTENTIAL FOR LOW ENERGY EMITTERS TO FACILITATE SOLAR-POWERED DRIP IRRIGATION IN SUB-SAHARAN AFRICA

Introducing irrigation to smallholder farms in Sub-Saharan Africa (SSA) can increase food security, improve nutrition, and reduce poverty. To explore the possibility of using drip irrigation on smallholder farms in SSA, we introduce a feasibility study that views the design space from both a user-centered lens, explaining how drip might be successful in the future, and from an engineering lens. With a first-order model, we compare estimated capital costs of drip and sprinkler systems for various farm profiles and show that drip has the potential to be a viable technology for many farms in SSA.

<https://doi.org/10.1017/dsd.2020.329>

Wilson Barlow, Thomas; Greene, Melissa T.; Papalambros, Panos Y.

University of Michigan, United States of America

REVIEW OF DESIGN RESEARCH FOR SUSTAINABLE DEVELOPMENT IN AFRICA: A DESIGN SCIENCE PERSPECTIVE

The design community can contribute significantly to the success of the United Nations Sustainable Development Goals in Africa. Currently, alignment of the design research community on sustainable development goals in Africa is not well understood. In this paper, we review relevant literature and identify trends in research topics studied and in patterns of collaboration between researchers. We find differences in topic representation and collaboration trends between African-based and non-African based researchers. Understanding these differences better will be important for future research.

<https://doi.org/10.1017/dsd.2020.154>

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12:45	D3-O: PRE-SESSION GET-TOGETHER <i>Message from the Programme Chair: P. John Clarkson, University of Cambridge, United Kingdom</i> VIRTUAL STAGE								12:45
13:00	D311 AGILE DEVELOPMENT VR1 <i>Chair: Boris Eisenbart</i>	D312 REQUIREMENTS ENGINEERING VR2 <i>Chair: Christian Weber</i>	D313 SUSTAINABLE DESIGN METHODS VR 3 <i>Chair: Daniela C. A. Pigosso</i>	D314 CO-DESIGN VR 4 <i>Chair: Eric Blanco</i>	D315 VIRTUAL, AUGMENTED AND MIXED REALITY VR5 <i>Chair: Asko Ellman</i>	D316 DESIGN EDUCATION METHODS I VR6 <i>Chair: Johan Malmqvist</i>	D317 USER EXPERIENCE VR7 <i>Chair: Robert E. Wendrich</i>	D318 APPLICATION OF METHODS IN DESIGN PRACTICE I VR8 <i>Chair: Oscar Gabriel Nespoli</i>	13:00
14:00	REFRESHMENT BREAK								14:00
14:15	D3-P: PLENARY SESSION II KEYNOTE: ZEHA VIT REISIN – WHAT’S NEW WITH MATERIALS? VIRTUAL STAGE <i>Chair: P. John Clarkson</i>								14:15
15:00	REFRESHMENT BREAK								15:00
15:15	D321 INDUSTRY 4.0 VR 1 <i>Chair: Josef Oehmen</i>	D322 ARCHITECTING ENGINEERING SYSTEMS VR2 <i>Chair: Kevin N. Otto</i>	D323 QUANTITATIVE SUSTAINABILITY ASSESSMENT VR 3 <i>Chair: Tim C. McAloone</i>	D324 COLLABORATIVE DESIGN VR 4 <i>Chair: Julie Stal-Le Cardinal</i>	D325 ADVANCED VISUALISATION VR5 <i>Chair: Neven Pavković</i>	D326 DESIGN EDUCATION CONCEPTS & COMPARISONS VR6 <i>Chair: Yvonne Eriksson</i>	D327 USER BEHAVIOUR VR7 <i>Chair: Monica Bordegoni</i>	D328 APPLICATION OF METHODS IN DESIGN PRACTICE II VR8 <i>Chair: Dietmar Göhlich</i>	15:15
16:15	D3-S: SOCIAL EVENT II SOCIAL EVENT ROOM								16:15
18:00									18:00



Thiele, Henrik ⁽¹⁾; Weber, Sebastian ⁽²⁾; Reichwein, Jannik ⁽³⁾; Bartolo, Joseph A. ⁽⁴⁾; Tchana, Yvan ⁽⁵⁾; Jimenez, Lucas ⁽⁶⁾; Borg, Jonathan C. ⁽⁴⁾

¹Paderborn University, Germany; ²Bundeswehr University Munich, Germany; ³Technische Universität Darmstadt, Germany; ⁴University of Malta, Malta; ⁵University of Technology of Troyes, France; ⁶Université de Technologie de Belfort-Montbéliard, France

A SCRUM AGILE INTEGRATED DEVELOPMENT FRAMEWORK

With design methodologies, as Integrated Product Development, industry is continuously looking to improve their product development processes. Staying ahead concurrence forces them to deliver new and more complex products in shorter time. When it comes to fast delivery and requirement changes, product development can be inspired by agile methods. Although the application is difficult, the idea to implement these methods for development of products other than software comes out. To ease its implementation, this paper proposes to use IPD as a framework for agile product development.

<https://doi.org/10.1017/dsd.2020.9>

Heimicke, Jonas; Chen, Rongde; Albers, Albert

Karlsruhe Institute of Technology, Germany

AGILE MEETS PLAN-DRIVEN – HYBRID APPROACHES IN PRODUCT DEVELOPMENT: A SYSTEMATIC LITERATURE REVIEW

More than 15 years after the publication of the agile manifesto of software development, agile development approaches have also reached the processes of physical product development. Because of the boundary conditions and requirements here, which differ strongly from those of pure software development, these approaches often reach their limits. However, research and practice have quickly recognized that hybrid approaches integrate the strengths of agile and plan-driven development. This paper presents 25 hybrid development approaches that have been identified in a Systematic Literature Review.

<https://doi.org/10.1017/dsd.2020.259>

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WED



Trauer, Jakob; Schweigert-Recksiek, Sebastian; Gövert, Kristin; Mörtl, Markus; Lindemann, Udo

Technical University of Munich, Germany

COMBINING AGILE APPROACHES AND RISK MANAGEMENT FOR MECHATRONIC PRODUCT DEVELOPMENT – A CASE STUDY

As the benefits and potentials of agile approaches become increasingly clearer, also hardware product development seeks to apply those methods and procedures. However, mechatronic hardware products are often subject to stricter safety regulations so that a consequent risk management is essential. This paper presents a risk management method suitable for agile product development projects. The method together with an adapted agile procedure were applied and evaluated in a successful industrial case study. This lead to the extended application of agile approaches in other parts of the company.

<https://doi.org/10.1017/dsd.2020.16>

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¹Technische Universität Clausthal, Germany; ²University of Technology Sydney, Australia;

³Technische Universität Braunschweig, Germany

RECAP – A FRAMEWORK TO SUPPORT STRUCTURED REFLECTION IN ENGINEERING PROJECTS

Reflection is understood as an integral part of designing and design processes. Despite the high relevance and an ongoing discussion about agile engineering, we found that reflection is rarely established in industrial practice. There is a need for an approach structuring the wide range of levels, stakeholders, objects and timing of reflections. The introduced RECAP framework is an important step towards a guideline (heuristic) for reflection in engineering projects. Based on the four dimensions objectives, stakeholders, objects, and processes it supports structured planning of reflection.

<https://doi.org/10.1017/dsd.2020.99>



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Mies, Robert ⁽¹⁾; Bonvoisin, Jérémy ⁽²⁾; Stark, Rainer ⁽¹⁾

¹Technische Universität Berlin, Germany; ²University of Bath, United Kingdom

DEVELOPMENT OF OPEN SOURCE HARDWARE IN ONLINE COMMUNITIES: INVESTIGATING REQUIREMENTS FOR GROUPWARE

Open source hardware is hardware whose design is shared online so that anyone can study, modify, distribute, make, and sell it. In spite of the increasing popularity of this alternative IP management approach, the field of OSH remains fragmented of diverse practices seeking for settlement. This challenges providers of groupware solutions to capture the specific needs of open source product development practitioners. This contribution therefore delivers a list of basic requirements and verifies them by comparing offered functions of existing groupware solutions.

<https://doi.org/10.1017/dsd.2020.38>

Batista, Jardel ⁽¹⁾; Hassan, Alaa ⁽²⁾; Bonjour, Eric ⁽²⁾

¹Universidade Regional do Cariri, Brazil; ²Université de Lorraine, France

DESIGN THINKING TO ENHANCE REQUIREMENTS ANALYSIS IN SYSTEMS ENGINEERING

Systems engineering (SE) is a general methodological approach that includes all relevant activities to design, develop and verify a system. This work was based on the need to enhance the integration of the customer needs into the design phases of SE. A joint methodology was proposed integrating the SE approach with the Design Thinking (DT). An analysis was conducted as part of a case study proposed by IBM Corporation for the development of a security system for a building. The results confirm that the insertion of the DT in the SE has a significant impact on the generation of concept solutions.

<https://doi.org/10.1017/dsd.2020.257>

Horber, Dennis; Schleich, Benjamin; Wartzack, Sandro

Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

CONCEPTUAL MODEL FOR (SEMI-) AUTOMATED DERIVATION OF EVALUATION CRITERIA IN REQUIREMENTS MODELLING

Requirements act as a limitation of the solution space, which represents the stakeholders' needs and guides the whole product development process. Therefore, forgotten requirements can lead to wrong decisions when using them as a basis for decision-making. This contribution introduces a novel approach to link the requirement and evaluation criteria models to address this problem. For setting up those criteria consistently, the requirements are classified using natural language processing and derived by a ruleset based on a developed mapping between requirement classes and criteria types.

<https://doi.org/10.1017/dsd.2020.52>

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Ozdemir, Mehmet; Cascini, Gaetano

Politecnico di Milano, Italy

AN EXPERIMENT-DRIVEN MASS-PERSONALISATION MODEL: APPLICATION TO SAXOPHONE MOUTHPIECE PRODUCTION

Mass-personalization (MP) presents an opportunity to meet diversifying customer needs in consumer products market with a near mass-production efficiency. Traditional product development methodologies fall short to guide design for MP and a dedicated systematic methodology is essential. The proposed approach bases on a dynamic product template that automatically adapts with user input and produces a reliable output. This paper presents the workflow towards mass-personalization of saxophone mouthpieces with focus on design automation.

<https://doi.org/10.1017/dsd.2020.169>

Kloock-Schreiber, Daniel; Siqueira, Renan; Gembarski, Paul Christoph; Lachmayer, Roland

Leibniz Universität Hannover, Germany

DISCRETE-EVENT SIMULATION FOR SPECIFICATION DESIGN OF PRODUCTS IN PRODUCT-SERVICE SYSTEMS

Boundaries between products and services vanish and companies increasingly offer hybrid solutions known as Product Service Systems (PSS). Thereby, a holistic view that includes both the product and service parts must be taken. This paper presents a discrete-event simulation of a PSS as a method for the specification of the product part. Besides product and service, the application scenario and the decision-making are also modeled. Based on the results for a case study, the customer requirements could be guaranteed as the essential product specifications were optimized to minimize total costs.

<https://doi.org/10.1017/dsd.2020.295>

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Maccioni, Lorenzo ⁽¹⁾; Borgianni, Yuri ⁽¹⁾; Pigosso, Daniela C. A. ⁽²⁾; McAloone, Tim C. ⁽²⁾

¹Free University of Bozen-Bolzano, Italy; ²DTU-Technical University of Denmark, Denmark

ARE ECO-DESIGN STRATEGIES IMPLEMENTED IN PRODUCTS? A STUDY ON THE AGREEMENT LEVEL OF INDEPENDENT OBSERVERS

Eco-Design Strategies lead to both enhanced environmental sustainability and product differentiation, which, however, takes place only if observers recognize and value these advantages. To study this aspect, a sample of 40 product pictures has been administered to 12 subjects with experience in eco-design. They were asked to evaluate whether one or more Eco-Design Strategies (in Vezzoli and Manzini's version) were implemented in each depicted product. The outcome of the evaluation was an overall fair agreement. Useful information for eco-design is inferred from nuances of the results.

<https://doi.org/10.1017/dsd.2020.272>

Watz, Matilda; Hallstedt, Sophie I.

Blekinge Institute of Technology, Sweden



GROUP MODEL BUILDING WITH CAUSAL LOOP DIAGRAMS TO FOSTER CAPABILITIES FOR SUSTAINABLE DESIGN AND PRODUCT DEVELOPMENT

This research proposes a group model building workshop method that uses causal loop diagrams to foster capabilities for sustainable product development based on feedback and observations from several cases. The method's potential to enhance sustainability system thinking skills and to identify relationships between sustainability criteria and traditionally identified requirements is evaluated. The method can trigger discussion, visualize complexity and dependencies of sustainable design problems. Other application areas are e.g., sustainability training for practicing engineers and students.

<https://doi.org/10.1017/dsd.2020.53>

Chatty, Tejaswini ⁽¹⁾; Faludi, Jeremy ^(1,2)

¹Dartmouth College, United States of America; ²Delft University of Technology, The Netherlands

PERCEPTION OF SUSTAINABLE DESIGN INTEGRATION BENEFITS AMONG INDUSTRY PRODUCT DEVELOPMENT TEAMS: A CASE STUDY

How do employees perceive the impact of incorporating sustainability considerations into their product development practice? In this case study, we observe how these perceptions can be shifted by teaching workshops on how to apply sustainable design methods in practice. We compare the trends for different methods on various dimensions such as creativity, design process time, product marketability etc. Results show an overall shift towards positive perception for all the methods on a majority of factors, indicating a way to ease the adoption of sustainable design into industry practice.

<https://doi.org/10.1017/dsd.2020.54>

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Villanueva, Marcel ^(1,2); Yannou, Bernard ⁽¹⁾; Leroy, Yann ⁽¹⁾; Cluzel, François ⁽¹⁾; Vautier, Marc ⁽²⁾; Vaija, Samuli ⁽²⁾

¹CentraleSupélec, France; ²Orange Labs, France

DESIGN-FOR-COST-AND-ENVIRONMENT: ONTOLOGICAL ANALYSIS AND COMPARISON OF SERVICE REPRESENTATION APPROACHES

Brought by the need for competent approaches to assess the financial cost and environmental impact towards service design-for-cost-and-environment, this paper investigates on the following service representation approaches: Service Blueprinting, Process Chain Network, Business Process Model & Notation, and Customer Journey Mapping. An ontological analysis further compares their similarities and differences. Lastly, a table summarizes the findings, where further insights could be drawn to help service companies be more aware of both their spending and ecological responsibility.

<https://doi.org/10.1017/dsd.2020.130>

Livotov, Pavel; Mas'udah; Chandra Sekaran, Arun Prasad

Offenburg University of Applied Sciences, Germany

RELIABLE IDENTIFICATION AND SELECTION OF CRITICAL INNOVATION DESIGN TASKS FOR PROCESS INTENSIFICATION IN PROCESS ENGINEERING

Sustainable design of equipment for process intensification requires a comprehensive and correct identification of relevant stakeholder requirements, design problems and tasks crucial for innovation success. Combining the principles of the Quality Function Deployment with the Importance-Satisfaction Analysis and Contradiction Analysis of requirements gives an opportunity to define a proper process innovation strategy more reliably and to develop an optimal process intensification technology with less secondary engineering and ecological problems.

