



THE 20<sup>TH</sup> INTERNATIONAL CONFERENCE  
ON ENGINEERING DESIGN (ICED15)

**DESIGN FOR LIFE**

27th-30th July 2015  
Politecnico di Milano, Italy

**Organised By**

Politecnico di Milano, Politecnico di Torino  
and the Design Society

**Proceedings of ICED15**

Volume 5: DESIGN METHODS AND TOOLS – PART 1  
**DS 80-05**

**Edited By**

Christian Weber  
Stephan Husung  
Gaetano Cascini  
Marco Cantamessa  
Dorian Marjanovic  
Federico Rotini

Published by the Design Society, Glasgow, Scotland

## First published in 2015

This publication is copyright under the Berne Convention and the International Copyright Convention. All rights reserved. Apart from any fair dealing for the purpose of private study, research, criticism or review, as permitted under the Copyright, Designs and Patents Act of 1988, no part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, electrical, chemical, mechanical, photocopying, recording or otherwise, without the prior permission of the copyright owners. Unlicensed multiple copying of the contents of this publication is illegal. Inquiries should be addressed to the Design Society.

© 2015 The Design Society, Glasgow, Scotland, UK, unless otherwise stated.  
The Design Society is a charitable body, registered in Scotland,  
number SC 031694

ISBN 978-1-904670-68-1

Printed by Lightning Source, Inc., La Vergne, TN, USA,  
and by Lightning Source UK Ltd., Milton Keynes, UK

The publishers are not responsible for any statement made in this publication.  
Data, discussion, and conclusions developed by authors are for information only and  
are not intended for use without independent substantiating investigation on the part  
of potential users. Opinions expressed are those of the authors and not necessarily  
those of the Design Society.

## Preface by the Programme Chair

We welcome you to the proceeding of the 20th International Conference on Engineering Design 2015 (ICED 15) held at the Bovisa campus of Politecnico di Milano, Milan, Italy. The theme of the Conference is “DESIGN FOR LIFE”, inspired by EXPO 2015 in Milan.

These proceedings of ICED 15 contain 427 double-blind peer-reviewed and accepted papers. The proceedings are published in different forms: a book of abstracts and a soft-copy of all contributions on a USB-based memory device for conference delegates plus printed books (11 volumes), which are available to the public via a print-on-demand service. All these different forms of proceedings are numbered against both Design Society and ISSN/ISBN referencing to allow wider access, better referencing and improved citation in the near and distant future. Additionally, all papers contain a citation proposal for a reproducible citation. The 11 volumes of the books are structured according to the conference topics and the sequence of the sessions. All papers in the proceedings have successfully fulfilled the criteria for acceptance in ICED 15.

Continuing on from the changes introduced for ICED 13, the papers in the proceedings were produced by combining an automatically generated cover page, based on the contribution details in the Conference Management System (ConfTool), with the paper as submitted by the authors, starting with the introduction section. This procedure supports consistent data for the papers, the conference programme, the Book of Abstracts, etc.

ICED 15 and its proceedings are the result of the dedicated efforts of many people:

- the authors who submitted excellent papers (both in content and form),
- the reviewers who provided timely comments and positive feedback that helped to optimise the quality of papers,
- the chairs, assistant chairs and members of the Programme and Organising Committee and the Design Society Administration who had to deal with details galore in getting the conference and the proceedings planned, structured, organised and ready to go (it was also fun, though!).

Thank you all very much!

On behalf of the Programme Committee we hope that you enjoy the programme and participate fully in what is arguably the Premier engineering design research conference in the world. We also hope that you find time to discover Milan and EXPO 2015, that you meet old friends and make some new ones, and that – besides work – you also have as much fun as we had when preparing the conference!



A handwritten signature in cursive script, reading "Christian Weber".

**Christian Weber**  
Programme Chair



A handwritten signature in cursive script, reading "Stephan Husung".

**Stephan Husung**  
Assistant Programme Chair

## Preface by ICED15 Conference Chair

Having reached its 20th edition, ICED15 confirms to be a well-established conference in the scientific design community and we are very pleased and honoured to host this edition, which has received a very significant attention from researchers and practitioners throughout the world.

ICED15 is being organized at the same time and in the same location as the Universal EXPO. The EXPO has also inspired the theme of our conference - Design for Life - which has been further formulated as Design for a Healthy, a Sustainable and a Contented Life. While the submissions were arriving and the conference program was taking shape, we were very pleased to observe that this conference theme has indeed been picked up by many authors and has permeated their contributions. As an outcome of this emerging synergy between ICED and EXPO, we expect participants to return to their countries not only with the usual benefits that come from the ICED experience, but also with a stronger capability and determination to make positive and effective contributions to humankind through design research, education and practice.

If one looks at the program of previous ICED conferences, it is quite apparent that the field of design is continuously evolving, and that the Design Society community that is at the heart of ICED is also at the forefront of this continual evolution and adaptation to emerging opportunities and challenges. Specifically, ICED15 welcomes a growing number of contributions in fields pertaining to the human and social aspects of design, looking at humans both as actors and as recipients of the design activity. We all know that these advancements do not only take place in the formal presentation sessions, but also through other gatherings, including business meetings, information events, workshops and – of course – social events. The conference program has therefore been designed with the objective of providing ICED participants with a variety of opportunities for meeting and exchanging views.

All this will occur within the setting of a country such as Italy that – since ancient times, going through the Renaissance and until today – has been uniquely able to blend its technical know-how with an amazing quality of life. We therefore hope that you will make a memorable experience of ICED 15, the EXPO and of the ideal of Designing for Life.



A stylized, handwritten signature in dark ink.

**Gaetano Cascini**  
Conference Chair



A stylized, handwritten signature in dark ink.

**Marco Cantamessa**  
Conference Chair

## Preface by the Design Society President

ICED 15, the 20th edition of the International Conference on Engineering Design (ICED) is coming back to Italy, the country where the idea of a design conference first took shape. The first ICED took place in Rome in March 1981. The aims were, as its initiator Vladimir Hubka wrote in December 1980, set towards: "... *determining the latest state of knowledge in areas of scientific design methods, and of gathering information about current results and future trends in research, to achieve a free co-ordination of scarce research resources.*"

This year, we are not in Rome, but in Milan - and for a good reason. The city of Milan itself is a synonym for quality of design as a way of thinking and living, in activity or in outcome. The conference themes indicate the broadness of thinking about design in and around the host city and connect the conference with the Universal EXPO that is also taking place at the same time. ICED 15 participants will have chance to experience the dynamics of a city that reflects all of the dichotomies that define design old and new, the art and technology, the research and practice, the chaotic and systematic. In the past thirty-five years the conference has become the event where all the richness of design research from all the continents is presented and all aspects of design explored ICED 15 sessions are the results of continuous improvements in every aspect of conference organisation. The format of the conference is based on the previous events with a programme made up of plenary sessions, podium presentations, discussion sessions with a focused debate and workshops led by the Design Society's Special Interest Groups. In addition, the Young Members' Event and PhD Forum extend the networking opportunities of ICED 15 for younger or first-time participants. The ICED 15 programme will provide an exciting opportunity for researchers and practitioners to learn about the latest developments in design research and practice.