<https://doi.org/10.1017/dsd.2020.175>

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Poulin, Maud; Masclet, Cédric; Boujut, Jean-François
Grenoble INP, France

THE CO-DESIGN COGNITIVE PROCESS: IMPACTS OF A SPATIAL AUGMENTED REALITY PLATFORM

The study of design cognitive activity began in the 70s under the influence of psychology and ergonomics. Since then, the design process has undergone many changes with the advent of technology. This paper will notably present you to one of them: the Spatial Augmented Reality (SAR). The study conducted with this technology will focus on multimodal analysis in co-design meetings where we have compared two co-design sessions. We notice that the design activity is unchanged by the introduction of such a technology but could encourage interactions from clients who are usually less invested.

<https://doi.org/10.1017/dsd.2020.104>

Välik, Sander; Mougenot, Céline
Imperial College London, United Kingdom

GENERATIVE BOUNDARY OBJECTS AS INTEGRAL PARTS OF FRAMING IN DESIGN AND BIOSCIENCE COLLABORATIONS

Collaborations between design engineers and bioscientists offer novel opportunities that could help solving some of the biggest challenges organisations and societies are facing. Combining design and bioscience has the potential to create responsible and desirable products/services, however such ventures come with challenges rising from boundaries between practices. This research explores boundary objects as sources of framing in multidisciplinary collaborations. The results are based on a descriptive study with synthetic biologists and design engineers working on an innovation-driven task.

<https://doi.org/10.1017/dsd.2020.106>

Aranda Muñoz, Álvaro ^(1,2); Florin, Ulrika ⁽¹⁾; Eriksson, Yvonne ⁽¹⁾; Yamamoto, Yuji ⁽¹⁾; Sandström, Kristian ⁽²⁾

¹Mälardalen University, Sweden; ²RISE, Sweden

THE KARAKURI CARD DECK: CO-DESIGNING INDUSTRIAL IOT CONCEPTUAL SOLUTIONS

Novel IoT market solutions and research promise IoT modules that do not require programming or electrical setup, yet shop floor personnel need to face problem solving activities to create technical solutions. This paper introduces the Karakuri card deck and presents a case study composed of four workshop sessions in four manufacturing settings, where shop floor personnel tested the cards as a means of ideating and presenting conceptual IoT solutions in the form of diagrams. The results indicate the validity of the proposed conceptual solutions and suggest prototyping as a next step.

<https://doi.org/10.1017/dsd.2020.127>



Kerpen, Daniel; Conrad, Jan; Wallach, Dieter
Hochschule Kaiserslautern, Germany

A FORMALISATION APPROACH FOR COLLABORATIVE USER EXPERIENCE DESIGN

We propose to combine Collaborative User Experience Design (CUXD) projects with the integrated product and process modelling theory CPM/PDD to formalise the CUXD process model. CPM/PDD is discussed as a Design Theory and Methodology (DTM) to describe a product as well as the product development process based on a clear distinction of characteristics and properties. CUXD is presented as a cross-disciplinary, human-centred development model. It focuses on team collaboration, relates to concepts of Design Thinking, Agile Development as well as Lean UX and it highlights user experience metrics.

<https://doi.org/10.1017/dsd.2020.312>

Kimber, Alexander John Edward; Hansen, Camilla Arndt; Özkil, Ali Gürcan
DTU-Technical University of Denmark, Denmark

MAKING THE MOST OF MAKERS: AN EXPLORATION OF THE NEED FOR A PROTOTYPING TOOL FOR COMPANIES TO ENGAGE WITH THE MAKER MOVEMENT

Makers have proven to be skilled at prototyping and therefore present a unique opportunity for companies, who seek to improve their capabilities, to learn from them. In this study, a mixed methods approach was used to understand possible benefits to both companies and makers from collaborating in prototyping, and to identify a set of design considerations to guide the future development of a tool to facilitate such collaboration. Despite challenges to collaboration, a tool designed to help companies engage with makers in prototyping could be beneficial to both and should be developed.

<https://doi.org/10.1017/dsd.2020.145>



Kunnen, Steffen Georg; Adamenko, Dmytro; Pluhnau, Robin; Nagarajah, Arun
University of Duisburg-Essen, Germany

SYSTEM BASED COMPONENT IDENTIFICATION USING COORDINATE DETERMINATION IN MIXED REALITY

The maintenance of an industrial plant is mainly based on analogue and manual methods and processes. In the future, the maintenance data of the real object should be determined digital and transferred to a PDM system in real time. This is made possible with a digital method of component identification. This publication presents a system-based component identification using Mixed Reality. Coordinates are determined by the terminal device and compared with a reference structure. After successful identification, maintenance data can be determined and automatically transferred to a PDM System.

<https://doi.org/10.1017/dsd.2020.22>

Joundi, Jamil; Christiaens, Yannick; Saldien, Jelle; Conradie, Peter; De Marez, Lieven
Ghent University, Belgium

AN EXPLORATIVE STUDY TOWARDS USING VR SKETCHING AS A TOOL FOR IDEATION AND PROTOTYPING IN PRODUCT DESIGN

The advancements in the field of VR allow designers to use VR as a technology for sketching ideas in a virtual space. In this paper, Gravity Sketch (a VR sketching software) is used as an ideation sketching tool in the process of product styling. The goal of this research is to examine the advantages and points-of-pain when using virtual reality tools in the process of product styling. 29 Master students used the VR sketching tool in their design process and all of them had feedback and insights on the tool.

<https://doi.org/10.1017/dsd.2020.61>

Horvat, Nikola; Škec, Stanko; Martinec, Tomislav; Lukačević, Fanika; Perišić, Marija Majda
University of Zagreb, Croatia

IDENTIFYING THE EFFECT OF REVIEWERS' EXPERTISE ON DESIGN REVIEW USING VIRTUAL REALITY AND DESKTOP INTERFACE

This paper suggests that analysing the effect of visualisation technologies during design reviews should include variables related to design reviewers' expertise and focus on the process variables rather than the outcomes. The experiment showed better averages in terms of design understanding for groups in desktop interface than for groups in virtual reality. However, the observed difference might also be due to experience with the technology. Finally, regardless of the visualisation technology, higher expertise group showed consistently better design understanding than lower expertise groups.

<https://doi.org/10.1017/dsd.2020.304>

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Giunta, Lorenzo; Dekoninck, Elies; Gopsill, James
University of Bath, United Kingdom

INVESTIGATING THE IMPACT OF SCALE IN DESIGN SESSIONS SUPPORTED BY A SPATIAL AUGMENTED REALITY (SAR) TOOL

Spatial Augmented Reality (SAR) differs from other forms of AR by allowing the projection of digital images onto a model. This allows the AR to be more tangible and for interaction to be more realistic. The scale of the model plays a role in the realism but may be constrained by technical factors. This study attempts to understand the influence scale has on a design session by analysing the concept generation process, the ease of designing and the design behaviour. Understanding how these factors are influenced by the model scale better the understanding of how SAR can influence design.

<https://doi.org/10.1017/dsd.2020.148>

Balzerkiewitz, Hans-Patrick; Stechert, Carsten
Ostfalia University of Applied Sciences, Germany

THE EVOLUTION OF VIRTUAL REALITY TOWARDS THE USAGE IN EARLY DESIGN PHASES

The aim of the present work is to show possibilities with which 3D models in virtual reality (VR) can be created and exported. First an overview of the existing hard- and software is given. Subsequently, existing solution concepts are analysed which, however, are not used in product development. Based on these knowledge a concept for the creation of 3D models in VR and the export of these models is developed.

<https://doi.org/10.1017/dsd.2020.159>

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Jobst, Birgit ^(1,2); Thoring, Katja ^(1,2); Badke-Schaub, Petra ⁽²⁾

¹Anhalt University of Applied Sciences, Germany; ²Delft University of Technology, The Netherlands

INTRODUCING A TOOL TO SUPPORT REFLECTION THROUGH SKETCHING AND PROTOTYPING DURING THE DESIGN PROCESS

Sketching and prototyping are parts of a 'reflective conversation with materials of a design situation' (Schön, 1992). To support this conversation, we developed a reflective tool -the Reflection Canvas- that facilitates reflection activities through sketching and prototyping on the one hand and verbalisation on the other. We introduced the reflective tool to design students. Based on observation and answers from a questionnaire data reveal that guided reflection structured the process in a helpful way. It also turned out students had difficulties to switch from visualisation to verbalisation.

<https://doi.org/10.1017/dsd.2020.263>

Koronis, Georgios; Silva, Arlindo; Kang, Jacob Kai Siang; Yogiaman, Christine

Singapore University of Technology and Design, Singapore

HOW TO BEST FRAME A DESIGN BRIEF TO MAXIMIZE NOVELTY AND USEFULNESS IN IDEA GENERATION

This paper aims to identify factors that influence creativity, and strives towards understanding the effect of representations, namely abstract and concrete design outcomes. Three conditions are compared; a control group, an abstract group, and a group provided with various example solutions. The implications of this work can strongly impact the formulation of design briefs, where the goal is to stimulate the creativity of design brief outcomes and examine their relationship to product awareness.

<https://doi.org/10.1017/dsd.2020.77>

Milovanovic, Julie ⁽¹⁾; Gero, John ⁽²⁾

¹UMR AUU-CRENAU, France; ²UNC Charlotte, United States of America

MODELING DESIGN STUDIO PEDAGOGY: A MENTORED REFLECTIVE PRACTICE

This paper explores the notion of mentored reflective practice to describe design studio pedagogy. Students learn how to design by doing design in the studio. Design critiques are a key element in design studio pedagogy as they capture a moment where students get feedback from their tutors on their designs. The research questions addressed concern the roles of each participant during design studio reviews and their interactions with design representations. The protocol analysis methodology and the Function Behavior Structure ontology are utilized to convey our case study analysis.

<https://doi.org/10.1017/dsd.2020.118>

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Costa, Nina ⁽¹⁾; Branco, Vasco ⁽¹⁾; Costa, Rui ⁽¹⁾; Borges, Afonso ^(1,5); Modesto, António ⁽³⁾; Silva, Catarina ⁽⁴⁾; Cunca, Raul ⁽²⁾

¹University of Aveiro, Portugal; ²Universidade de Lisboa, Portugal; ³University of Porto, Portugal; ⁴Polytechnic Institute of Cavado e do Ave, Portugal; ⁵University of Beira Interior, Portugal

TOWARDS A DESIGN OBSERVATORY: THE CASE OF SCHOLARLY DESIGN RESEARCH IN PORTUGAL

The DesignOBS project was created to collect, map and interpret data about the Portuguese Design Ecosystem, providing supportive information for decision making. This study takes advantage of a participative Design perspective to define and test an observation process via a case based on Design doctorates undertaken in Portugal. It emphasises the need for additional participatory analysis and curation by experts to evaluate and develop more reliable information about the discipline. Moreover, it develops recommendations that can enhance the communicability of Design doctorates.

<https://doi.org/10.1017/dsd.2020.327>

Mina, Mani ⁽¹⁾; Cowan, John ⁽²⁾; Fila, Nicholas D. ⁽¹⁾; Theh, Wei Shen ⁽¹⁾

¹Iowa State University, United States of America; ²The Open University, United Kingdom

PROMOTING GRADUATE AND PROFESSIONAL ATTRIBUTES BY COORDINATING KOLBIAN REFLECTIONS FOR INDUSTRIAL DESIGN AND ENGINEERING STUDENTS

This work features challenges of using integrated reflections in undergraduate Industrial Design and Engineering. Reflection activities can be challenging for the students and hard to implement in design and engineering classes. This report has two goals. The first is to introduce a process for more successful engagement for the students in problem solving and design. The second is to show that the process has validity and usefulness for Industrial Design students who are in a College of Design.

<https://doi.org/10.1017/dsd.2020.174>

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Rautray, Priyabrata ⁽¹⁾; Mathew, Deepak John ⁽¹⁾; Eisenbart, Boris ⁽²⁾
¹IIT Hyderabad, India; ²Swinburne University of Technology, Australia

USERS' SURVEY FOR DEVELOPMENT OF PASSENGER DRONES

The prosperity of any megacities heavily depends on smooth transport systems. In India, however, most cities are failing to keep in step with the growing demands. With new technologies, such as passenger drones, an alternate mode of intra-city transportation seems within reach. For successful development of passenger drones in a diverse country like India, understanding users' needs are vital. This paper presents the results from a survey of potential users of passenger drones from across India. These are then used to derive concrete recommendations for passenger drones design parameters.

<https://doi.org/10.1017/dsd.2020.39>

Gandrez, Clara ^(1,2); Mantelet, Fabrice ⁽¹⁾; Aoussat, Améziame ⁽¹⁾; Jeremie, Francine ⁽²⁾; Landel, Eric ⁽²⁾

¹Arts et Métiers ParisTech, France; ²Renault, France

ASSESSING THE DRIVER'S RISK PERCEPTION DURING AUTONOMOUS DRIVING

Advanced Driver-Assistance Systems were created to address the driver's failures. All these ADAS are a part of the evolution of the vehicles towards whole automation. To complete its launch in the automotive market, autonomous vehicles have to pass safety tests to acquire the consumers' trust. To receive the approval of the public, the self-driving car has to take into account the human feeling. The risk perceived by the driver is one of the new emotional form to integrate at the validation plan. The purpose of this study is to examine the perception of the risk of a self-driving car's driver.

<https://doi.org/10.1017/dsd.2020.276>

Millar, Jason ⁽¹⁾; Paz, Dana ⁽²⁾; Thornton, Sarah M. ⁽²⁾; Parisi, Celeste ⁽³⁾; Gerdess, J. Christian ⁽²⁾

¹University of Ottawa, Canada; ²Stanford University, United States of America; ³Apple Inc., United States of America



A FRAMEWORK FOR ADDRESSING ETHICAL CONSIDERATIONS IN THE ENGINEERING OF AUTOMATED VEHICLES (AND OTHER TECHNOLOGIES)

Policymakers have attempted to preemptively address the concern of ethical issues with the regulation of automated vehicles. Unfortunately, both policymakers and designers of these technologies struggle to articulate ethical issues and their resolution. We propose a framework that engineers and designers of automated technologies can apply that allows them to identify and resolve ethical tensions within the design task. We demonstrate the practicability of the framework to the engineering design process through a human-subject study where engineers applied the framework in a workshop.

<https://doi.org/10.1017/dsd.2020.78>

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Felton, Harry; Yon, Jason; Hicks, Ben
University of Bristol, United Kingdom

LOOKS LIKE BUT DOES IT FEEL LIKE? INVESTIGATING THE INFLUENCE OF MASS PROPERTIES ON USER PERCEPTIONS OF RAPID PROTOTYPES

Prototyping is a key part of the design process, with artefacts increasingly fabricated using 3D printing methods. However, these printed parts often lack internal structure and the mass properties of the artefact – mass, balance and moments of inertia – differ from the design. It is hypothesised that a stakeholder's assessment of a design is affected by this misrepresentation. The work presented demonstrates that mass properties have a significant effect on stakeholder perception of prototypes. This is done through a study of University of Bristol students and consultation with industry.

<https://doi.org/10.1017/dsd.2020.111>

Papp, Emese; Wölfel, Christian; Krzywinski, Jens
Technische Universität Dresden, Germany



ACCEPTANCE AND USER EXPERIENCE OF WEARABLE ASSISTIVE DEVICES FOR INDUSTRIAL PURPOSES

This paper presents experience-oriented aspects of the development of wearable assistive devices (exoskeletons) for industrial purposes, an area which has only begun to be explored. Our research aims to examine user acceptance criteria for assistive devices and understand the meaning of interaction with wearable assistive devices for the users. The resulting models deliver new insights about the importance of user experience for technology acceptance and should be generally considered in development processes of wearable assistive devices.

<https://doi.org/10.1017/dsd.2020.319>

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Grafinger, Manfred
TU Wien, Austria

USING KINEMATIC ANALYSIS TO DEVELOP A NEW TOOTH SYSTEM FOR GEARINGS WITH VARIABLE SHAFT ANGLE

The belt units of an omnidirectional treadmill need to be connected for a continuous rotational transmission with varying axes angle. Torus gearing is not appropriate due to kinematic reasons, therefore a crown gearing with cone-shaped teeth is proposed. Parameter analysis on a virtual kinematics model show that depending on the cone angle, overlaps occur at different axis angles. Consequently, the shape of the teeth is modified with tip and foot relief and optimized so that no overlapping of the teeth occurs while a large path of contact is provided.

<https://doi.org/10.1017/dsd.2020.8>

Miler, Daniel; Hoić, Matija; Žeželj, Dragan
University of Zagreb, Croatia

OPTIMISATION OF WELDED BEAMS: HOW COST FUNCTIONS AFFECT THE RESULTS

The increasing market competitiveness and CAE availability require the products to be optimised. This practice is exceedingly present when producing semi-standard parts like structural elements. Several cost calculation methods are developed, bringing up the question - which one to use? In this article, we compared three methods; a welded I-section beam was used as an example. The optimisation was carried out using two objectives (mass and cost) and was submitted to Eurocode boundary conditions. The results have shown that the cost calculation method has a negligible influence on the results.

<https://doi.org/10.1017/dsd.2020.44>

Petterson, Timothy Clarrie; Gooch, Shayne Douglas
University of Canterbury, New Zealand



ROLLING RESISTANCE OF ATV TYRES IN AGRICULTURE

Electric vehicles are playing an increasingly important role in the agricultural sector. The selection of tyres for reducing energy loss due to rolling resistance is an important consideration in determining the viability of these vehicles. To date little is known about rolling resistance of small all-terrain vehicles. In this study a test rig was used to collect rolling resistance data for seven ATV tyres. The study verifies the relationship between normal load and rolling resistance and gives insight into some of the important considerations when selecting tyres for small off road vehicles.

<https://doi.org/10.1017/dsd.2020.75>



Zahn, Aljoscha; Diwisch, Pascal; Rieg, Frank; Alber-Laukant, Bettina
University of Bayreuth, Germany

DESIGN MODIFICATION OF AN INNOVATIVE SPLIT-SINGLE TWO-STROKE ENGINE

A prototype of an innovative split-single two stroke engine is presented. With the aim of increasing the power-to-weight ratio for later mobile use, the individual engine components have to be revised. The focus is on the development process for the redesign of the crankcase. Through a preliminary examination of the necessary CAx systems, an iterative process chain that combines suitable synthesis and analysis tools is derived. This includes the design of the machine elements, a numerical strength verification using FEM and preparing the model for machining.

<https://doi.org/10.1017/dsd.2020.102>

Auflem, Marius⁽¹⁾; Boe, Hans Hagenes⁽²⁾; Erichsen, Jørgen Falck⁽¹⁾; Steinert, Martin⁽¹⁾

¹Norwegian University of Science and Technology, Norway; ²CERN Idea Square, Switzerland

ON PROTOTYPING METHODS TO LEVERAGE NON-RIGID MATERIALS IN THE EARLY STAGES OF ENGINEERING DESIGN

Prototyping has been shown important to facilitate learning, inform decisions and to communicate ideas in engineering design. However, it is not evident which methods, tools and materials to use, as prototyping is practised differently across development contexts, and stages. In the early stages of design, different choices in prototyping methods, tools and materials all affect prototyping outcome. This paper is focused on prototyping methods in the context of early stages of design and attempts to highlight identified strengths and limitations of using non-rigid materials for prototyping.

<https://doi.org/10.1017/dsd.2020.120>



WHAT'S NEW WITH MATERIALS?

Zehavit Reisin

Vice President and Head of Materials Business, EMEA and APJ, Stratasys, Israel



Within the Stratasys offering, designers and engineers are able today to leverage the benefits of two distinct 3D printing material technologies: FDM thermoplastics and PolyJet photopolymer resins. By expanding upon the applicative benefits of both current and newly launched materials, the Stratasys team provides key insights into how every stage of the product development and the manufacturing cycle can be improved, to effectively meet time-to-market requirements, at reduced cost and without compromising on quality and design creativity.

BIOGRAPHICAL SKETCH

Zehavit B. Reisin is Stratasys Vice President, Head of EMEA and APJ Material Business Unit since 2018 and Head of the RP Business Unit between the years 2016 – 2018. Brings over 25 years of project, product and business management experience in the printing industry (Scitex, Creo, Kodak), including over 12 years' experience in 3D printing for Stratasys. Holds an MA and BA in Physics from Tel Aviv University and is a graduate of the Senior Business Management course at Recanati Graduate School for Business Administration at Tel Aviv University.

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Trauer, Jakob⁽¹⁾; Schweigert-Recksiek, Sebastian⁽¹⁾; Engel, Carsten⁽²⁾; Spreitzer, Karsten⁽²⁾; Zimmermann, Markus⁽¹⁾

¹Technical University of Munich, Germany; ²Viessmann Werke GmbH & Co. KG, Germany

WHAT IS A DIGITAL TWIN? – DEFINITIONS AND INSIGHTS FROM AN INDUSTRIAL CASE STUDY IN TECHNICAL PRODUCT DEVELOPMENT

Over the last two decades, a concept called Digital Twin has evolved rapidly. Yet, there is no unified definition of the term. Based on a literature study and an industrial case study, an overarching definition of Digital twins is presented. Three characteristics were identified – representation of a physical system, bidirectional data exchange, and the connection along the entire lifecycle. Further, three sub-concepts are presented, namely: Engineering Twin, Production Twin, and Operation Twin. The presented paper thus formulates a consistent and detailed definition of Digital Twins.

<https://doi.org/10.1017/dsd.2020.15>

Schneider, David; Huth, Tobias; Vietor, Thomas; Schumacher, Patrick; Weckenborg, Christian; Spengler, Thomas

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DEVELOPMENT OF A POTENTIAL MODEL TO SUPPORT THE ASSESSMENT AND INTRODUCTION OF INDUSTRY 4.0 TECHNOLOGIES

As digitalisation progresses, the demands placed on companies are increasing at all stages of the product generation process. In order to address these requirements and maintain economic strength, companies must implement innovative and intelligent technologies. Small and medium-sized enterprises in particular are confronted with various obstacles, the overcoming of which is addressed by the "Potential Model" presented in this publication.

<https://doi.org/10.1017/dsd.2020.85>

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A NOVEL PROCEDURE MODEL FOR DEVELOPING INDIVIDUALIZED DIGITALIZATION STRATEGIES

Many companies face a challenge while defining their individualized digitalization strategy. Therefore, the interrelation of corporate and digitalization strategy is addressed and a novel procedure model to assist companies in defining their strategy is introduced. Based on their corporate strategy, the introduced model allows companies to simply identify suitable business model patterns, digitization use cases and offers a possibility to assess the maturity level of their internal processes and evaluate the added value from an economic point of view.

<https://doi.org/10.1017/dsd.2020.308>

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TRANS-EPISTEMIC DESIGN-(RESEARCH): THEORIZING DESIGN WITHIN INDUSTRY 4.0 AND COGNITIVE ASSISTIVE SYSTEMS

The paper suggests an innovative design research and intervention approach using a poststructuralist organizational education perspective. The potential of a high impact trans-epistemic design process is shown for the field of industry 4.0 and the specific context of cognitive assistive systems (CASs). The multi-layered approach addresses the design of technical, social and educational complexity to implement CASs sustainably on the shopfloor and exploit their potential in industry 4.0. Finally, we will shed light on how the approach can enhance deep organizational transformation in industry.

<https://doi.org/10.1017/dsd.2020.173>

Schweigert-Recksiek, Sebastian⁽¹⁾; Trauer, Jakob⁽¹⁾; Engel, Carsten⁽²⁾; Spreitzer, Karsten⁽²⁾; Zimmermann, Markus⁽¹⁾

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CONCEPTION OF A DIGITAL TWIN IN MECHANICAL ENGINEERING – A CASE STUDY IN TECHNICAL PRODUCT DEVELOPMENT

A Digital Twin as a virtual representation of a physical system is becoming a key technology. While potential benefits are evident, there is no approach in literature or practice comprehensively supporting its introduction. In an industrial case study, a generic procedure model for the conception and implementation of a Digital Twin was developed. The relations between use cases, usage data, and virtual models resulted in a target concept as well as requirements for the implementation. Thereby, companies can access the potentials of a Digital Twin taking into account their specific situation.

<https://doi.org/10.1017/dsd.2020.23>

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REVERSE-ARCHITECTING APPROACH FOR SYSTEM ARCHITECTURE MODELS

For an efficient product family development an abstraction of concrete product variants is necessary in order to recognize and systematically describe characteristic properties of a variant. System architecture models represent a possibility for the systematic description of the product variety. The structure of architecture models for existing product families resembles a reverse engineering process, in which products have to be analyzed on their structures. This paper describes a reverse engineering approach for building up system architecture models as basis for developing product families.

<https://doi.org/10.1017/dsd.2020.268>

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PARTITIONING TYPES IN PRODUCT MODULARISATION

Alternative ways to divide the product into modules, partitioning types, have been identified. The research material consists of the modularisation exercise at the university. Students modularised LEGO wheel loaders for product configuration. We began to see certain basic principles for partitioning the product into modules. From these, we compiled a collection of partitioning types. Similarities between the identified partitioning types and the literature exists. Future research is concerned with whether identified partitioning types would also support modularisation in industrial projects.

<https://doi.org/10.1017/dsd.2020.40>

Bertram, Christian Alexander; Mueller, Georg Otto; Løkkegaard, Martin; Mortensen, Niels Henrik; Hvam, Lars
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WHY ENGINEER-TO-ORDER PORTFOLIO RATIONALIZATION STALLS: CHALLENGES IN STANDARDIZATION, MODULARIZATION, PLATFORM DESIGN AND MASS CUSTOMIZATION

There are various strategies to control complexity and variety growth in ETO businesses. Such portfolio rationalization initiatives sometimes stall. This paper elaborates on the challenges that cause this. Challenges described in literature and challenges seen in five different industry cases are consolidated. The challenges are combined into groups and presented in the ADKAR change management model. The authors intend this list to be used for guidance in industry and expect the collection to be extended with future industry cases and challenges.

<https://doi.org/10.1017/dsd.2020.45>

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Redeker, Julian; Gebhardt, Philipp; Reichler, Ann-Kathrin; Türck, Eiko; Dröder, Klaus; Vietor, Thomas
Technische Universität Braunschweig, Germany

AUTOMATED PART DECOMPOSITION FOR PRODUCT ARCHITECTURE MODELING

This paper presents an algorithm that contributes to an automatic decomposition of a mechanical part based on geometric features and methods of unsupervised machine learning. For the development of the algorithm, existing techniques of 3D shape segmentation, especially surface-based part segmentation procedures are reviewed and important areas of activities are revealed. The developed multi-step approach results in an abstract product model. This representation leads to a new way of designing and redesigning parts for the novel hybrid manufacturing concept Incremental Manufacturing (IM).

<https://doi.org/10.1017/dsd.2020.144>

Alonso Fernández, Iñigo; Panarotto, Massimo; Isaksson, Ola
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IDENTIFICATION OF TECHNOLOGY INTEGRATION CHALLENGES AT TWO GLOBAL AUTOMOTIVE OEMS

Platform design has been firmly established in the automotive industry as a strategy to provide wider product variety while maintaining cost effective production. But this strategy can struggle to keep up with the pace and nature of emerging technologies. This paper reviews the existing approaches to modelling product platforms, and showcases the challenges at OEMs introducing new technological innovations in their platforms. A gap is identified in the methods to assess the ability of existing platforms to integrate new technologies whenever they become available.

<https://doi.org/10.1017/dsd.2020.314>



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Léonard, Pauline Louise Yolande; Nylander, Johanna Wallin
GKN Aerospace, Sweden

SUSTAINABILITY ASSESSMENT OF COMPOSITES IN AERO-ENGINE COMPONENTS

Environmental issues such as climate change are leading to sustainability challenges for the aerospace industry. New materials such as composites allow significant weight reduction, which leads to a lower fuel consumption. However, composites involve complex processes and there is a lack of knowledge on their social and environmental consequences. Through two cases based on real aero-engines components, this paper shows that the weight savings provided by composites reduce significantly the CO₂ emissions during flight which compensates the environmental drawbacks from production and recycling.

<https://doi.org/10.1017/dsd.2020.29>

Horrell, Mike; Shekar, Aruna; McLaren, Sarah
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USE OF DESIGN OF EXPERIMENTS TO OPTIMISE THE ENVIRONMENTAL PERFORMANCE OF CONSUMER PRODUCTS: A CASE STUDY OF SHOWERS AND TAPWARE IN NEW ZEALAND

Eco-tools and techniques often lack guidance and a robust methodology for improving the environmental performance of products with an active use phase. A case study was undertaken to investigate the role of Design of Experiments (DoE) in providing insights to improve the environmental performance of two product categories with active use phases: showers and tapware. The results show how varying the components can reduce energy use and demonstrated how DoE can be used as an objective method for optimising a products environmental performance when user behaviour can influence the results.

<https://doi.org/10.1017/dsd.2020.269>

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DESIGN FOR SUSTAINABLE BEHAVIOR: OPPORTUNITIES AND CHALLENGES OF A DATA-DRIVEN APPROACH

The article stems from the main informative gaps of Design for Sustainable Behaviour and discusses the paramount role of a data-driven approach to inform design. The article stresses how quantitative data can address global sustainability, determine behaviours to modify, measure the impact of new learned sustainable behaviours as well as support the definition of behaviour change strategies, widening the spatial and temporal scales to communities and longitudinal studies and reducing unpredictable biases coming from tacit knowledge externalization and interpretation.

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Syal, Sita M.; MacDonald, Erin F.

Stanford University, United States of America

QUANTIFYING THE UNCERTAINTY OF SOLAR PHOTOVOLTAIC SOFT COSTS IN THE "COST OF RENEWABLE ENERGY SPREADSHEET TOOL" (CREST) MODEL

While solar photovoltaics are projected to grow, major financial barriers exist that impede installation. Soft costs (human-driven costs) can account for over half of total project costs and are often simplified in typical models. We use the National Renewable Energy Laboratory's "Cost of Renewable Energy Spreadsheet Tool" to quantify uncertainty of three soft cost inputs and their influence on the output cost of energy using variance-based sensitivity indices. We then suggest how the development process and model can be redesigned to represent the complexities of this socio-technical system.

<https://doi.org/10.1017/dsd.2020.171>

Kwok, Sze Yin; Schulte, Jesko; Hallstedt, Sophie I.