The programme of ICED 15 is the result of a joint effort from great teams that have been working together since the last ICED conference in Seoul. The Society extends its gratitude to all the authors who have submitted their papers and all the reviewers who have helped to select papers ensuring an outstanding conference experience for all participants. A special thank you goes to all the authors and Session Chairs who will make this experience possible.

Many things have changed through the last 19 conferences. The conference started in Rome by WDK (Workshop – Design – Konstruktion), has, since 2001, been organised by the Design Society. Design as a field has expanded tremendously and the conference programme has become more interactive and complex, opening new opportunities and challenges. Organising a conference with such a history takes an enormous amount of work and attention to detail. I would like to express sincere thanks of the Society to Gaetano Cascini and Marco Cantamessa and all colleagues from Politecnico di Milano and Politecnico di Torino who have made this conference happen. Special thanks also to Programme Chair Christian Weber and Assistant Programme Chair Stephan Husung and all the members of Programme Committee for ensuring that this conference presents a tremendous quality of content. Finally, thank you to all of the participants whose attendance and input are a constant sign that this conference and design as a field are going in the right direction.



A handwritten signature in dark ink, appearing to read 'D. Marjanovic'.

**Dorian Marjanovic**  
Design Society President

## **ICED15 Programme Committee**

Christian Weber - TU Ilmenau, Germany

Stephan Husung - TU Ilmenau, Germany

Monica Bordegoni - Politecnico di Milano, Italy

Marco Cantamessa - Politecnico di Torino, Italy

Gaetano Cascini - Politecnico di Milano, Italy

Dorian Marjanovic - University of Zagreb, Croatia

Srinivasan Venkataraman - TU Munich, Germany

## **ICED15 Organising Committee**

Gaetano Cascini - Politecnico Di Milano

Marco Cantamessa - Politecnico di Torino, Italy

Serena Graziosi - Politecnico Di Milano, Italy

Francesca Montagna - Politecnico Di Torino, Italy

Federico Rotini - Università degli studi di Firenze, Italy

## ICED15 Scientific Committee

- Agogino, Alice Merner** - University of California at Berkeley
- Agogue, Marine** - HEC Montréal
- Ahmed-Kristensen, Saeema** - DTU
- Albers, Albert** - Karlsruhe Institute of Technology (KIT)
- Allen, Janet Katherine** - University of Oklahoma
- Allison, James T.** - University of Illinois at Urbana-Champaign
- Almefelt, Lars** - Chalmers University of Technology
- Anderl, Reiner** - TU Darmstadt
- Andersson, Kjell** - KTH Royal Institute of Technology
- Andrade, Ronaldo** - Universidade Federal do Rio de Janeiro
- Annamalai Vasantha, Gokula Vijaykumar** - University of Strathclyde
- Aoussat, Améziame** - ENSAM
- Arai, Eiji** - Osaka University
- Arciszewski, Tomasz** - George Mason
- Aurisicchio, Marco** - Imperial College London
- Austin-Breneman, Jesse** - Massachusetts Institute of Technology
- Badke-Schaub, Petra** - TU Delft
- Balan, Gurumoorthy** - Indian Institute of Science
- Becattini, Niccolo** - Politecnico di Milano
- Becetic, Sanja** - University of Zagreb
- Ben-Ahmed, Walid** - RENAULT
- Bender, Beate** - Ruhr-Universität Bochum
- Beneke, Frank** - FH Schmalkalden
- Bertoni, Marco** - Blekinge Institute of Technology
- Bhamra, Tracy** - Loughborough University
- Binz, Hansgeorg** - University of Stuttgart
- Birkhofer, Herbert** - TU Darmstadt
- Björnemo, Robert** - Lund University
- Björk, Evastina, Lilian** - Gjøvik University College
- Blanco, Eric** - Univ. Grenoble Alpes, G-SCOP, F-38000 Grenoble, France CNRS, G-SCOP, F-38000 Grenoble, France
- Blessing, Lucienne** - University of Luxembourg
- Boa, Duncan R** - University of Bristol
- Bohemia, Erik** - Loughborough University
- Bojetic, Nenad** - Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb
- Boks, Casper** - Norwegian University of Science and Technology
- Booker, Julian David** - University of Bristol
- Bordegoni, Monica** - Politecnico di Milano
- Borg, Jonathan C.** - University of Malta
- Borgianni, Yuri** - Free University of Bolzano-Bozen
- Boujut, Jean-François** - Grenoble Institute of Technology
- Bouwhuis, Dominic G** - TU Eindhoven
- Broberg, Ole** - TU Denmark
- Brown, David C.** - Worcester Polytechnic Institute
- Burvill, Colin Reginald** - University of Melbourne
- Bylund, Nicklas** - Sandvik Coromant
- Cagan, Jonathan** - Carnegie Mellon University
- Caillaud, Emmanuel** - Université de Strasbourg
- Campean, Felician** - University of Bradford
- Cantamessa, Marco** - Politecnico di Torino
- Casakin, Hernan** - Ariel University
- Cascini, Gaetano** - Politecnico di Milano
- Cash, Philip** - TU Denmark
- Cavallucci, Denis** - INSA Strasbourg
- Chakrabarti, Amaresh** - Indian Institute of Science
- Chen, Wei** - Northwestern University
- Chen, Chun-Hsien** - Nanyang Technological University
- Childs, Peter R.N.** - Imperial College London