Blekinge Institute of Technology, Sweden

APPROACH FOR SUSTAINABILITY CRITERIA AND PRODUCT LIFE-CYCLE DATA SIMULATION IN CONCEPT SELECTION

Companies struggle with identifying relevant sustainability aspects strategically, assessing alternative solutions quantitatively, and making trade-offs. This paper reports results from a prescriptive study with an aerospace company, and presents the Sustainability Criteria And product life-cycle Data Simulation (SCADS) approach. Based on strategic integration of sustainability indicators, this approach aims to enable visualisation and comparison of the sustainability implications of different concepts in early design phases of product development.

<https://doi.org/10.1017/dsd.2020.297>

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Juranić, Jasmin; Pavković, Neven; Jurinić, Dominik
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MANAGEMENT OF DESIGN ITERATIONS ON COUPLED PARAMETERS IN DESIGN TEAMWORK USING MULTIPLE DOMAIN MATRIX AND COLOURED PETRI NETS

A new way of structuring and interpretation of multiple domain matrix is proposed as the basis for categorisation of design parameter relations complexity. Depending on the kind and the degree of coupling of the parameters, the developed methodology activates the appropriate coloured Petri net (CPN) models for semi-automatic support of communication between the members of the design team. The proposed extension of MDM combined with CPN is a novel approach to predicting and managing communication patterns necessary during teamwork coordination on critical interfaces between product components.

<https://doi.org/10.1017/dsd.2020.264>

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TOWARDS A FRAMEWORK FOR INTEGRATED AND COLLABORATIVE KNOWLEDGE MANAGEMENT FOR ENGINEERING DESIGN – A CASE STUDY

In automotive industry, the design process is costly and time-consuming. Car safety is a crucial factor in the development of a vehicle, which is why crash simulation is an essential step in the design process. To improve car crash simulation analysis, it is necessary to reduce the time required and support the resolution of encountered design issues. We propose a knowledge management approach to support car crash simulation analysis and ensure the collaboration of different stakeholders. In a knowledge-intensive context, we used an ontology-based approach to formalise and capture knowledge.

<https://doi.org/10.1017/dsd.2020.136>

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Wöhr, Ferdinand⁽¹⁾; Stanglmeier, Max⁽¹⁾; Königs, Simon⁽¹⁾; Zimmermann, Markus⁽²⁾
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SIMULATION OF GRADIENT-BASED INDIVIDUAL DESIGN BEHAVIOUR IN DISTRIBUTED DEVELOPMENT PROCESSES

As current vehicle development processes in the automotive industry are highly distributed, the interaction between design teams is limited. In this paper we use a simulation in order to investigate how the rate of design team interaction affects the solution quality and development cost. Results show, that in case of no limiting constraints, a low rate of interaction yields the best results regarding solution quality and development cost. If design activities are affected by constraints, however, the rate of interaction is subject to a conflict between solution quality and development cost.

<https://doi.org/10.1017/dsd.2020.51>

Nguyen, Quynh Trang; Mougenot, Céline
Imperial College London, United Kingdom

DIMENSIONS OF MULTIDISCIPLINARY COLLABORATION: A COMPARATIVE LITERATURE REVIEW WITHIN DESIGN CONTEXT

In this paper, we review empirical studies of multidisciplinary collaboration in design and innovation activities. From 200 papers, we selected 17 for a meta-synthesis review. When revisited and compared, they present common themes and dichotomy in findings. This literature review discusses such diversity, offering a methodological critique of unclear areas. Four emerged themes were identified: (1) Knowledge diversity, (2) Trust, (3) Barrier and (4) Jargon and communication, providing perspectives for further research on how online collaboration will influence multidisciplinary team processes.

<https://doi.org/10.1017/dsd.2020.325>



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Stadler, Sebastian ⁽¹⁾; Cornet, Henriette ⁽¹⁾; Mazeas, Damien ⁽¹⁾;
Chardonnet, Jean-Rémy ⁽²⁾; Frenkler, Fritz ⁽³⁾

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IMPRO: IMMERSIVE PROTOTYPING IN VIRTUAL ENVIRONMENTS FOR INDUSTRIAL DESIGNERS

Computer-Aided Design (CAD) constitutes an important tool for industrial designers. Similarly, Virtual Reality (VR) has the capability to revolutionize how designers work with its increased sense of scale and perspective. However, existing VR CAD applications are limited in terms of functionality and intuitive control. Based on a comparison of VR CAD applications, ImPro, a new application for immersive prototyping for industrial designers was developed. The user evaluations and comparisons show that ImPro offers increased usability, functionality, and suitability for industrial designers.

<https://doi.org/10.1017/dsd.2020.81>

Brinkmann, Jens Thomas; Wynn, David C.

The University of Auckland, New Zealand

ASSESSING, AGGREGATING AND VISUALISING PRELIMINARY DESIGN INFORMATION MATURITY TO SUPPORT COLLABORATIVE DESIGN

Engineering projects involve the progressive development of preliminary information until a final design is reached. Appreciating its status may help make better decisions about task sequencing and may reduce unnecessary iteration. We present an approach to 1) elicit this maturity, 2) aggregate several of its facets per subsystem and generate insights for task prioritisation, and 3) overlaying this information in Augmented Reality onto a physical prototype. The progress is discussed and it is proposed that the approach can aid understanding, communication and management of design progress.

<https://doi.org/10.1017/dsd.2020.65>

Bravo, Andrea; Maier, Anja M.

DTU-Technical University of Denmark, Denmark

IMMERSIVE VISUALISATIONS IN DESIGN: USING AUGMENTED REALITY (AR) FOR INFORMATION PRESENTATION

Immersive visualisations introduce new possibilities for experiencing design, and as such for presenting information. To date, studies in design have focused mostly on immersive visualisations supporting product decisions. However, little attention has been paid to information presentation, e.g. in design reviews, for decisions in the boardroom, and/or for client presentations. This study with industry practitioners identifies information presentation practices and challenges, develops an immersive visualisation prototype, and explores opportunities for the use of immersive visualisations.

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Gräßler, Iris; Pottebaum, Jens

Paderborn University, Germany

IMMERSIVE ABSTRACTION: A NEW MORPHOLOGY OF INTUITIVE INTERACTION WITH SYSTEM MODELS

The value of models is well recognised in product and systems engineering. Modelling languages and diagrams are used to capture mental models and to handle model complexity. Literature research indicates that there are only very few approaches to utilise the potential of virtual and augmented reality for supporting tasks in model based (systems) engineering. The paper at hand contributes a new morphology of intuitive interaction for Immersive Abstraction as a holistic approach to extend that coverage. It presents a holistic framework to categorise solutions and future research directions.

<https://doi.org/10.1017/dsd.2020.158>

Ramsaier, Manuel ⁽¹⁾; Stetter, Ralf ⁽¹⁾; Till, Markus ⁽¹⁾; Rudolph, Stephan ⁽²⁾

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ABSTRACT PHYSICS REPRESENTATION OF A BALANCED TWO-WHEEL SCOOTER IN GRAPH-BASED DESIGN LANGUAGES

This paper presents a novel approach to include a holistic description of abstract physics in a digital engineering framework. Physical phenomena realize the numerous functions of technical systems and are an important link between rather abstract product functions and the concrete product geometry and material. Until now, a possibility to integrate the analysis and synthesis on this level of abstraction into a holistic engineering frameworks is not existing. The novel approach employs graph-based design languages using UML for this endeavour; the product example is a two-wheel scooter.

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Thoring, Katja ^(1,2); **Mueller, Roland M.** ^(3,4); **Giegler, Sandra** ⁽¹⁾; **Badke-Schaub, Petra** ⁽²⁾
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FROM BAUHAUS TO DESIGN THINKING AND BEYOND: A COMPARISON OF TWO DESIGN EDUCATIONAL SCHOOLS

This paper compares two pioneering design educational approaches: the historic Bauhaus school founded in 1919 in Germany, and contemporary design thinking education, based on the example of the "HPI School of Design Thinking". We compare both approaches according to six emerging categories: (1) curriculum, (2) multi-disciplinarity, (3) mind-set and culture, (4) study environment, (5) conditions for innovation, and (6) socio-economic context. We outline differences and similarities and discuss the possible impact for future design education.

<https://doi.org/10.1017/dsd.2020.19>

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ENTREPRENEURIAL MINDSET DEVELOPMENT IN BUSINESS AND ENGINEERING EDUCATION – AN EXPERIMENT

This paper presents an experimental comparative study into the entrepreneurial mindset of engineering and business students at a Canadian University. The study wants to test if the discipline has an effect on students' perceptions of their entrepreneurial mindsets, when engaged in a similar educational approach. Key findings show that entrepreneurship can be taught and that there are differences in mindset change related to the discipline.

<https://doi.org/10.1017/dsd.2020.71>

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MEASURING THE VALUE OF SYSTEMS THINKING FOR DESIGN-CENTRIC ENGINEERING EDUCATION

Systems thinking, design thinking and strategic thinking have been identified as important competencies for future engineers. Many institutions have introduced these subjects into their engineering courses. However, there is need for a deeper appreciation of the underlying assumptions behind these strands of thinking and ways to measure their impact. This paper draws on a four-year experience in implementing systems thinking in a design-centric engineering program in India. It presents the approach adopted and a complexity-based measure to track development in systems thinking competence.

<https://doi.org/10.1017/dsd.2020.72>

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STATE OF DESIGN EDUCATION IN SINGAPORE – INSIGHTS FROM DESIGN EDUCATION SUMMIT 2018

This study aims to understand the main issues in design education and discuss solutions. We conducted two workshops on the state of implementation of design in the Singaporean education system at the Design Education Summit, a conference for educators. We found that the main issues were the inclusion of design education within curriculum and change of stakeholder mindsets. Several solutions were discussed, such as ways to introduce design as part of the organization culture. We summarize results into action items and recommendations.

<https://doi.org/10.1017/dsd.2020.79>

Guaman-Quintanilla, Sharon ^(1,2); **Chiluiza, Katherine** ⁽¹⁾; **Everaert, Patricia** ⁽²⁾; **Valcke, Martin** ⁽²⁾

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MAPPING IMPACT OF DESIGN THINKING IN TEAMWORK, PROBLEM-SOLVING AND CREATIVITY

The present study analyzes the impact of a Design Thinking course on undergraduate students during an academic term. The impact was measured on three key outcomes: teamwork, problem-solving and creativity; using VALUE rubrics. The evaluation was carried out at three different moments during the course. Three types of evaluators participated: facilitators, students (self-evaluation) and peers. The results show statistically significant improvement on the three outcomes comparing students' initial and final performance. Despite the promising results, the current study has some limitations.

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Söderlund, Carina; Florin, Ulrika; Lundin, Jonatan; Uggla, Karolina
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PARTICIPATORY INVOLVEMENT AND MULTITHEORETICAL PERSPECTIVES IN VISUAL MANAGEMENT DESIGN

This paper deals with the development of participatory methods in visual management (VM) when investigating parts and system/s related to VM devices in organisational contexts. Four theoretical perspectives – sociocultural theory, boundary objects, diagrams, maps and models, and visual rhetoric – have been applied to gain an overall understanding of the participants' collective investigation of the system/s. Managers and co-workers in five Lean-inspired organisations have used the method Multimodal Origami (MO) to design their VM devices, in this case the VM boards and associated meetings.

<https://doi.org/10.1017/dsd.2020.46>

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THE USER-DRIVEN MINIMUM FEASIBLE PRODUCT – TOWARDS A NOVEL APPROACH ON USER INTEGRATION

User integration is a key aspect of new product development. When applying corresponding methods, however, there is a communication gap that needs to be overcome by the designer. Prototyping is a means to bridge this disjunction, yet brings its own set of hermeneutic limitations. Taking a closer look at the processual information exchange, we propose the concept of the user-driven minimum feasible product (UD-MFP). It describes the artefact generated by the users themselves in their specific context, which contains the essence of the problem's solution as a possible source of validation.

<https://doi.org/10.1017/dsd.2020.49>

Yashmi, Negin⁽¹⁾; Momenzadeh, Elham⁽¹⁾; Taghipour Anvari, Sara⁽²⁾; Adibzade, Paria⁽³⁾; Moosaviipoor, Mehrzad⁽⁴⁾; Sarikhani, Mohammad⁽¹⁾; Feridouni, Kiarash⁽¹⁾

¹Bahar E-Commerce Services, Iran; ²University of Tehran, Iran; ³Tehran University of Art, Iran;

⁴infinityDesign, Iran

THE EFFECT OF INTERFACE ON USER TRUST; USER BEHAVIOR IN E-COMMERCE PRODUCTS

In this analytical research, the dependency of trust on the user interface in e-commerce has been reviewed. The approach of this case study on payment gateways (PGs) was a combination of the cross-sectional analysis and empirical study. First, the situation of a PG was evaluated in the marketing campaign. Then, the UI of 8 famous PGs was redesigned and 160 volunteers ranked the credibility of each page. Finally, the highest-ranked page was implemented, and the campaign was repeated. Results showed the users who trusted increased from 23.4% to 54.5% due to a new UI design.

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DISCERNING BEHAVIOURAL DESIGN: A CONCEPTUAL MODEL

Behavioural design has emerged as an important domain of design practice and research due to its ability to deliver the desired outcomes beyond technical designs. Research on behavioural design is not successful in discerning it from other design domains, which is important for theory building. This paper discerns the unique characters of behavioural design by tracing the emergence of behaviour in design. Twelve interviews from six behaviour design cases belonging to four firms has been used to further discern the unique characteristics resulting into the conceptual model of behavioural design.

<https://doi.org/10.1017/dsd.2020.167>

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TOWARD A COMPREHENSIVE DEFINITION OF THE NON-USER

The user has been very well defined over the last decades. With human-centered design becoming more widely applied within various industries, the user's needs are being taken into account more than ever. What is often overlooked is the user's counterpart: the non-user. Integrating the non-user into modern development projects provides great additional value. This paper is compiling current definitions in order to analyse them within the context of product development and to make a contribution toward a comprehensive definition of the non-user that can be applied to various disciplines.

<https://doi.org/10.1017/dsd.2020.124>

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Eisenmann, Matthias; Matthiesen, Sven
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IDENTIFYING REASONS FOR A LACK OF METHOD APPLICATION IN ENGINEERING DESIGN PRACTICE – AN INTERVIEW STUDY

Design methods are seldom used in engineering design practice. The presented study aims at finding the alternative strategies for situations with a need for methodological support. Semi-structured interviews were conducted with ten experienced design engineers to identify causes of and strategies for those situations. Three strategy clusters could be identified: generating information, experience and method application. As the individual's and the team's experience compete with the application of methods, they are seen as reasons for a lack of method application.

<https://doi.org/10.1017/dsd.2020.261>

Eikevåg, Sindre Wold; Kvam, Andris; Bjølseth, Magnus Kjærnet; Erichsen, Jørgen Falck; Steinert, Martin
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DESIGNING AN EXPERIMENT FOR EVALUATING SEATING POSITIONS IN PARALYMPIC ROWING

When designing high performance sports equipment for Paralympic athletes, there are many unknowns for the design engineer to consider. The design challenge is an optimisation task per individual athlete. However, modelling this optimisation is difficult due to the many variables. This article presents the design of an experiment for identifying and evaluating various seating positions in Paralympic rowing by using a rowing ergometer with a modified seat. Results indicate that changing seating position has a substantial impact on per-athlete rowing performance.