## ICED15 Scientific Committee cont.

- Chiu, Ming-Chuan - National Tsing Hua University
- Choi, Young Mi - Georgia Institute of Technology
- Chu, Chih-Hsing - National Tsing Hua University
- Clarkson, Peter John - University of Cambridge
- Coatanéa, Eric - Aalto University
- Collado-Ruiz, Daniel - Dynavio Cooperative
- Cormican, Kathryn - National University of Ireland
- Coutellier, Daniel - University of Valenciennes
- Crawford, Richard - University of Texas at Austin
- Crilly, Nathan - University of Cambridge
- Cugini, Umberto - Politecnico di Milano
- Culley, Steve - University of Bath
- De Guio, Roland - INSA de Strasbourg
- Deans, Joe - University of Auckland
- Dekoninck, Elies Ann - University of Bath
- Dhokia, Vimal - University of Bath
- Dong, Andy - The University of Sydney
- Donndelinger, Joseph A. - General Motors LLC
- Dorst, Kees - University of Technology, Sydney
- Duffy, Alex - University of Strathclyde
- Duflou, Joost - KU Leuven
- Eckert, Claudia - Open University
- Egan, Paul Francis - ETH Zurich
- Eifler, Tobias - Technical University of Denmark
- Eigner, Martin - TU Kaiserslautern
- Ekman, Kalevi - Aalto University
- Ellman, Asko Uolevi - Tampere University of Technology
- Emrah Bayrak, Alparслан - University of Michigan
- Eppinger, Steven - Massachusetts Institute of Technology
- Erbe, Torsten - Jenoptik OS GmbH
- Ericson, Åsa - Luleå University of Technology
- Eris, Ozgur - MITRE Corporation
- Fadel, Georges M. - Clemson University
- Fan, Ip-Shing - Cranfield University
- Fantoni, Gualtiero - University of Pisa
- Fargnoli, Mario - Ministry of Agriculture
- Ferrise, Francesco - Politecnico di Milano
- Filippi, Stefano - University of Udine
- Finger, Susan - Carnegie Mellon University
- Fischer, Xavier - ESTIA
- Frankenberger, Eckart - Airbus
- Fu, Katherine Kai-Se - Georgia Institute of Technology
- Fujita, Kikuo - Osaka University
- Fukuda, Shuichi - Keio University
- Gardoni, Mickael - ÉTS / INSA de Strasbourg
- Georgiev, Georgi V. - Kobe University
- Gerhard, Detlef - Vienna University of Technology
- Gericke, Kilian - University of Luxembourg
- Gero, John - UNCC & GMU
- Goel, Ashok - Georgia Institute of Technology
- Goh, Yee Mey - Loughborough University
- Göhlich, Dietmar - TU Berlin
- Goker, Mehmet H. - Salesforce.com
- Goldschmidt, Gabriela - Technion - Israel Institute of Technology
- Gooch, Shayne - University of Canterbury
- Gopsill, James Anthony - University of Bristol
- Governi, Lapo - University of Florence
- Graessler, Iris - Heinz Nixdorf Institute, University of Paderborn
- Graziosi, Serena - Politecnico di Milano
- Grimheden, Martin - KTH Royal Institute of Technology
- Grobman, Yasha Jacob - Technion, Israel Institute of Technology
- Gupta, Ravi Kumar - Ecole Centrale de Nantes
- Gzara, Lilia - Grenoble Institute of Technology
- Hales, Crispin - Hales & Gooch Ltd.
- Hallstedt, Sophie - Blekinge Tekniska Högskola



**Hansen, Claus Thorp** - TU Denmark  
**Hasse, Alexander** - FAU University of Erlangen-Nuremberg  
**Hatchuel, Armand** - Mines ParisTech  
**Hicks, Ben** - University of Bath  
**Höhne, Günter** - Technische Universität Ilmenau  
**Holliger, Christoph** - University of Applied Sciences Northwestern Switzerland  
**Holmlid, Stefan** - Linköping University  
**Hong, Yoo Suk** - Seoul National University  
**Horvath, Imre** - Delft University of Technology  
**Hosnedl, Stanislav** - University of West Bohemia  
**Howard, Thomas J.** - Technical University of Denmark  
**Husung, Stephan** - Technische Universität Ilmenau  
**Ijomah, Winifred** - University of Strathclyde  
**Ilies, Horea** - University of Connecticut  
**Ion, William** - University of Strathclyde  
**Isaksson, Karl Ola** - GKN Aerospace Engine Systems  
**Jackson, Mats** - Malardalen University  
**Jagtap, Santosh** - Lund University  
**Ji, Haifeng** - Massachusetts Institute of Technology  
**Johansson, Glenn** - Jönköping University  
**Johnson, Aylmer** - University of Cambridge  
**Jones, Simon Lloyd** - University of Bath  
**Jowers, Iestyn** - The Open University  
**Jun, Thomas** - Loughborough University  
**Kannengiesser, Udo** - Metasonic GmbH  
**Karlsson, Lennart** - Alkit Communications AB  
**Kazakci, Akin Osman** - Mines ParisTech  
**Keates, Simeon** - University of Greenwich  
**Keldmann, Troels** - Keldmann Healthcare A/S  
**Kim, Yong Se** - Sungkyunkwan University  
**Kim, Kee-Ok** - Sungkyunkwan University  
**Kim, Harrison** - University of Illinois at Urbana-Champaign  
**Kiriyama, Takashi** - Tokyo University of the Arts  
**Kishita, Yusuke** - Osaka University  
**Kitamura, Yoshinobu** - Osaka University  
**Kleinsmann, Maaïke** - TU Delft  
**Kloberdanz, Hermann** - TU Darmstadt  
**Koh, Edwin** - National University of Singapore  
**Kokkolaras, Michael** - McGill University  
**Komoto, Hitoshi** - National Institute of Advanced Industrial Science and Technology  
**Kota, Srinivas** - Birla Institute of Technology and Science  
**Kovacevic, Ahmed** - City University London  
**Krause, Dieter** - Hamburg University of Technology  
**Kreimeyer, Matthias** - MAN Truck & Bus AG  
**Kremer, Gul** - Penn State University  
**Kroll, Ehud** - Technion  
**Krömker, Heidi** - Technische Universität Ilmenau  
**Krus, Petter** - Linköping University  
**Kuosmanen, Petri** - Aalto University  
**Le Masson, Pascal** - Mines ParisTech  
**Leary, Martin John** - RMIT university  
**Lee, Sang Won** - Sungkyunkwan University  
**Legardeur, Jeremy** - ESTIA  
**Lenau, Torben Anker** - TU Denmark  
**Liem, André** - Norwegian University of Science and Technology  
**Lindahl, Mattias** - Linköping University  
**Lindemann, Udo** - TU Munich  
**Linsey, Julie** - Georgia Institute of Technology  
**Liu, Ying** - Cardiff University  
**Lloveras, Joaquim** - TU Catalonia (Universitat Politècnica de Catalunya)  
**Long, David Scott** - University of Dayton  
**Lulham, Rohan** - University of Technology Sydney  
**Mabogunje, Ade** - Stanford University  
**Maier, Anja Martina** - Technical University of Denmark (DTU)  
**Malak, Richard** - Texas A&M  
**Malmqvist, Johan Lars** - Chalmers University of Technology