<https://doi.org/10.1017/dsd.2020.101>

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DESIGN OF AN ACTIVE SEAT SUSPENSION FOR A PASSENGER VEHICLE

The design of an active seat suspension for a mid-class passenger vehicle based on the given set of requirements is considered a combination of four subsystems; the carrier, the actuator, the spring, and the damper. The design of the former two is considered through the 10 and 16 concepts for each, respectively. Two overall designs are proposed for further development. One based on a dual Scott-Russell mechanism and one based on Sarrus mechanism. The first one is evaluated to have high stiffness, the second to be more cost-effective. The detailed design of the first concept is presented.

<https://doi.org/10.1017/dsd.2020.119>

Iuskevich, Ilija^(1,2); Hein, Andreas Makoto⁽¹⁾; Amokrane-Ferka, Kahina⁽²⁾; Doufene, Abdelkrim⁽²⁾; Jankovic, Marija⁽¹⁾
¹CentraleSupélec, France; ²IRT SystemX, France

A DISCRETE-EVENT SIMULATION MODEL FOR DRIVER PERFORMANCE ASSESSMENT: APPLICATION TO AUTONOMOUS VEHICLE COCKPIT DESIGN OPTIMIZATION

The latest advances in the design of vehicles with the adaptive level of automation pose new challenges in the vehicle-driver interaction. Safety requirements underline the need to explore optimal cockpit architectures with regard to driver cognitive and perceptual workload, eyes-off-the-road time and situation awareness. We propose to integrate existing task analysis approaches into system architecture evaluation for the early-stage design optimization. We built the discrete-event simulation tool and applied it within the multi-sensory (sight, sound, touch) cockpit design industrial project.

<https://doi.org/10.1017/dsd.2020.157>



Schweigert-Recksiek, Sebastian; Udo Lindemann
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CHOOSING THE RIGHT MEASURES TO IMPROVE COLLABORATION BETWEEN DESIGN AND SIMULATION DEPARTMENTS

Increasing complexity of products and design processes leads to intensive collaboration of different stakeholders in technical product development. This causes a demand for suitable methods of collaboration across department interfaces, as between design and simulation. The paper investigates typical barriers of collaboration at this interface and measures to overcome them. Methods of complexity management form links based on literature and empirical data from online surveys and interview studies. The framework uses a set of structural metrics to analyse collaboration networks systematically.

<https://doi.org/10.1017/dsd.2020.57>

Stal-Le Cardinal, Julie
CentraleSupélec, France

STEREOTYPES AND PERCEPTIONS OF GENDER EQUALITY IN GLOBAL CORPORATIONS IN EUROPE AND THE USA – SUMMARY OF RESULTS FROM EUROPEAN COMPANIES

While women are underrepresented in leadership across the industrial western world, there is a dearth of empirical evidence on how these stereotypes play out across cultural contexts, and their relative strengths. Our goal was to launch an ambitious comparative survey study of global corporations to increase knowledge on how gender stereotypes operate across cultures, and employee perceptions of gender equality in the workplace. The results provide a better understanding of the obstacles to women's professional development and identify levers for promoting gender diversity in large groups.

<https://doi.org/10.1017/dsd.2020.275>

Vettorello, Mattia; Eisenbart, Boris; Ranscombe, Charlie
Swinburne University of Technology, Australia

PARADOXICAL TENSION: BALANCING CONTEXTUAL AMBIDEXTERITY

The concepts of high-velocity, complexity and interdependency are nowadays vividly discussed in design-led innovation management. Design organisations seek to manage innovation in a more dynamic way to ensure competitive advantage and long-term competitiveness. Contextual ambidexterity is advised to be a dynamic capability that can facilitate firms to effectively manage incremental and radical innovation alike. This paper proposes an approach that focuses on the individual and the underlying thinking which bases its foundations on ambidextrous leadership, abductive reasoning and strategic fit.

<https://doi.org/10.1017/dsd.2020.74>

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Holliman, Alexander; Thomson, Avril; Hird, Abigail
University of Strathclyde, United Kingdom

COLLABORATIVE PROJECT BRIEF SCORECARD METHOD: EVALUATING PRODUCT DESIGN PROJECTS TO AID DESIGN EFFORT ESTIMATION

Designers use their tacit knowledge to estimate project design effort needs, which can be enhanced through the understanding of the factors that most influence those needs. Evaluating and assessing project briefs against these factors can assist designers when planning their projects. The Collaborative Project Brief Scorecard (CPDS) Method identifies those factors and produces a scorecard for designers to evaluate project briefs based on these factors and allows for project comparisons, aids in past project recall and provides a focal point for collaborative reflection on design activities.

<https://doi.org/10.1017/dsd.2020.298>

Wilmsen, Miriam⁽¹⁾; Gericke, Kilian⁽²⁾; Jäckle, Michael⁽¹⁾; Albers, Albert⁽¹⁾
¹Karlsruhe Institute of Technology, Germany; ²University of Rostock, Germany

METHOD FOR THE IDENTIFICATION OF REQUIREMENTS FOR DESIGNING REFERENCE PROCESSES

A reference process should consider to the needs and behaviors of the process users, as well as all relevant restrictions and boundary conditions within the company and its environment. Therefore, this contribution provides a method to synthesize relevant requirements on reference processes and supports the consideration of these requirements during the design of a new, company-specific reference process based on meta-models. The developed method was used to design a reference process for automotive predevelopment projects and its applicability and usefulness was evaluated successfully.

<https://doi.org/10.1017/dsd.2020.301>

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Gräßler, Iris; Thiele, Henrik; Scholle, Philipp
Paderborn University, Germany

ASSESSING THE FUTURE: METHODS AND CRITERIA

As time-to-market is getting shorter, customer needs have to be identified as early as possible in product development. Correctly applied, corporate foresight can give a glimpse into the future to anticipate such needs and thus gain a competitive advantage. A support tool to choose the appropriate method of foresight is not available yet. Thus, a literature study on foresight methods in industry is performed and a novel decision support tool is proposed which avoids high entrepreneurial risks. Based on the findings, potentials for future work are identified for different types of methods.

<https://doi.org/10.1017/dsd.2020.278>

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A FRAMEWORK FOR TECHNOLOGY DRIVEN DESIGN: CRITICALITY AND COMFORT ZONE FOR EMERGING TECHNOLOGIES

This paper proposes an analytical framework for estimating the domain where a type of technology can be used in a system. In order to achieve this aim, we have elaborated on the concepts of technology critical, technology sensitive, and the technology comfort zone, to analytically assess the impact of a new technology in the early phases of system design. The result is a general method to indicate the range of requirements that can result in valid designs. This tool can assist in the decision-making processes for technology portfolio selection based on sustainable principles.

<https://doi.org/10.1017/dsd.2020.281>

Weinreich, Simon⁽¹⁾; Şahin, Tarık⁽¹⁾; Inkermann, David⁽²⁾; Huth, Tobias⁽¹⁾; Vietor, Thomas⁽¹⁾

¹Technische Universität Braunschweig, Germany; ²Technische Universität Clausthal, Germany

MANAGING DISRUPTIVE INNOVATION BY VALUE-ORIENTED PORTFOLIO PLANNING

Innovation portfolio management (IPM) aims at selecting ideas with regard to their potential for innovation and measuring them considering customer and business value. The evaluation of benefits and risk is especially challenging for disruptive innovation (DI) due to their characteristics such as low comparability to existing technologies and uncertain customer reactions. This paper highlights the lack of approaches to managing DI in IPM and addresses it through a framework that expands the understanding of value-orientation in IPM, allowing for the inclusion of DI.

<https://doi.org/10.1017/dsd.2020.155>



Faidi, Safa; Olechowski, Alison
University of Toronto, Canada

IDENTIFYING GAPS IN AUTOMATING THE ASSESSMENT OF TECHNOLOGY READINESS LEVELS

Crucial in the design process, Technology Readiness Levels are a common form of technology maturity assessment. Studies suggest that the TRL scale can be subjective and biased. Automating the assessment can reduce human bias. This paper highlights important challenges of automation by presenting data collected on 15 technologies from the nanotechnology sector. Our findings show that, contrary to claims from the literature, patent data exists for low maturity technologies and may be useful for automation. We also found that there exists unexpected trends in data publications at TRL 2, 3 and 4.

<https://doi.org/10.1017/dsd.2020.160>

Gräßler, Iris; Scholle, Philipp; Thiele, Henrik
Paderborn University, Germany

IMPROVING SCENARIO-TECHNIQUE BY A SEMI-AUTOMATIZED CONSISTENCY ASSESSMENT BASED ON PATTERN RECOGNITION BY ARTIFICIAL NEURAL NETWORKS

To enhance the success of innovations, various methods for foresight have been developed. Automatization yields the potential of shifting effort away from the process to the actual in-depth analysis of resulting scenarios in scenario-technique. Within this paper, an approach based on a user-specific classification of input factors (consistency values) is presented. Generic consistency patterns used for a semi-automatized consistency assessment based on artificial neural networks are identified using a case study approach. Hereby, the effort for scenario-technique can be reduced significantly.

<https://doi.org/10.1017/dsd.2020.279>



Grauberger, Patric; Bremer, Frank; Sturm, Carolin; Hoelz, Kevin; Wessels, Holger; Gwosch, Thomas; Wagner, Raphael; Lanza, Gisela; Albers, Albert; Matthiesen, Sven

Karlsruhe Institute of Technology, Germany



QUALITATIVE MODELLING IN EMBODIMENT DESIGN – INVESTIGATING THE CONTACT AND CHANNEL APPROACH THROUGH ANALYSIS OF PROJECTS

Purposeful qualitative modelling of embodiment function relations is a challenge in embodiment design. This contribution investigates the applicability and usefulness of the Contact and Channel Approach as a qualitative modelling approach in a survey study. From 23 development and research projects, advantages and challenges regarding applicability and usefulness are identified. A further result is that many different models are used additionally to the Contact and Channel Approach. Based on the findings, research potential for optimization and development of links to other models emerges.

<https://doi.org/10.1017/dsd.2020.260>

Formentini, Giovanni⁽¹⁾; Favi, Claudio⁽¹⁾; Bouissiere, Francois⁽²⁾; Cuiller, Claude⁽²⁾; Dereux, Pierre-Eric⁽²⁾; Guillaume, Romain⁽²⁾; Malchair, Corentin⁽²⁾

¹University of Parma, Italy; ²Airbus S.A.S., France

EXTRAPOLATION OF DESIGN GUIDELINES DURING THE CONCEPTUAL DESIGN PHASE: A METHOD TO SUPPORT PRODUCT ARCHITECTURE DESIGN

The work aims at the definition of a design methodology able to drive designers in the definition of product architectures, starting from rough information available at the conceptual design. The methodology identifies design guidelines useful for the development of product architectures optimized for a given target (i.e. assembly, cost). The methodology is based on domains which combine attributes related to a specific aspect of the target. The exploratory application of the methodology was performed to address the equipment installation of a civil aircraft for assembly/installation target.

<https://doi.org/10.1017/dsd.2020.26>

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COST OPTIMIZATION OF PRODUCT FAMILIES USING SOLUTION SPACES

Maximizing the number of shared components does not always produce cost-optimal product families. Shared components can yield economies of scale due to reuse of components, but also increases material cost due to over dimensioning. In this paper, we present an approach to identify a cost-optimal design for product families. It consists of two steps: (1) identifying a scheme to share components in the product family and (2) finding the cost optimal design for the product family.

<https://doi.org/10.1017/dsd.2020.178>

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Jin, Xiaoneng⁽¹⁾; Dong, Hua⁽²⁾

¹Tongji University, China; ²Loughborough University, United Kingdom

NEW DESIGN HEURISTICS IN THE DIGITAL ERA

In the digital era, products' forms do not necessarily follow their function. Design fixation may happen when a designer attempts to generate diverse concepts. New design heuristics for digital design were extracted to support designers in the early conceptual design stage. Ten design heuristics were extracted from 998 RedDot award-winning concept designs (2013-2017) through a five-step process. It was preliminarily tested by four practitioners and proved to have positively influenced their conceptual design.

<https://doi.org/10.1017/dsd.2020.321>

Friedrich, Timo; Schmitt, Sebastian; Menzel, Stefan

Honda Research Institute Europe GmbH, Germany

RAPID CREATION OF VEHICLE LINE-UPS BY EIGENSPACE PROJECTIONS FOR STYLE TRANSFER

In product development, an automated generation of shape variations enables a rapid assessment of potentially appealing design directions. We present a framework for computing a product line-up of automotive body shapes based on spectral methods for mesh processing. We calculate the eigenspace projections of 3D vehicle meshes and identify the relevant style as well as content components based on the eigenvalues. The style of a model is then transferred to arbitrary prototype content car shapes, which allows for a rapid portfolio generation of various car types with minimal user interaction.

<https://doi.org/10.1017/dsd.2020.162>

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Berni, Aurora; Maccioni, Lorenzo; Borgianni, Yuri
Free University of Bozen-Bolzano, Italy

AN EYE-TRACKING SUPPORTED INVESTIGATION INTO THE ROLE OF FORMS OF REPRESENTATION ON DESIGN EVALUATIONS AND AFFORDANCES OF ORIGINAL PRODUCT FEATURES

The paper investigates the relationship between the forms through which products are represented and the outcomes of evaluations made by observers. In particular, the study focuses on perceived affordances of creative designs, meant as the capability of capturing original elements and corresponding functions, for products presented through static images or videos. Also thanks to the use of Eye Tracking, the experimental results show how dynamic effects that involve salient aspects of products, as well as creative features, are critical to observers' capability of capturing design intentions.

<https://doi.org/10.1017/dsd.2020.296>

Nolte, Hannah; McComb, Christopher

The Pennsylvania State University, United States of America

IDENTIFYING STRESS SIGNATURES ACROSS THE ENGINEERING DESIGN PROCESS: PERCEIVED STRESS DURING CONCEPT GENERATION, CONCEPT SELECTION, AND PROTOTYPING

Various aspects of the design process often lead to stress. This study used pre- and post-task surveys to gather information regarding the designer's cognitive experience, physiological response, and perceived sources of stress during concept generation, concept selection, and prototyping. Results confirmed that design is highly cognitive, and that mental stress is present. Variability in the results also suggests that a physiological stress component might be present. Additionally, perceived sources of stress were examined, and recommendations were offered for instructors of design courses.

<https://doi.org/10.1017/dsd.2020.69>

Vieira, Sonia ⁽¹⁾; Gero, John ⁽²⁾; Gattol, Valentin ⁽³⁾; Delmoral, Jessica ⁽⁴⁾; Li, Shumin ⁽¹⁾; Cascini, Gaetano ⁽¹⁾; Fernandes, Antonio ⁽⁴⁾

¹Politecnico di Milano, Italy; ²UNC Charlotte, United States of America; ³AIT Austrian Institute of Technology, Austria; ⁴University of Porto, Portugal

THE NEUROPHYSIOLOGICAL ACTIVATIONS OF NOVICE AND EXPERIENCED PROFESSIONALS WHEN DESIGNING AND PROBLEM-SOLVING

We present results from an EEG experiment EEG to measure neurophysiological activation to study novice and experienced designers when designing and problem-solving. We adopted and extended the tasks described in a previous fMRI study. The block experiment consists of 3 tasks: problem-solving, basic design, and open layout design. The block is preceded by a familiarizing pre-task and extended to an open design sketching task. Results from 36 sessions of mechanical engineers and industrial designers indicate significant differences in activations between the problem-solving and the design tasks.