## ICED15 Scientific Committee cont.

**Manfredi, Enrico** - University of Pisa  
**Marjanovic, Dorian** - University of Zagreb  
**Marle, Franck** - Ecole Centrale Paris  
**Matta, Nada** - Universite of Technology of Troyes  
**Matthews, Jason Anthony** - University of the West of Englsnf  
**Matthiesen, Sven** - Karlsruhe Institute of Technology  
**Maurer, Christiane** - The Hague University  
**Maurer, Maik** - TU Munich  
**McAlpine, Hamish Charles** - University of Bristol  
**McDonnell, Janet Theresa** - Central Saint Martins  
**McKay, Alison** - University of Leeds  
**McMahon, Christopher Alan** - University of Bristol  
**Meboldt, Mirko** - ETH Zurich  
**Mekhlief, Mounib** - University of Orleans  
**Merlo, Christophe** - ESTIA  
**Millet, Dominique** - SEATECH Toulon  
**Mocko, Gregory Michael** - Clemson University  
**Moehringer, Stefan** - Simon Moehringer Anlagenbau GmbH  
**Mohan, Rajesh Elara** - Singapore University of Technology and Design  
**Montagna, Francesca** - Politecnico di Torino  
**Moreno Grandas, Diana Paola** - University of Luxembourg  
**Mortensen, Niels Henrik** - TU Denmark  
**Mörtl, Markus** - Technische Universitaet Muenchen, Germany  
**Mougenot, Céline** - Tokyo Institute of Technology  
**Moullec, Marie-Lise Therese Lydia** - University of Cambridge  
**Moultrie, James** - University of Cambridge  
**Mulet, Elena** - University of Jaume  
**Mullineux, Glen** - University of Bath  
**Murakami, Tamotsu** - University of Tokyo  
**Nagai, Yukari** - Japan Advanced Institute of Science and Technology  
**Newnes, Linda** - University of Bath  
**Ng, Ricky, Yuk-kwan** - Vocational Training Council, Hong Kong  
**Nicquevert, Bertrand** - CERN  
**Nielsen, Ole Fiil** - Worm Development  
**Nomaguchi, Yutaka** - Osaka University  
**Norell Bergendahl, Margareta E B** - KTH Royal Institute of Technology  
**Oehmen, Josef** - Technical University of Denmark  
**Öhrwall Rönnbäck, Anna B** - Luleå University of Technology  
**Olsson, Annika** - Lund University  
**Onkar, Prasad** - Indian Institute of Technology Hyderabad  
**Otto, Kevin** - Singapore University of Design and Technology  
**Ottosson, Stig** - Gjøvik University College  
**Ouertani, Mohamed Zied** - ABB / University of Cambridge  
**Paetzold, Kristin** - University Bundeswehr Munich  
**Palm, William John** - Roger Williams University  
**Papalambros, Panos Y.** - University of Michigan  
**Parkinson, Matt** - Pennsylvania State University  
**Pavkovic, Neven** - University of Zagreb  
**Peters, Diane** - Kettering University  
**Petersen, Soren Ingomar** - ingomar&ingomar - consulting  
**Petiot, Jean-François** - Ecole Centrale de Nantes  
**Pigosso, Daniela** - Technical University of Denmark  
**Prakash, Raghu Vasu** - Indian Institute of Technology Madras  
**Qureshi, Ahmed Jawad** - Newcastle University  
**Radkowski, Rafael** - Iowa State University

- Raine, John Kenneth** - Auckland University of Technology
- Ray, Pascal** - Ecole Nationale Supérieure des Mines de Saint-Etienne
- Reich, Yoram** - Tel Aviv University
- Reid, Tahira** - Purdue University
- Remmen, Arne** - Aalborg University
- Ren, Yi** - Arizona State University
- Riel, Andreas Erik** - Grenoble Institute of Technology
- Riitahuhta, Asko Olavi** - Tampere University of Technology
- Rinderle, James** - University of Massachusetts
- Ringen, Geir** - Sintef Raufoss Manufacturing
- Ritzén, Sofia** - KTH Royal Institute of Technology
- Rizzi, Caterina** - University of Bergamo
- Robotham, Antony John** - Auckland University of Technology
- Rohmer, Serge** - University of Technology of Troyes
- Rosen, David** - Georgia Institute of Technology
- Rotini, Federico** - Università degli Studi di Firenze
- Roucoules, Lionel** - ENSAM
- Rovida, Edoardo** - Politecnico di Milano
- Russo, Davide** - University of Bergamo
- Sakao, Tomohiko** - Linköping University
- Salehi, Vahid** - University of Applied Sciences Munich
- Salustri, Filippo Arnaldo** - Ryerson University
- Sarkar, Prabir** - Indian Institute of Technology Ropar
- Sarkar, Somwrita** - University of Sydney
- Sato, Keiichi** - Illinois Institute of Technology
- Schabacker, Michael** - Otto-von-Guericke University Magdeburg
- Schaefer, Dirk** - Georgia Institute of Technology
- Schaub, Harald** - IABGmbH
- Seepersad, Carolyn Conner** - University of Texas at Austin
- Seering, Warren** - Massachusetts Institute of Technology
- Sen, Dibakar** - Indian Institute of Science, Bangalore
- Setchi, Rossi** - Cardiff University
- Shah, Jami** - Arizona State University
- Shea, Kristina** - ETH Zurich
- Sheldrick, Leila** - Loughborough University
- Shi, Lei** - University of Bath
- Shimomura, Yoshiki** - Tokyo Metropolitan University
- Siadat, Ali** - ENSAM
- Sigurjónsson, Jóhannes B.** - Norwegian University of Science and Technology
- Simpson, Timothy W.** - Penn State University
- Singh, Vishal** - Aalto University
- Škec, Stanko** - University of Zagreb
- Snider, Chris** - University of Bristol
- Söderberg, Rikard** - Chalmers University of Technology
- Sonalkar, Neeraj** - Stanford University
- Spitas, Christos** - TU Delft
- Stal-Le Cardinal, Julie** - Ecole Centrale Paris
- Stankovic, Tino** - ETH Zurich
- Stappers, Pieter Jan** - Delft University of Technology
- Stark, Rainer G.** - Berlin Institute of Technology
- Stetter, Ralf** - University of Applied Sciences Ravensburg-Weingarten
- Stevanovic, Milan** - Markot.tel
- Stören, Sigurd** - Norwegian University of Science and Technology
- Storga, Mario** - University of Zagreb/Faculty of Mechanical Engineering and Naval Architecture
- Subrahmanian, Eswaran** - Carnegie Mellon University
- Suh, Eun Suk** - Seoul National University
- Summers, Joshua David** - Clemson University
- Sundin, Erik** - Linköping University
- Tahera, Khadija** - University of Huddersfield