<https://doi.org/10.1017/dsd.2020.121>



Pooripanyakun, Munyaporn; Wodehouse, Andrew; Mehnen, Jorn
University of Strathclyde, United Kingdom

THE EFFECT OF TIME PRESSURE ON THE PERFORMANCE OF DEXTEROUS OPERATIONS

This study explores the effects of time pressure in dexterous operations on two types of interface: the fixed interface and the moving interface. Results show that the accuracy of finger movement is decreased, the information processing on the sense of sequence, position and direction is worsened by the psychological disturbance. The findings indicate that a fixed interface is more robust to performance and participants can learn and perform tasks quicker than a moving interface. Finally, the researchers give some practices on both fixed and moving interface design.

<https://doi.org/10.1017/dsd.2020.149>

Colombo, Samuele ⁽¹⁾; Mazza, Alessandro ⁽²⁾; Montagna, Francesca ⁽¹⁾; Ricci, Raffaella ⁽²⁾; Dal Monte, Olga ⁽²⁾; Cantamessa, Marco ⁽¹⁾

¹Politecnico di Torino, Italy; ²University of Turin, Italy

NEUROPHYSIOLOGICAL EVIDENCE IN IDEA GENERATION: DIFFERENCES BETWEEN DESIGNERS AND ENGINEERS

The paper describes the rigorous implementation of a validated methodological experimental protocol to divergent and convergent thinking tasks occurring in Design by neurophysiological means (EEG and eye-tracking). EEG evidence confirms the findings coherently to the literature. Interesting is the confirmation of such results through eye-tracking ones, and further evidence emerged. In particular, neurophysiological results in idea generation differ between designers and engineers. This study was supported by a multidisciplinary team, both for the neuropsychological and data analysis aspects.

<https://doi.org/10.1017/dsd.2020.161>



Hommel, Patrick; Roth, Daniel; Binz, Hansgeorg
University of Stuttgart, Germany

DEFICITS IN THE APPLICATION OF ALUMINUM FOAM SANDWICH: AN INDUSTRIAL PERSPECTIVE

Aluminum foam sandwich (AFS) is an innovative sandwich material for designing lighter products and has many advantages such as high stiffness and high mechanical-energy absorption capacity. Although AFS is ready for series production, the number of use cases is low. A survey was carried out in order to identify the obstacles in the application of aluminum foam sandwich. This paper presents the results of the survey, derives the demand for a support method for designing with aluminum foam sandwich and shows various support options to simplify the application of the material.

<https://doi.org/10.1017/dsd.2020.13>

Revfi, Sven⁽¹⁾; Wilwer, Jürgen⁽¹⁾; Behdinin, Kamran⁽²⁾; Albers, Albert⁽¹⁾
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DESIGN READINESS OF MULTI-MATERIAL CONCEPTS: MANUFACTURING AND JOINING TECHNOLOGY INTEGRATED EVALUATION OF CONCEPT MATURITY LEVELS USING CARDINAL COEFFICIENTS

Maturity levels of components in early phases of product development are often assessed with Technology Readiness Levels. However, developing Multi-Material-Design (MMD) concepts for lightweight design, not only the manufacturability of the individual components is decisive, but also their joinability with each other and their integration into the rest system. This paper presents an approach for the evaluation of maturity levels of MMD concepts on the basis of cardinal coefficients considering a time forecast of the manufacturing and joining technologies required in the concept.

<https://doi.org/10.1017/dsd.2020.274>

Uttich, Eike Sebastian; Bartz, Marcel; Bender, Beate
Ruhr-Universität Bochum, Germany

EXAMINING THE TENSION CHORDING PRINCIPLE FOR A BEAM UNDER TORSION LOAD

Tension chording is a lightweight design principle in the human motion system. More muscles than necessary are available in this system to generate motion. By using these redundant muscles the principle contributes to the lightweight design of the motion segments. The lightweight design benefits of the principle for technical structures loaded with bending torques were shown in prior studies. This paper presents a pilot study on lightweight design benefits of using tension chording for torsion loaded structures.

<https://doi.org/10.1017/dsd.2020.60>

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Schmitt, Pascal; Gericke, Kilian
University of Rostock, Germany

FACTORS INFLUENCING THE DECISION OF CONVENTIONAL/HYBRID LIGHTWEIGHT DESIGN STRATEGIES AND THEIR EFFECT ON THE DESIGN PROCESS

Lightweight design (LWD) is partly reaching its limits. New technologies must not only be used to make products more functional, but also to make LWD more efficient. Here additive manufacturing (AM) should be named. Potentials of the use in LWD are not yet clear. In this work, existing LWD strategies and their location in the design process are presented. Criteria are worked out which influence the design process and the use of LWD strategies. The use of AM in (hybrid) LWD will be investigated in order to overcome design trade-offs and what influence its use could have on the design process.

<https://doi.org/10.1017/dsd.2020.181>

Laufer, Felix; Roth, Daniel; Binz, Hansgeorg
University of Stuttgart, Germany

AN APPROACH FOR THE MULTI-CRITERIA DERIVATION OF LIGHTWEIGHT POTENTIAL

Lightweight potential is a powerful indicator – but not as powerful as it could be. Current methods for analyzing a product's potential to be reduced in mass only deal with a few of the most important criteria for lightweight design. This paper presents an approach transferring cost-benefit analysis to the holistic derivation of lightweight potential. The approach is able to deal with different types of criteria supporting the designer in identifying the most promising components for mass reduction. An evaluation example is given showcasing a tooling machine.

<https://doi.org/10.1017/dsd.2020.21>

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Lagun Mesquita, Patricia; Missimer, Merlina
Blekinge Institute of Technology, Sweden

SUPPORTING ENGINEERING STUDENTS IN ANALYZING SOCIAL SUSTAINABILITY OF A PRODUCT: LESSONS LEARNED

Though many engineering schools are integrating sustainability in the curriculum, most are still struggling, especially with social sustainability. The aim with this study was to test a process created to help students work systematically with these issues. Results show that students in the study did indeed benefit from structured process support as their general knowledge level of social sustainability issues as well as their understanding of how to integrate them in a product assessment was very low. Reflections from teaching staff on how to further develop such a process are also shared.

<https://doi.org/10.1017/dsd.2020.266>

Kattwinkel, Daniela; Bender, Beate
Ruhr-Universität Bochum, Germany

COMPETENCES FOR THE DEVELOPMENT OF ECODESIGN PRODUCTS

To respond to today's needs, engineers must be able to develop sustainable and environmentally compatible products and systems. To do so, they have to carry out new or changed activities and tasks within the product development process and therefore have to obtain new or changed competences. This publication examines which specific competences from the competence groups system thinking and communication are especially important for the development of Ecodesign products apart from technical know-how and should thus be included in a future higher education engineering course.

<https://doi.org/10.1017/dsd.2020.43>

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Valderrama Pineda, Andres Felipe; Niero, Monia
Aalborg University Copenhagen, Denmark

WHAT IS SUSTAINABLE DESIGN ENGINEERING (SDE)? PERSPECTIVES FROM A PROBLEM-BASED LEARNING EDUCATION: M.SC. IN SDE AT AALBORG UNIVERSITY COPENHAGEN

Sustainable Design Engineering (SDE) is an emerging research field and the development of programmes aiming at educating sustainable design engineers is very limited. One example is the SDE program at the Aalborg University in Copenhagen, which is based on a Problem Based Learning (PBL) model. In this article we aim to address the following three research questions: i) why Sustainable Design Engineering? ii) what is Sustainable Design Engineering? iii) How can Sustainable Design Engineering be implemented? By means of two examples from master thesis projects in the building and food sectors.

<https://doi.org/10.1017/dsd.2020.55>

Nilsson, Susanne Carin; Norell Bergendahl, Margareta
KTH Royal Institute of Technology, Sweden

DESIGN FOR TEACHER TRAINING – TO FACILITATE STUDENT TEAMS WORKING WITH REAL-LIFE SUSTAINABILITY CHALLENGES

The aim of the study is to contribute to the knowledge on how to develop students' skills and capabilities required when addressing complex societal challenges in practice. In this paper we are investigating the design and implementation of a teacher training module focusing on improving teacher's ability to facilitate students' teams learning and collaboration skills. The feedback and learning from the design and implementation of the module at universities in Botswana, Kenya and Sweden is presented and discussed in this paper.

<https://doi.org/10.1017/dsd.2020.163>

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Wolff, Sebastian ⁽¹⁾; Auernhammer, Jan ⁽²⁾; Schockenhoff, Ferdinand ⁽¹⁾;
Angerer, Christian ⁽¹⁾; Wittmann, Michael ⁽¹⁾

¹Technical University of Munich, Germany; ²Stanford University, United States of America

MOBILITY BOX: A DESIGN RESEARCH METHODOLOGY TO EXAMINE PEOPLE'S NEEDS IN RELATION TO AUTONOMOUS VEHICLE DESIGNS AND MOBILITY BUSINESS MODEL

The future focus of research in the automotive sector will be on automation and data-driven technologies. These technologies provide new services and values to customers, owners and other stakeholders in mobility. We propose a wizard-of-oz like method to evaluate future user needs and redesign the current approach of vehicle development. The mobility box provides a modular and extendable framework to merge user centred design with vehicle data acquisition. This enables the design of services and properties for unknown mobility concepts.

<https://doi.org/10.1017/dsd.2020.285>

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ADOPTION OF INSECT-EATING THROUGH PACKAGING DESIGN

Edible insects have been introduced as a novel protein source. Although the rationales for insect-eating highlight the urgency of changing diets into more sustainable solutions, there is still a need for better understanding how packaging design is related to adoption of insects. Much consumer research has been conducted to understand the acceptance of insects, but packaging design connected to practices has been given less focus. This article looks at packaging as a medium for stimulating adoption and links an empirical study on analogies for packaging design to practices of eating insects.

<https://doi.org/10.1017/dsd.2020.336>

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Serhan, Hiam; Yannou-LeBris, Gwenola

AgroParisTech, France

SOCIOTECHNICAL INNOVATIONS OF SHORT FOOD SYSTEMS CASE STUDY OF THE CITY REGION ÎLE DE FRANCE

This paper relies on four case studies designed as short food systems aimed at coupling production, distribution, and consumption to contribute to the ecological transition of the City-Region Île-de-France. Through documentary research and interviews, we explore the growth strategies and sociotechnical innovations these short food systems implemented, and the links that can be established between these innovations, localism strategies, and the regional sustainable development.

<https://doi.org/10.1017/dsd.2020.338>

Khayamian Esfahani, Bahar

University of East London, United Kingdom

PUTTING USER IN CONTEXT: A PARTICIPATORY DESIGN APPROACH USING A SIMULATED BEACH ENVIRONMENT

The research outlined in this paper investigated the sun protection behaviour in young men age 18 to 24. Firstly, field observations were conducted on the beach where the sun protection behaviour occurs. The findings highlighted the importance of gender linked with low levels of sun protection behaviour in young men. This informed the next study through participatory design sessions using a simulated beach environment. The results showed design opportunities with taking an account of gender in sun protection behaviour which opens new avenues where design has a key role in health promotion.

<https://doi.org/10.1017/dsd.2020.331>

<https://doi.org/10.1017/dsd.2020.341>

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Stetter, Ralf ⁽¹⁾; Göser, Richy ⁽¹⁾; Gresser, Sebastian ⁽¹⁾; Witczak, Marcin ⁽²⁾; Markus Till ⁽¹⁾

¹University of Applied Sciences Ravensburg-Weingarten, Germany; ²University of Zielona Góra, Poland

FAULT-TOLERANT DESIGN OF A GEAR SHIFTING SYSTEM FOR AUTONOMOUS DRIVING

This paper reports the application of the methods and tools of fault-tolerant design to an automated shifting system and their reflection and extension. Fault-tolerant design has emerged in the last years and is generally understood as a collection of strategies, methods, algorithms, tools and insights which are intended to support the development of technical systems which are fault-tolerant because of their controllability but also their inherent fault-tolerant design qualities. The field of application is a shifting system for the gear system of a formula student driverless race car.

<https://doi.org/10.1017/dsd.2020.31>

Kong, Penny ⁽¹⁾; Cornet, Henriette ⁽¹⁾; Frenkler, Fritz ⁽²⁾;

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CLOSING THE HUMAN-MACHINE DISCONNECT: DESIGN REQUIREMENTS FOR TWO EXTREME COMPANIONS FOR FUTURE AUTONOMOUS MOBILITY

In an era of increased automation in commuters' everyday life, addressing the disconnect caused by taking the human out of the loop is critical. This paper describes the development of two extreme Companions for a public autonomous bus interface in Singapore. Attributes were identified in a benchmarking study and tested in a survey to investigate local users' key preferences for must-have and ideal-to-have traits and Companion qualities. Finally, two contrasting Companion concepts are proposed and design strategies considering user expectations of Companions versus humans are discussed.

<https://doi.org/10.1017/dsd.2020.92>

Grahle, Alexander ⁽¹⁾; Song, Young-Woo ⁽²⁾; Brüske, Konstantin ⁽¹⁾; Bender, Beate ⁽²⁾; Göhlich, Dietmar ⁽¹⁾

¹Technische Universität Berlin, Germany; ²Ruhr-Universität Bochum, Germany

AUTONOMOUS SHUTTLES FOR URBAN MOBILITY ON DEMAND APPLICATIONS – ECOSYSTEM DEPENDENT REQUIREMENT ELICITATION

Future transport will change drastically with the introduction of automated vehicles. Here, Autonomous Mobility on Demand (AMoD) will play a major role, requiring a radical change of vehicle design, with many different conceivable concepts. This technology shift holds high potentials and high risks. Uncertainties about future usage profiles, operator and customer requirements have to be dealt with. An approach to elicit initial requirements for future vehicle concepts considering the entire ecosystem is introduced. The applicability is shown for a specific urban mobility scenario.

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Henrikke, Dybvik; Erik, Veitch; Martin, Steinert;

Norwegian University of Science and Technology, Norway



EXPLORING CHALLENGES WITH DESIGNING AND DEVELOPING SHORE CONTROL CENTERS (SCC) FOR AUTONOMOUS SHIPS

The concept of remotely operated, unmanned, and autonomous ships is creating increasing interest in the maritime domain, promising safety, increased efficiency and sustainability. Shore control centers (SCCs) have been proposed to operate such vessels and some industry projects are initiated. This paper aims at bringing knowledge about what a SCC is envisioned to be. It identifies and explores challenges related to designing and developing SCCs through semi-structured interviews with the research community and industry. We discuss tasks, functions and interactions between human and machine.

<https://doi.org/10.1017/dsd.2020.131>

Robert, Graubohm; Tobias, Schröder; Markus, Maurer

Technische Universität Braunschweig, Germany

VALUE SENSITIVE DESIGN IN THE DEVELOPMENT OF DRIVERLESS VEHICLES: A CASE STUDY ON AN AUTONOMOUS FAMILY VEHICLE

Complex new functionalities and dissimilar stakeholder groups pose challenges to the requirement analysis for driverless vehicles. To overcome these challenges, we propose a value-oriented reference process for innovative functionalities of an autonomous family vehicle. The value-oriented measures are taken from the approach of Value Sensitive Design. In our application, we have found that the consideration of the human values involved is of great importance for the identification of stakeholders and the management of their potentially conflicting interests throughout the development process.

<https://doi.org/10.1017/dsd.2020.140>

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AI; THE END FOR THE DESIGNER AS WE KNOW IT?

Professor Tobias Larsson

Director of Product Development Research Lab, and Research Director in Mechanical Engineering, Blekinge Institute of Technology, Sweden



Will the introduction of AI into the design process make the designer of today obsolete and turn the design office into a Robotic Design Automation lab to match the industry4.0 facilities in production? Is there a role for human design input in future product development or will AI sweep design spaces and by itself find disruption potential in increasing tempo?

In this keynote we will explore the impact of AI to the design process, and specifically the role AI might play in the pre-production parts of the design process. The production system has seen several disruptions over the years, the most recent being the currently ongoing industry 4.0 movement aka the 4th industrial revolution. Industry 4.0 represents the trend towards automation and data exchange in manufacturing technologies and processes which include cyber-physical systems (CPS), the internet of things (IoT), industrial internet of things (IIOT), cloud computing, cognitive computing and artificial intelligence; basically creating a “dark factory” capable of high flexibility in production and with virtual interfaces towards the system, moving humans yet another step away from the factory floor. At the same time, in highly repetitive and predictable office processes, AI has made its entrance via Robotic Process Automation taking over a growing number of work tasks, feeding the theory of “robots taking my job”, and studies on what jobs might go extinct via computerisation (either via robotics or via software AI/Machine Learning bots). Following the recent technological advancements of RPA deployments in processes (office flow processes around administrative tasks), robotics deployment (industry 4.0, order picking in warehouses, agriculture robots etc.), the AI design of products (Starck AI Kartell chair, design automation in engineering design) we take a look at the design process take-over with AI; Robotic Design Automation. Grounding in industry examples and research we plot the likely course of events for the design profession and also take a look at the outskirts of dystopian and promising scenarios for the future of design.

BIOGRAPHICAL SKETCH

Starting out as a PhD with research in the area of simulation driven design within a product development context, he is continuously focusing on the digitalisation and transformation going on in industry with start in computer aided engineering processes (1996-) and more recently (2011-) on a model based digitalisation work where digital twin and IoT comes together for delivering customer value through product-service systems in a circular economy. Most of efforts are directed to simulation driven decision support in the conceptual design phase of the development of innovative product-service systems, supporting organisations in the development of innovation capability to deliver the innovative and sustainable solutions of tomorrow. He has extensive experience from applied research and projects in the intersection between academia and industry and has initiated, led, and concluded several national and international research projects. Primarily researching digitalized product development, and innovation engineering, within the aerospace, automotive and industrial sector. Healthcare sector applications is on the rise. Has been supervisor to several PhD (26) and Lic degrees (30) and currently supervisor for 10 PhD candidates. Contributed to 100+ publications within the engineering research area.



Duehr, Katharina; Hirsch, Manuel; Albers, Albert; Bursac, Nikola
Karlsruhe Institute of Technology, Germany

A METHODOLOGY TO IDENTIFY AND ADDRESS IMPROVEMENT POTENTIALS IN COMMUNICATION PROCESSES OF DISTRIBUTED PRODUCT DEVELOPMENT – AN INITIAL APPROACH

The advantages of distributed development teams help companies to address megatrends like globalization and individualization. However, development teams are facing challenges according to increasing requirements on communication processes. This approach provides a methodology to identify and address improvement potentials in communication processes of distributed product development by including the dimensions technology, organization and human involved in the development process. The validation of the methodology's process steps was carried out together with a machine tool manufacturer.

<https://doi.org/10.1017/dsd.2020.35>

Wilms, Robert^(1,2); Kronsbein, Philipp⁽¹⁾; Inkermann, David⁽³⁾; Huth, Tobias⁽¹⁾; Reik, Michael⁽²⁾; Vietor, Thomas⁽¹⁾

¹Technische Universität Braunschweig, Germany; ²Volkswagen AG, Germany; ³Technische Universität Clausthal, Germany

USING A CROSS-DOMAIN PRODUCT MODEL TO SUPPORT ENGINEERING CHANGE MANAGEMENT

Engineering changes (ECs) and engineering change management (ECM) are crucial for successful product design processes (PDP). Due to the increasing complexity of today's products (like vehicles) and the interaction of different engineering domains (mechanics, electric/electronics, software) involved in the PDP, cross-domain EC impact assessments as well as processes are required. To better support engineers in assessing change propagation across domains and products, existing approaches for ECM product models are analyzed in this paper and an enhanced product model is derived using MBSE.

<https://doi.org/10.1017/dsd.2020.90>

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Riesener, Michael; Dölle, Christian; Mendl-Heinisch, Michael; Schuh, Günther; Keuper, Alexander
RWTH Aachen University, Germany

DERIVATION OF DESCRIPTION FEATURES FOR ENGINEERING CHANGE REQUEST BY AID OF LATENT DIRICHLET ALLOCATION

Complex products and shorter development cycles lead to an increasing number of engineering changes. In order to be able to process these changes more effectively and efficiently, this paper develops a description model as a first step towards a data driven approach of processing engineering change requests. The description model is systematically derived from literature using text mining and natural language processing techniques. An example of the application is given by an automated classification based on similarity calculations between new and historic engineering change requests.

<https://doi.org/10.1017/dsd.2020.98>

Block, Lukas

University of Stuttgart, Germany

GUIDING LOCAL DESIGN DECISIONS TOWARDS A FLEXIBLE AND CHANGEABLE PRODUCT ARCHITECTURE

Flexibility and changeability are crucial when it comes to the design of embedded automotive architectures. However, flexibility and changeability are concepts rooted in the overall product and its objectives, while architectural design decisions may affect local subsystems as well as the overall system. Axiomatic design is applied to bridge this gap: The architecture is decomposed into its entities and changeability is described through the design's information content. Five domains of actions to foster changeability are identified and generic action schemes are derived.

<https://doi.org/10.1017/dsd.2020.134>

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Rapp, Simon; Altner, Moritz; Albers, Albert
Karlsruhe Institute of Technology, Germany

BENCHMARKING OF RISK MANAGEMENT METHODS WITH REGARD TO VARIATIONS AS A SOURCE OF RISK

When developing new systems, there is always some kind of reference to existing systems. Various approaches aim at describing qualitatively different characteristics of such connections, often depicted as some form of variation. Among other things, this is done with regard to innovation potential and development risk. In this paper, we investigate the extent to which established methods of risk management refer to modelling approaches for variations by means as mentioned above. After a literature search 11 methods and method clusters are analyzed more in detail within a method benchmark.

<https://doi.org/10.1017/dsd.2020.292>

Vasnier, Jean-Marc ⁽¹⁾; Maranzana, Nicolas ⁽²⁾; Messaadia, Mourad ⁽¹⁾; Aoussat, Améziane ⁽²⁾

¹CESI - Lineact, France; ²Arts et Métiers ParisTech, France

PRELIMINARY DESIGN AND EVALUATION OF STRATEGIC DASHBOARDS THROUGH THE TECHNOLOGY ACCEPTANCE MODEL

In the age of the fourth industrial revolution, the competition between enterprises is fierce to operate efficiently and hold on to their customers. Due to lack of time and methodology, many leaders struggle to establish optimized strategies for their businesses. To do so, the key processes need to be measured using dashboards that proactively help decisions making, facilitate the strategy execution and keep the employees focused. The purpose of this article is to identify the design features of a risk analysis dashboard and their effects on the perceived ease of use and perceived usefulness.

<https://doi.org/10.1017/dsd.2020.18>

Oehmen, Josef ⁽¹⁾; Guenther, Agnes ⁽²⁾; Herrmann, Jeffrey W. ⁽³⁾; Schulte, Jesko ⁽⁴⁾; Willumsen, Pelle ⁽¹⁾

¹DTU-Technical University of Denmark, Denmark; ²Copenhagen Business School, Denmark; ³University of Maryland, United States of America; ⁴Blekinge Institute of Technology, Sweden

RISK MANAGEMENT IN PRODUCT DEVELOPMENT: RISK IDENTIFICATION, ASSESSMENT, AND MITIGATION – A LITERATURE REVIEW

This paper reviews the literature on risk management practices and methods in product design and development. Based on an expert workshop by the Risk Management Processes and Methods in Design Special Interest Group within the Design Society and literature review, three key areas are discussed: risk identification, assessment, and mitigation. In each area, researchers have described practices that are used in product development organizations, proposed new methods to support risk management processes and decision-making, and generated evidence to evaluate the effectiveness of these activities.

<https://doi.org/10.1017/dsd.2020.27>

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Wichmann, Robert Lawrence ⁽¹⁾; Eisenbart, Boris ⁽¹⁾; Gericke, Kilian ⁽²⁾; Lux, Benedikt ⁽¹⁾

¹Swinburne University of Technology, Australia; ²University of Rostock, Germany

CONCEPT COMPARISON: A FUNCTION INTEGRITY INDICATOR

Comparing the propensity for risk in concepts with little commonality, such as different working principles, different number of functions and components, is challenging to achieve in a systematic and traceable manner. This paper builds on the Function Integrity Diagnosis and Documentation method to introduce a Function Integrity indicator as a means to quantitatively compare dissimilar design concepts based on risk assessment. The proposed indicator is intended to support designers converge on a suitable design concept based on considerations of risk to concept functions.

<https://doi.org/10.1017/dsd.2020.70>

Riascos Castaneda, Roberto ⁽¹⁾; Ostrosi, Egon ⁽²⁾; Majić, Tomislava ⁽³⁾; Stjepandić, Josip ⁽⁴⁾; Sagot, Jean-Claude ⁽²⁾

¹Roche Diabetes Care, Germany; ²Université Bourgogne Franche-Comté, France; ³Croatian Academy of Sciences and Arts in Diaspora and Homeland, Switzerland; ⁴PROSTEP AG, Germany

A METHOD TO EXPLORE PRODUCT RISK IN PRODUCT LIFECYCLE MANAGEMENT OF CONFIGURED PRODUCTS

Today high quality and low product development turnaround time are company-wide priorities. Quality supporting processes such as an effective risk management system shall support continuous business running and meeting the goals of an organization. In this paper, an approach is presented on how to integrate the product risk management in Product Lifecycle Management for configured products by definition of an additional software module and its implementation.

<https://doi.org/10.1017/dsd.2020.318>

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Üreten, Selin⁽¹⁾; Eisenmann, Matthias⁽²⁾; Nelius, Thomas⁽²⁾; Garrelts, Enno⁽³⁾; Krause, Dieter⁽¹⁾; Matthiesen, Sven⁽²⁾

¹Hamburg University of Technology, Germany; ²Karlsruhe Institute of Technology, Germany;

³University of Stuttgart, Germany

CURRENT CHALLENGES AND SOLUTION APPROACHES IN EMPIRICAL ENGINEERING DESIGN RESEARCH – A WORKSHOP FOR EMPIRICAL RESEARCH

The requirements on validity for studies in design research are very high. Therefore, this paper aims at identifying challenges that occur when setting up studies and suggests solution strategies to address them. Three different institutes combining their experience discussed several studies in a workshop. Resulting main challenges are to find a suitable task, to operationalise the variables and to deal with a high analysis effort per participant. Automation in data evaluation and a detailed practical guideline on studies in design research are considered necessary.

<https://doi.org/10.1017/dsd.2020.280>

Isaksson, Ola⁽¹⁾; Eckert, Claudia⁽²⁾; Panarotto, Massimo⁽¹⁾; Malmqvist, Johan⁽¹⁾

¹Chalmers University of Technology, Sweden; ²The Open University, United Kingdom

YOU NEED TO FOCUS TO VALIDATE

Many research students find challenges when validating their research. Especially when they have expectations to contribute to both practice and the research body of knowledge. This paper argues that a key to successful validation of design research lies in the ability to focus on what to validate in advance of how to validate. The paper provide a set of guidelines to support a discussion on how to converge to a claim that actually can be validated. The paper reports on experiences from PhD level course on validation in design research.

<https://doi.org/10.1017/dsd.2020.116>

Deval, Marie-Alix; Hooge, Sophie; Weil, Benoit

Mines ParisTech, France

IDENTIFICATION AND EXPLOITATION OF NEW DESIGN PATHS BY BREAKTHROUGH INNOVATION EXPERTS IN A GENERATIVE DESIGN PARTNERSHIP

For the past 5 years, more and more established technological firms have structured domain of expertise dedicated to breakthrough innovation management, in order to foster their innovative capabilities. Our paper studies how such expertise may be organised to identify and exploit more effectively new design paths. Our case study is based on the Renault's experts who demonstrate how the design theories could support the firm's innovation capabilities through an exploration partnership. The conclusion presents new co-exploration models and proposes organisations of the expert's activities.

<https://doi.org/10.1017/dsd.2020.117>



Jones, David Edward; Snider, Chris; Hicks, Ben

University of Bristol, United Kingdom

A FRAMING OF DESIGN AS PATHWAYS BETWEEN PHYSICAL, VIRTUAL AND COGNITIVE MODELS

During engineering design, designers employ three types of model: physical, virtual and cognitive. The role and contribution of each is documented in literature albeit fragmented in nature. Consequentially, a gap in understanding exists in terms of how these models and the transitions between them impact the designer and design process. This paper begins to address this through a characterisation of each model class and an appraisal of the transitional pathways including their alignment to seminal design frameworks.

<https://doi.org/10.1017/dsd.2020.128>

Dragicevic, Nikolina⁽¹⁾; Lee, W. B.⁽¹⁾; Tsui, Eric⁽¹⁾; Chew, Eng⁽²⁾

¹The Hong Kong Polytechnic University, Hong Kong; ²University of Technology Sydney, Australia

MODELLING THE GENERATIVE POWER OF SERVICE DESIGN PRACTICE THROUGH THE REFINED LANGUAGE OF THE "C-K THEORY"

"C-K theory", a theory of reasoning in design, offers a formal modelling language with the power to describe the unfolding of creativity and the generation of new innovative objects as integral parts of design practice. However, the theory has limited ability to analyze and describe the particulars of design practice when the target area is service. To address this question, the purpose of this paper is to refine the "C-K theory" by embedding service relevant constructs and exploring strategies for enhancing the creative engagement resulting in the innovative service concepts.

<https://doi.org/10.1017/dsd.2020.156>



Georgiev, Georgi V. ⁽¹⁾; Georgiev, Danko D. ⁽²⁾

¹University of Oulu, Finland; ²Institute for Advanced Study, Varna, Bulgaria

SEMANTIC ANALYSIS OF ENGINEERING DESIGN CONVERSATIONS

To objectively and quantitatively study transcribed protocols of design conversations, we apply a semantic analysis approach based on dynamic semantic networks of nouns. We examined the applicability of the approach focused on a dynamic evaluation of the design problem solving process in engineering design educational settings. Using a case of real-world case, we show that the approach is able to determine the time dynamics of semantic factors such as level of abstraction, polysemy, information content, and quantify convergence/divergence in engineering design conversations.