## ICED15 Scientific Committee cont.

- Tan, James Ah-Kat - Ngee Ann Polytechnic  
 Taura, Toshiharu - Kobe University  
 Terpenny, Janis P. - Iowa State University  
 Thoben, Klaus-Dieter - University Bremen  
 Tiwari, Ashutosh - Cranfield University  
 Todeti, Somasekhara Rao - National Institute of Technology- Goa, India  
 Tollenaere, Michel - Grenoble Institute of Technology  
 Tomiyama, Tetsuo - Cranfield University  
 Törlind, Peter - Luleå University of Technology  
 Trimmingham, Rhoda - Loughborough uni  
 Troussier, Nadege - University of Technology of Troyes  
 Udiljak, Toma - University of Zagreb/FMENA  
 Uflacker, Matthias - Hasso Plattner Institute  
 Umeda, Yasushi - the University of Tokyo  
 Vajna, Sandor J. - Otto-von-Guericke University Magdeburg  
 Valderrama Pineda, Andres Felipe - Aalborg University  
 Valkenburg, Rianne C. - The Hague University of Applied Sciences  
 van der Bijl-Brouwer, Mieke - University of Technology, Sydney  
 Van der Loos, Mike - University of British Columbia  
 Vaneke, Tom Henricus Jozef - University of Twente  
 Venkataraman, Srinivasan - Technische Universität München  
 Vidovics, Balazs - Budapest University of Technology and Economics  
 Vietor, Thomas - Braunschweig University of Technology  
 Vukasinovic, Nikola - Faculty of Mechanical Engineering, University of Ljubljana  
 Vukic, Fedja - Graduate School of Design, Faculty of Architecture, University of Zagreb  
 Walter, Michael - Friedrich-Alexander-Universität Erlangen-Nürnberg  
 Wang, Charlie C.L. - Chinese University of Hong Kong  
 Wang, Yue - Hang Seng Management College  
 Wartzack, Sandro - Friedrich-Alexander-Universität Erlangen-Nürnberg  
 Watanabe, Kentaro - National Institute of Advanced Industrial Science and Technology  
 Watty, Robert - University of Applied Sciences Ulm  
 Weber, Christian - Technische Universität Ilmenau  
 Weil, Benoit - Mines ParisTech-PSL Research University  
 Weiss, Menachem Peter - Technion - Israel Institute of Technology  
 Whitfield, Ian - University of Strathclyde  
 Whitney, Daniel E - Massachusetts Institute of Technology  
 Winkelman, Paul Martin - University of British Columbia  
 Wodehouse, Andrew James - University of Strathclyde  
 Wood, Kristin - Singapore University of Design and Technology  
 Yan, Xiu-Tian - University of Strathclyde  
 Yanagisawa, Hideyoshi - University of Tokyo  
 Yang, Maria - Massachusetts Institute of Technology  
 Yannou, Bernard - Ecole Centrale Paris  
 Yilmaz, Seda - Iowa State University  
 Zainal Abidin, Shahrman - Universiti Teknologi MARA  
 Zavbi, Roman - University of Ljubljana  
 Zeng, Yong - Concordia University  
 Zolghadri, Marc - Supmeca

# Table of Contents

Preface by ICED15 Programme Chair  
Preface by ICED15 Conference Chair  
Preface by the Design Society President  
ICED15 Programme Committee  
ICED15 Organising Committee  
ICED15 Scientific Committee

## VOLUME 1: Proceedings of the 20th International Conference on Engineering Design (ICED15)

### DESIGN FOR LIFE

#### DESIGN FOR A SUSTAINABLE LIFE

Design Strategies for Circular Economy <i>Devadula, Suman; Chakrabarti, Amaresh</i> .....	1-1
Implementing Ecodesign Principles in Product Design: the Role of Usability <i>Sousa, Ana M.; Sampaio, Alvaro M.; Simoes, Paulo; Oliveira, Raquel</i> .....	1-11
Model Based Decision Support for Value and Sustainability in Product Development <i>Isaksson, Ola; Bertoni, Marco; Hallstedt, Sophie; Lavesson, Niklas</i> .....	1-21
Improving the Management of Environmental Requirements in Clients/ Suppliers Co-Design Process <i>Michelin, Fabien; Reyes, Tatiana; Vallet, Flore; Eynard, Benoît; Duong, Viet-Long</i> .....	1-31
The Business Model, A Tool for Transition to Sustainable innovation <i>Bisiaux, Justine; Gidel, Thierry; Huet, Frédéric; Millet, Dominique</i> .....	1-43
Quantification of Indoor Environmental Quality in Sustainable Building Designs using Structural Equation Modeling <i>Piacenza, Joseph R; Fields, John J; Hoyle, Christopher; Tumer, Irem Y</i> .....	1-53
Archaeonics – How to use Archaeological Solutions for Modern Product Development <i>Guertler, Matthias R.; Schaefer, Simon; Lipps, Johannes; Stahl, Stephan; Lindemann, Udo</i> .....	1-65
Comparison and Classification of Eco Improvement Methods <i>Russo, Davide; Serafini, Marco; Rizzi, Caterina; Duci, Stefano</i> .....	1-77
Ecodesign Maturity Model as a Framework to Support the Transition towards ISO 14.001:2015 Certification <i>Pigosso, Daniela C. A.; McAloone, Tim C.</i> .....	1-87
Introduction of the Ideality Tool for Sustainable Design <i>Helfman Cohen, Yael; Reich, Yoram</i> .....	1-97
Development of a System for Production Energy Prognosis <i>Stetter, Ralf; Witczak, Piotr; Witczak, Marcin; Kauf, Florian; Staiger, Benjamin; Spindler, Claudius</i> .....	1-107
Environmental Evaluation of Ideas in Early Phases: A Challenging Issue for Design Teams <i>Leroy, Yann; Tyl, Benjamin; Vallet, Flore; Cluzel, François</i> .....	1-117

<b>Identifying Needs for New Ecodesign Tools with the DSM Value Bucket tool - An Example in the Construction industry</b>	
<i>Lamé, Guillaume; Leroy, Yann; Lasvaux, Sébastien</i>	1-127
<b>Supporting Environmentally-Benign Design - Elucidating Environmental Impact Propagation in Conceptual Design Phase By Sapphire Model of Causality</b>	
<i>Acharya, Shakuntala; Chakrabarti, Amaresh</i>	1-139
<b>Collaborative Process Between Functional Analysis et Life Cycle Assesment: Integrating Environmental Considérations into Early Stages of Design Process</b>	
<i>Rodriguez Moreno, Paulina; Rohmer, Serge; Ma, Hwong-Wen</i>	1-151
<b>Task-Based LCA for Environmental Impact Assessment of Multiple Heterogenous Systems</b>	
<i>Quan, Ning; Kim, Harrison; Knight, Erica; Nelson, Jeffrey; Finamore, Peter</i>	1-161
<b>Heuristic Guidelines in Ecodesign</b>	
<i>Sarnes, Julian; Kloberdanz, Hermann</i>	1-171
<b>Investigating the Sustainability of Product Supply Chains</b>	
<i>Germani, Michele; Mandolini, Marco; Marconi, Marco; Marilungo, Eugenia; Papetti, Alessandra</i>	1-181
<b>Degrees of Customization and Sales Support Systems - Enablers to Sustainability in Mass Customization</b>	
<i>Gembarski, Paul Christoph; Lachmayer, Roland</i>	1-191
<b>Interaction Design for Sustainable Mobility System</b>	
<i>Gaiardo, Andrea; Di Salvo, Andrea</i>	1-199
<b>Meeting Sustainability Challenges: Soft Systems Thinking as an Enabler for Change</b>	
<i>Ericson, Åsa; Holmqvist, Johan</i>	1-209
<b>Bringing a Fuller Socio-Technical Perspective to Design Decisions</b>	
<i>Kokotovich, Vasilije</i>	1-217
<b>Firing up Sustainable Behaviour</b>	
<i>Daae, Johannes; Boks, Casper; Goile, Franziska; Seljeskog, Morten</i>	1-227
<b>Design for Sustainability – Trade-off Dilemmas from the Consumer Perspective</b>	
<i>Shiu, Eric</i>	1-239
<b>Systematic Framework for the Development of Fuons</b>	
<i>Ostad-Ahmad-Ghorabi, Hesamedin; Collado-Ruiz, Daniel</i>	1-249
<b>Application of Subtract and Operate Method for Developing Function Energy Structures of Products and Systems - A Rule-Guided Approach</b>	
<i>Markos, Panagiotis; Dentsoras, Argyris</i>	1-259
<b>Stakeholder Centred Approach to Sustainable Design: A Case Study of Co-Designing Community Enterprises for Local Food Production And Consumption</b>	
<i>Pahk, Yoonyee; Baek, Joonsang</i>	1-269
<b>Substituting Conventional Materials and Manufacturing for Sustainable, Near Net Shape Grown Components</b>	
<i>Löwer, Manuel; Beger, Anna-Lena; Feldhusen, Jörg; Wormit, Alexandra; Prell, Jürgen; Usadel, Björn; Seiler, Thomas-Benjamin; Kämpfer, Christoph; Hollert, Henner; Moser, Franziska; Trautz, Martin</i>	1-279