<https://doi.org/10.1017/dsd.2020.294>

Han, Ji ⁽¹⁾; Hua, Min ⁽²⁾; Park, Dongmyung ⁽²⁾; Wang, Pan ⁽²⁾; Childs, Peter R. N. ⁽²⁾

¹University of Liverpool, United Kingdom; ²Imperial College London, United Kingdom

COMPUTATIONAL CONCEPTUAL DISTANCES IN COMBINATIONAL CREATIVITY

Combinational creativity can play a significant role in supporting designers to produce creative ideas during the early stages of new product development. This paper explores conceptual distances in combinational creativity from computational perspectives. A study conducted indicates that different computational measurements show different conceptual distance results. However, the study suggests far-related ideas could lead to outcomes that are more creative than closely-related ones. This paper provides useful insights into exploring future computational design support tools.

<https://doi.org/10.1017/dsd.2020.36>

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El Dehaibi, Nasreddine; MacDonald, Erin F.

Stanford University, United States of America

INVESTIGATING INTER-RATER RELIABILITY OF QUALITATIVE TEXT ANNOTATIONS IN MACHINE LEARNING DATASETS

An important step when designers use machine learning models is annotating user generated content. In this study we investigate inter-rater reliability measures of qualitative annotations for supervised learning. We work with previously annotated product reviews from Amazon where phrases related to sustainability are highlighted. We measure inter-rater reliability of the annotations using four variations of Krippendorff's U-alpha. Based on the results we propose suggestions to designers on measuring reliability of qualitative annotations for machine learning datasets.

<https://doi.org/10.1017/dsd.2020.153>

Becattini, Niccolo ⁽¹⁾; Georgiev, Georgi V. ⁽²⁾; Barhoush, Yazan ⁽²⁾; Cascini, Gaetano ⁽¹⁾

¹Politecnico di Milano, Italy; ²University of Oulu, Finland

EXPLORING THE APPLICABILITY OF SEMANTIC METRICS FOR THE ANALYSIS OF DESIGN PROTOCOL DATA IN COLLABORATIVE DESIGN SESSIONS

The paper presents the application of non-specialized lexical database and semantic metrics on transcripts of co-design protocols. Three different and previously analyzed design protocols of co-creative sessions in the field of packaging design, carried out with different supporting tools, are used as test-bench to highlight the potential of this approach. The results show that metrics about the Information Content and the Similarity maps with sufficient precision the differences between ICT- and non-ICT-supported sessions so that it is possible to envision future refinement of the approach.

<https://doi.org/10.1017/dsd.2020.141>

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***Bolifraud, Sylvain*** ^(1,2); ***Cryonnet, Jean-Claude*** ^(2,3); ***Stal-Le Cardinal, Julie*** ⁽¹⁾¹CentraleSupélec, France; ²Leynaud & Associés, France; ³SyRHèse, France**HOW A BETTER REPRESENTATION OF CONTRACTUAL RELATIONS CAN HELP TO DESIGN BETTER CONTRACTS**

This paper contributes to the reduction of conflicts arising along the construction process by improving contract management tools and contracts designing tools. We analyse the existing system of representation of relations between Owner and Contractor, the contract and the construction processes. We improve the actual representation of construction processes by creating a link with the contract. Our ambition is to create a representation that will allow organizations and project managers to represent the construction contracts and design better construction contracts.

<https://doi.org/10.1017/dsd.2020.30>***Jones, Darren Anthony; Eckert, Claudia; Garthwaite, Pamela****The Open University, United Kingdom***MANAGING MARGINS: OVERDESIGN IN HOSPITAL BUILDING SERVICES**

The capacity of building services in many hospitals exceeds the requirements by significant amounts. Oversizing of building services has a direct impact on building efficiency and operational costs, ultimately impacting upon patient care, by diverting much needed funding. A key factor leading to the oversizing is the excessive and uncoordinated application of design margins across various project stages. Based on a hospital case study, this paper analyses the reasons for the overdesign of a replacement cooling system and raises the importance of managing margins activity to avoid overdesign.

<https://doi.org/10.1017/dsd.2020.151><https://doi.org/10.1017/dsd.2020.340>Session
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***Mueller, Georg Otto; Bertram, Christian Alexander; Mortensen, Niels Henrik****DTU-Technical University of Denmark, Denmark***TOWARDS BEST PRACTICES IN THE ENGINEER-TO-ORDER BUSINESS: A FRAMEWORK FOR THE STRUCTURED ANALYSIS OF COMMISSIONING PROCESSES**

Engineer-To-Order (ETO) companies develop complex one-of-a-kind products based on specific customer demands. Given the product uniqueness, the commissioning plays an important role in the product development process. However, the project variety and low data availability hinder the analysis of the commissioning processes. This paper proposes a framework for the structured analysis of commissioning processes in ETO companies by analysing the impacts from product requirements and design on the commissioning performance. A case study presents the practical application of the developed framework.

<https://doi.org/10.1017/dsd.2020.122>***Sissoko, Timothé M.*** ^(1,3); ***Jankovic, Marija*** ⁽¹⁾; ***Paredis, Christiaan J. J.*** ⁽²⁾;***Landel, Eric*** ⁽³⁾¹CentraleSupélec, France; ²Clemson University, United States of America; ³Renault, France**EFFICIENT DATA GATHERING IN SUPPORT OF DESIGN ISSUE RESOLUTION IN AN AUTOMOTIVE COMPANY**

When designing complex systems, multiple people contribute to the process of information collection in support of decision making. In this paper, we study information collection in the Issue Resolution Decision Support (IRDS) framework. We assess the difficulties associated with uncertainty in the often scarce data when implementing the framework in a company and map out how the data sources are scattered across the organization. We study the elicitation process and propose to leverage sensitivity analysis to better allocate data collection efforts.

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Chlebusch, Jonas; Köhler, Iris; Stechert, Carsten
Ostfalia University of Applied Sciences, Germany

REASONABLE APPLICATION OF AUGMENTED REALITY IN ENGINEERING EDUCATION

Augmented Reality (AR) is to be used extensively in today's digitized teaching in order to enable students to a more efficient learning. However, teaching content must not be only digitised, but must be communicated in a meaningful way. For this purpose, a generally valid flowchart has been developed, that allows lectures to choose the right content for AR experiences. In order to create this flowchart, empirical values from test runs were combined with pedagogically proven empirical values for good teaching.

<https://doi.org/10.1017/dsd.2020.62>

Hansen, Camilla Arndt⁽¹⁾; Jensen, Lasse Skovgaard⁽¹⁾; Özkil, Ali Gürcan⁽¹⁾; Martins Pacheco, Nuno Miguel⁽²⁾
¹DTU-Technical University of Denmark, Denmark; ²Technical University of Munich, Germany

FOSTERING PROTOTYPING MINDSETS IN NOVICE DESIGNERS WITH THE PROTOTYPING PLANNER

Prototyping is an essential activity in product development, but novice designers lack awareness and purpose when they prototype. To foster prototyping mindsets in novice designers, we introduce a prototyping support tool that structures prototyping activities. This paper outlines the Prototyping Planner's development, evolution, and evaluation by 125 novice designers. The majority of novice designers' experienced that the Prototyping Planner helped them create purposeful prototypes and evaluate results from prototyping.

<https://doi.org/10.1017/dsd.2020.132>

Eriksson, Yvonne⁽¹⁾; Sjölander, Marie⁽²⁾; Wallberg, Anders⁽²⁾; Söderberg, Jonas⁽²⁾
¹Mälardalen University, Sweden; ²RISE, Sweden

VR FOR ASSEMBLY TASKS IN THE MANUFACTURING INDUSTRY – INTERACTION AND BEHAVIOUR

A testbed was developed aiming to contribute to further knowledge on what is required from a VR application in order to be useful for planning of assembly tasks. In a pilot study the testbed was tested on students. The focus of the study was to explore the users' behaviour, and to gain a better understanding of their experience using VR. The students experienced a gap between the real world and VR, which confirms theories that VR is not a copy or twin of an object or environment.

<https://doi.org/10.1017/dsd.2020.316>

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Domingo, Lawrence; Moore, Dylan; Sirkin, David; Toye, George; Leifer, Larry; Cutkosky, Mark
Stanford University, United States of America

STRATEGIC PROTOTYPING TO LEARN IN STANFORD UNIVERSITY'S ME310 DESIGN INNOVATION COURSE

Through a strategic learning process, prototypes unveil design directions. We provide a review of prototyping methods for novice designers to study and pedagogical practice for capstone design course faculty to juxtapose. Stanford University's ME310 graduate-level project-based learning course introduces students to various prototyping design techniques, such as Needfinding and Benchmarking, and prototyping methods, such as the Critical Experience Prototype, Critical Function Prototype, Dark Horse Prototype, Part-X is Finished, Funky System Prototype, and Functional System Prototype.

<https://doi.org/10.1017/dsd.2020.176>

Becattini, Niccolo⁽¹⁾; Škec, Stanko⁽²⁾; Pavković, Neven⁽²⁾; Cascini, Gaetano⁽¹⁾
¹Politecnico di Milano, Italy; ²University of Zagreb, Croatia

E-LEARNING INFRASTRUCTURE PROTOTYPE FOR GEOGRAPHICALLY DISTRIBUTED PROJECT-BASED LEARNING

The paper presents the original integration of ICT tools and e-learning platform into an infrastructure to support Project-based learning for a design class that is geographically distributed across different countries. 30 Mechanical Engineering students from 4 European countries tested the infrastructure prototype for the development of an innovative solution in the field of white goods. The results produced evidence about the suitability of the proposal together with strong and weak points of the infrastructure, that can support further development and adaptation into different contexts.

<https://doi.org/10.1017/dsd.2020.282>

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Dong, Fangzhou ⁽¹⁾; Sterling, Sara ⁽¹⁾; Schaefer, Dirk ⁽²⁾; Forbes, Hannah ⁽²⁾
¹Xi'an Jiaotong-Liverpool University, China; ²University of Liverpool, United Kingdom

BUILDING THE HISTORY OF THE FUTURE: A TOOL FOR CULTURE-CENTRED DESIGN FOR THE SPECULATIVE FUTURE

In this paper, the authors propose a culture-centred tool called Speculative Ethnography to support the practice of design for the speculative future. Most explorations of tools and techniques of design for the speculative future focus on materialising the speculation. Instead, Speculative Ethnography provides a guideline to help designers define their speculation through the scientific imagination of the plausible future. It ensures the effectiveness of design for the speculative future and supports the interaction of culture and design for the speculative future.

<https://doi.org/10.1017/dsd.2020.63>

Scurati, Giulia Wally ⁽¹⁾; Nylander, Johanna Wallin ⁽²⁾; Hallstedt, Sophie I. ⁽³⁾; Ferrise, Francesco ⁽¹⁾; Bertoni, Marco ⁽³⁾
¹Politecnico di Milano, Italy; ²GKN Aerospace, Sweden; ³Blekinge Institute of Technology, Sweden



RAISING VALUE AND SUSTAINABILITY AWARENESS FOR CRITICAL MATERIALS: A SERIOUS GAME FOR THE AEROSPACE SECTOR

Aviation strives today to include environmental and social considerations as drivers for decision making in design. This paper proposes a serious game to raise awareness of the value and cost implications of being 'sustainability compliant' when developing aerospace sub-systems and components. After describing the development of the game, from needfinding to prototyping and testing, the paper discusses the results from verification activities with practitioners, revealing the ability of the game to raise sustainability awareness and support negotiation across disciplinary boundaries in design.

<https://doi.org/10.1017/dsd.2020.86>

Lévêque, Jérémy; Levillain, Kevin; Segrestin, Blanche
Mines ParisTech, France

A MODEL OF THE INNOVATIVE PURPOSE FOR RESPONSIBLE INNOVATION: TOWARDS DESIGN-BASED CORPORATE GOVERNANCE

Evolutions in corporate law recently introduced an optional commitment mechanism in the corporate contract: a purpose. Its writing is a pivotal but is yet puzzling from a design perspective. Especially it raises questions about how that could help shaping a responsible governance model for innovation. Our paper builds on an extended-decision framework to propose a formal model of how a stated-purpose shapes the decision situation. Our results highlight several purpose formulation strategies and finally a typology regarding how robustness to changes is embedded in the process is proposed.

<https://doi.org/10.1017/dsd.2020.89>



Kravchenko, Mariia; Pigosso, Daniela C. A.; McAloone, Tim C.
DTU-Technical University of Denmark, Denmark



DEVELOPING A TOOL TO SUPPORT DECISIONS IN SUSTAINABILITY-RELATED TRADE-OFF SITUATIONS: UNDERSTANDING NEEDS AND CRITERIA

Early integration of sustainability considerations into decision making is seen as a key enabler for companies to understand the potential implications of their decisions on the triple bottom line aspects. Lack of the tools to support decisions when trade-off between sustainability aspects occur, however, may lead to uninformed decision-making and undesired outcomes. By consolidating the learnings from empirical work together with literature recommendations, we propose key criteria to be considered when developing decision support tools to manage sustainability-related trade-off situations.

<https://doi.org/10.1017/dsd.2020.137>

Santi, Romina ⁽¹⁾; Elegir, Graziano ⁽²⁾; Del Curto, Barbara ^(1,3)
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DESIGNING FOR SUSTAINABLE BEHAVIOUR PRACTICES IN CONSUMERS: A CASE STUDY ON COMPOSTABLE MATERIALS FOR PACKAGING

When assessing the sustainability of a product, an ideal life cycle is considered which could include the "Use" and "End of Life" phases. Does human behaviour affect the environmental sustainability? This paper intends to propose a methodological framework for assessing sustainable behavioural scenarios. The framework will be then developed in a specific case study on Compostable Single Use Products (CSUPs), with the aim of designing the identity of compostable materials for packaging in order to guide consumers to behave in a sustainable way in CSUPs disposal phase.

<https://doi.org/10.1017/dsd.2020.150>



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CHALLENGES FACED BY DESIGN ENGINEERS WHEN CONSIDERING MANUFACTURING IN DESIGN – AN INTERVIEW STUDY

The consideration of manufacturing in design is still a challenge for design engineers. This paper presents the results of an interview study, conducted with 15 participants. Challenges are identified in this study: Manufacturing-specific knowledge is mostly not sufficient. The design of manufacturing-oriented concepts in terms of costs is difficult. The feasibility of manufacturing is not assessed. The dimension of cost drivers is unknown, hindering optimisation in early stages of design. Based on these results the need for further research emerges regarding the impact of these challenges.

<https://doi.org/10.1017/dsd.2020.302>

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A DESIGN SUPPORT TOOL FOR IMPROVING MAINTENANCE SCHEDULING PROCESS

The challenge of user requirements for maintenance scheduling design in large asset-intensive industries suffers from lack of academic and empirical studies. Therefore, using a representative case study, this paper aims to: (1) identify the current practices and complex scheduling requirements; (2) propose a design support tool to optimize the maintenance scheduling process; and (3) report the gained benefits. The results reveal that the proposed tool can decrease the resource requirements, increase the capacity utilization, and reduce the cost while addressing the complex user requirements.

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AN ANALYTICAL COST MODEL FOR INVESTMENT CASTING

Analytical cost estimation of investment casted products during design phase is a complex task since the quantity of parameters to be evaluated. So far, there is a short literature on such cost estimation models. This paper attempts to improve the cost model presented by Boothroyd and Dewhurst. Improvements (mainly focused on cluster assembly and investment, sintering and melting phases) were defined and verified in cooperation with two foundries. Tested on eight components, deviation between estimated and actual costs is around 14% for manual production lines and 6% for automatic ones.

<https://doi.org/10.1017/dsd.2020.179>

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