<b>Similarities and Differences Between Environmental Soundness and Resource Efficiency and their Consequences for Design Support</b>	
<i>Link, Sandra; Kloberdanz, Hermann; Denz, Naemi</i>	1-289
<b>Integrated Design of Dynamic Sustainable Energy Systems</b>	
<i>Allison, James T.; Herber, Daniel R.; Deshmukh, Anand P.</i>	1-299
<b>Exploring Sustainability Impact on Interior Design Solutions</b>	
<i>Rashdan, Wael</i>	1-309
<b>Study on a Determination of Design Policies for Solar-Boats with Different Design Philosophies</b>	
<i>Oizumi, Kazuya; Aoyama, Kazuhiro</i>	1-319

## DESIGN FOR A HEALTHY LIFE

<b>Remember to Remember: A Feasibility Study Adapting Wearable Technology to the Needs of People Aged 65 and Older with Mild Cognitive Impairment (MCI) and Alzheimer's Dementia</b>	
<i>Maier, Anja M; Özkil, Ali Gürçan; Bang, Maria M; Forchhammer, Birgitte H</i>	1-331
<b>Prototyping and Testing Basic Designs of Centrifugal Microfluidic Platforms for Biomedical Diagnostics</b>	
<i>Fox, Stephan Cecil; Lohmeyer, Quentin; Meboldt, Mirko</i>	1-341
<b>A New Design System of Below-Limb Prostheses - the Role of a Visual Prosthetic Designer</b>	
<i>Sansoni, Stefania; Wodehouse, Andrew; Buis, Arjan</i>	1-351
<b>Feathers, A Bimanual Upper Limb Rehabilitation Platform: A Case Study of User-Centred Approach in Rehabilitation Device Design</b>	
<i>Shirzad, Navid; Valdés, Bulmaro A.; Hung, Chai-Ting; Law, Mimi; Hay, Justin; Van der Loos, H.F. Machiel</i>	1-361
<b>A Knowledge-Based Design Process for Custom Made Insoles</b>	
<i>Marinelli, Paola; Mandolini, Marco; Germani, Michele</i>	1-371
<b>Improving Wellbeing for Victims of Crime</b>	
<i>Kaldor, Lucy Joanna; Watson, Rodger</i>	1-381
<b>Can the Sports Design Process Help the inclusive Design Community?</b>	
<i>Wilson, Nicky; Thomson, Avril; Riches, Philip</i>	1-391
<b>Applying Design Ethnography to Product Evaluation: A Case Example of a Medical Device in a Low-Resource Setting</b>	
<i>Mohedas, Ibrahim; Sabet Sarvestani, Amir; Daly, Shanna R.; Sienko, Kathleen H.</i>	1-401
<b>Applying Fishbein's Multi-Attribute Attitude Model to the Tata Swach Water Purifier</b>	
<i>Ricks, Sean T; Winter V, Amos G</i>	1-411
<b>Design for Physical Activity: Design Aspects of Wearable Activity Trackers</b>	
<i>Kuru, Armağan; Erbuğ, Çiğdem</i>	1-421
<b>The Effects of Training Background and Design tools on Multi-Level Biosystems Design</b>	
<i>Egan, Paul; Ho, Tiffany; Schunn, Christian; Cagan, Jonathan; LeDuc, Philip</i>	1-433

Designing for the Deepest Needs of Both Public Service Consumers and Providers; Innovation in Mental Health Crisis Response <i>Van der Bijl-Brouwer, Mieke; Watson, Rodger</i> .....	1-443
Design and Validation of Diagnosis Tool of Inclusion of Children with Disabilities in Playgrounds <i>Mejia Piedrahita, Tatiana</i> .....	1-453
The HESD-Model: Merging Multiple Perspectives and Creating Flexible Use Scenarios for Service Design in Healthcare <i>Sarri, Tommaso; Kleinsmann, Maaïke; Melles, Marijke</i> .....	1-465
A Multi-Level Activity Analysis for Home Healthcare ICT Tool Redesign <i>Borgiel, Katarzyna; Christophe, Merlo; Minel, Stéphanie</i> .....	1-475
A Comprehensive Process of Care Coordination: A Skin Cancer Application <i>Boudjemil, Sonia; Duong, Tu-Anh; Jankovic, Marija; Le Cardinal, Julie</i> .....	1-485
The Competitive Advantage of Using 3D-Printing in Low-Resource Healthcare Settings <i>Rismani, Shalaleh; Van der Loos, H.F.Machiel</i> .....	1-495
Designing Child-Sized Hospital Architecture: Beyond Preferences for Colours and Themes <i>Verschoren, Laure; Annemans, Margo; Van Steenwinkel, Iris; Heylighen, Ann</i> .....	1-505

## DESIGN FOR A CONTENTED LIFE

A Framework for Understanding, Communicating and Evaluating User Experience Potentials <i>Kremer, Simon; Lindemann, Udo</i> .....	1-515
Why Product Design Support for Improved Worker Contentedness? <i>Farrugia, Lawrence; Borg, Jonathan</i> .....	1-525
Design for Infants is not Design for Children: On the Quest of Tools to Model a Method to Design for Infants <i>Monsalve, Juliana; Maya, Jorge</i> .....	1-537
Personal Values as a Catalyst for Meaningful Innovations: Supporting Young Designers in Collaborative Practice <i>Onselen, Lenny Van; Valkenburg, Rianne</i> .....	1-547
Reconceptualizing Design Thinking and Equipping Designers for the Next Wave of Digital Innovation <i>Kleinsmann, Maaïke; Snelders, Dirk</i> .....	1-557
Designing with Crime Prevention – Creating Community Wellbeing through Design <i>Watson, Rodger; Kaldor, Lucy</i> .....	1-565
Development of a National Survey on Aging and the Domestic Bathroom: the Livable Bathrooms Survey <i>Mintzes, Alicia; Bridge, Catherine; Demirbilek, Oya</i> .....	1-575
Design for Contented Life: A Proposed Framework <i>Ashour, Ayman Fathy</i> .....	1-585



## **VOLUME 2: Proceedings of the 20th International Conference on Engineering Design (ICED15)**

### **DESIGN THEORY AND RESEARCH METHODOLOGY, DESIGN PROCESSES**

#### **DESIGN THEORY AND METHODOLOGY**

<b>Case Study: Individualization of a Fully Automated Coffee Machine</b> <i>Kosiol, Maike; Böhmer, Annette Isabel; Lindemann, Udo</i> .....	2-1
<b>Design of Medical Devices for Pressure Ulcer Prevention</b> <i>Velasquez, Alejandro; Almonacid, Ana Maria; Jaramillo, Lisa Maria; Aramburo, Mauricio; Velasquez, David; Iza, Camilo; Zapata, Luis Miguel</i> .....	2-13
<b>Bioinspired Design: A Case Study of Reconfigurable Crawling-Rolling Robot</b> <i>Kapilavai, Aditya; Mohan, Rajesh Elara; Tan, Ning</i> .....	2-23
<b>Computational Design-to-Fabrication Using Spatial Grammars: Automatically Generating Printable Car Wheel Design Variants</b> <i>Chen, Tian; Shea, Kristina</i> .....	2-35
<b>Virtual Validation of Functional Automotive Door Assembly Properties by Means of Superposed CAT and FEM Analysis</b> <i>Ehlert, Matthias; Heling, Björn; Wartzack, Sandro</i> .....	2-45
<b>Generic Technique and the Dynamics of Technologies: Using Matroid and Design Theory to Design Techniques with Systemic Impact</b> <i>Le Masson, Pascal; Hatchuel, Armand; Kokshagina, Olga; Weil, Benoit</i> .....	2-55
<b>Definition of the Form-Based Design Approach and Description of it Using the FBS Framework</b> <i>Filippi, Stefano; Barattin, Daniela</i> .....	2-65
<b>Effectiveness of the Systematic Engineering Design Methodology</b> <i>Motte, Damien</i> .....	2-77
<b>Product Line Design, Evolution and Pricing</b> <i>Wu, Shuli; Chen, Songlin</i> .....	2-87
<b>An Approach for Industrial Application of Axiomatic Design</b> <i>Weber, Jakob; Köbler, Johannes; Paetzold, Kristin</i> .....	2-97
<b>How Much Design Does Research Need: An Inquiry of the Synergetic Potential of Methods of Social and Design Research.</b> <i>Dittenberger, Sandra; Koscher, Andrea</i> .....	2-107
<b>A Search and Optimization Perspective on Conceptual Design</b> <i>Kroll, Ehud; Weisbrod, Gil</i> .....	2-117
<b>Attributes in Integrated Design Engineering - A New Way to Describe both Performance Capability and Behaviour of a Product</b> <i>Vajna, Sandor J.</i> .....	2-127
<b>Designing PSI: An Introduction to the PSI Framework</b> <i>Reich, Yoram; Subrahmanian, Eswaran</i> .....	2-137
<b>Improving Design Methodology: Systematic Evaluation of Principle Synthesis</b> <i>Katzwinkel, Tim; Heller, Jan Erik; Schmid, Alexander; Schmidt, Walter; Löwer, Manuel; Feldhusen, Jörg</i> .....	2-147

<b>Towards Genetic Modeling of Machines for Engineering Design Synthesis</b> <i>Shah, Jami</i> .....	2-155
<b>Challenges in Developing an Ontology for Problem Formulation In Design</b> <i>Dinar, Mahmoud; Park, Yong-Seok; Shah, Jami J</i> .....	2-165
<b>Biocards and Level of Abstraction</b> <i>Lenau, Torben Anker; Keshwani, Sonal; Chakrabarti, Amaresh; Ahmed-Kristensen, Saeema</i> .....	2-177
<b>Using Biology as a Model for Sustainability: Insights for Ecodesign and Bioinspired Design Practitioners</b> <i>O'Rourke, Julia; Seepersad, Carolyn Conner</i> .....	2-187
<b>Influence of Information and Knowledge from Biology on the Variety of Technical Solution Ideas</b> <i>Hashemi Farzaneh, Helena; Helms, Katharina; Lindemann, Udo</i> .....	2-197
<b>Biologically Inspired Fault Adaptive Strategies for Engineered Systems</b> <i>Jensen, David Charles; Huisman, Nicholas</i> .....	2-207
<b>Visual Representations as a Bridge for Engineers and Biologists in Bio-Inspired Design Collaborations</b> <i>Hashemi Farzaneh, Helena; Helms, Katharina; Lindemann, Udo</i> .....	2-215
<b>Modeling Biological Systems to Facilitate their Selection During a Bio-Inspired Design Process</b> <i>Fayemi, Pierre-Emmanuel Ifeolohoum; Maranzana, Nicolas; Aoussat, Ameziane; Chekchak, Tarik; Bersano, Giacomo</i> .....	2-225
<b>System for Deriving Diverse Solutions via a Modification Method for Emergent Design</b> <i>Sato, Koichiro; Matsuoka, Yoshiyuki</i> .....	2-235
<b>Design Repository &amp; Analogy Computation via Unit-Language Analysis (Dracula) Matching Algorithm Development</b> <i>Briana, Lucero; Julie, Linsey; Turner, Cameron</i> .....	2-245
<b>Computational Support of Design Concept Generation through Interaction of Sketching, Ontology-Based Classification and Finding Voids</b> <i>Nomaguchi, Yutaka; Nakagiri, Taku; Fujita, Kikuo</i> .....	2-257
<b>Ontology in Design Engineering: Status and Challenges</b> <i>Lim, Soon Chong Johnson; Liu, Ying; Chen, Yong</i> .....	2-267
<b>Designing with Priorities and Thresholds for Health Care Heterogeneity: the Approach of Constructing Parametric Ontology</b> <i>Eivazzadeh, Shahryar; Anderberg, Peter; Berglund, Johan; Larsson, Tobias</i> .....	2-277
<b>Design Talking: An Ontology of Design Methods to Support a Common Language of Design</b> <i>Roschuni, Celeste; Kramer, Julia; Zhang, Qian; Zaksorn, Lauren; Agogino, Alice</i> .....	2-285

## DESIGN RESEARCH METHODOLOGY

<b>Measuring Prototypes - A Standardized Quantitative Description of Prototypes and their Outcome for Data Collection and Analysis</b> <i>Jensen, Matilde Bisballe; Balters, Stephanie; Steinert, Martin</i> .....	2-295
<b>Modelling in Business Model Design: Reflections on Three Experimental Cases In Healthy Living</b> <i>Simonse, Lianne W.L.; Badke-Schaub, Petra</i> .....	2-309
<b>Distributed Experiments in Design Sciences, a Next Step in Design Observation Studies?</b> <i>Kriesi, Carlo; Steinert, Martin; Aalto-Setälä, Laura; Anvik, Anders; Balters, Stephanie; Baracchi, Alessia; Bisballe Jensen, Matilde; Bjørkli, Leif Erik; Buzzaccaro, Nicolo; Cortesi, Dario; D'Onghia, Francesco; Dosi, Clio; Franchini, Giulia; Fuchs, Matt; Gerstenberg, Achim; Hansen, Erik; Hiekkanen, Karri Matias; Hyde, David; Ituarte, Iñigo; Kalasniemi, Jani; Kurikka, Joonas; Lanza, Irene; Laurila, Anssi; Lee, Tik Ho; Lønvik, Siri; Mansikka-Aho, Anniina; Nordberg, Markus; Oinonen, Päivi; Pedrelli, Luca; Pekuri, Anna; Rane, Enna; Reime, Thov; Repokari, Lauri; Rønningen, Martin; Rowlands, Stephanie; Sjöman, Heikki; Slåttsveen, Kristoffer; Strachan, Andy; Strømstad, Kirsti; Suren, Stian; Tapio, Peter; Utriainen, Tuuli; Vignoli, Matteo; Vijaykumar, Saurabh; Welo, Torgeir; Wulvik, Andreas</i> .....	2-319
<b>Teaching Nurses CAD: Identifying Design Software Learning Differences in a Non-Traditional User Demographic</b> <i>Stephenson, Katherine Jo; Pickham, David; Aquino Shluzas, Lauren</i> .....	2-329
<b>Differences in Analysis and Interpretation of Technical Systems by Expert and Novice Engineering Designers</b> <i>Ruckpaul, Anne; Nelius, Thomas; Matthiesen, Sven</i> .....	2-339
<b>Mobile Eye Tracking in Usability Testing: Designers Analysing the User-Product Interaction</b> <i>Mussnug, Moritz; Waldern, Michael Frederick; Meboldt, Mirko</i> .....	2-349
<b>How we Understand Engineering Drawings: An Eye Tracking Study Investigating Skimming and Scrutinizing Sequences</b> <i>Lohmeyer, Quentin; Meboldt, Mirko</i> .....	2-359
<b>Reviewing Peer Review, an Eye Tracking Experiment of Review Behaviour</b> <i>Boa, Duncan R; Hicks, Ben</i> .....	2-369

## DESIGN PROCESSES

<b>Enhanced Analytical Model for Planning the Verification, Validation &amp; Testing Process</b> <i>Yakov, Shabi; Reich, Yoram</i> .....	2-379
---	-------

<b>Integrated Product and Process Models: Towards an Integrated Framework and Review</b>	
<i>Eckert, Claudia; Albers, Albert; Bursac, Nikola; Chen, Hilario Xin; Clarkson, P. John; Gericke, Kilian; Gladysz, Bartosz; Maier, Jakob F.; Rachenkova, Galina; Shapiro, Daniel; Wynn, David</i>	2-389
<b>FBS Models: An Attempt at Reconciliation Towards a Common Representation</b>	
<i>Spreafico, Christian; Fantoni, Gualtiero; Russo, Davide</i>	2-399
<b>Modelling Practices Over Time: A Comparison of Two Surveys Taken 20 Years Apart</b>	
<i>Moullec, Marie-Lise; Maier, Jakob; Cassidy, Stephen; Sommer, Anita F.; Clarkson, P. John</i>	2-409
<b>Value Modelling in Aerospace Sub-System Design: Linking Quantitative and Qualitative Assessment</b>	
<i>Bertoni, Alessandro; Amnell, Henrik; Isaksson, Ola</i>	2-421
<b>Process Types and Value Configuration in Modelling Practice – An Empirical Study of Modelling in Design and Service</b>	
<i>Sommer, Anita Friis; Maier, Jakob; Mak, Jonathan; Moullec, Marie-Lise; Cassidy, Stephen; Clarkson, P. John</i>	2-431
<b>Towards the Next Generation of Design Process Models: A Gap Analysis of Existing Models</b>	
<i>Costa, Daniel Guzzo; Macul, Victor Cussiol; Costa, Janaina Mascarenhas Hornos; Exner, Konrad; Pförtner, Anne; Stark, Rainer; Rozenfeld, Henrique</i>	2-441
<b>An Investigation of Design Process Changes</b>	
<i>Shapiro, Daniel; Sommer, Anita Friis; Clarkson, Peter John</i>	2-451
<b>Structure-Based System Dynamics Analysis - A Case Study of Benchmarking Process Optimization</b>	
<i>Kasperek, Daniel; Berger, Sandra; Maisenbacher, Sebastian; Lindemann, Udo; Maurer, Maik</i>	2-461
<b>The Long Road to Improvement in Modelling and Managing Engineering Design Processes</b>	
<i>Gericke, Kilian; Eckert, Claudia</i>	2-471

## **VOLUME 3: Proceedings of the 20th International Conference on Engineering Design (ICED15)**

### **DESIGN ORGANISATION AND MANAGEMENT**

<b>The Evolution of Terminology within a Large Distributed Engineering Project</b> <i>Gopsill, James Anthony; Jones, Simon; Snider, Chris; Shi, Lei; Hicks, Ben James</i> .....	3-1
<b>Different Levels of Product Model Granularity in Design Process Simulation</b> <i>Maier, Jakob F.; Eckert, Claudia M.; Clarkson, P. John</i> .....	3-11
<b>Modularization Management and Network Configuration</b> <i>Hansen, Poul Kyvsgaard; Nielsen, Louise Møller</i> .....	3-21
<b>Influence of Design-For-X Guidelines on the Matching Between the Product Architecture and Supply Network</b> <i>Behncke, Florian G. H.; Thimet, Paula; Barton, Benjamin; Lindemann, Udo</i> .....	3-31
<b>A Study to Identify Engineering Design Resources in Complex Product Development Projects</b> <i>Xin Chen, Hilario Lorenzo; Clarkson, Peter John; Sommer, Anita Friis</i> .....	3-43
<b>Matching Product Architecture and Supply Network - Systematic Review and Future Research</b> <i>Behncke, Florian G. H.; Kayser, Liza; Lindemann, Udo</i> .....	3-53
<b>Understanding Engineering Projects: An Integrated Vehicle Health Management Approach to Engineering Project Monitoring</b> <i>Snider, Chris; Gopsill, James A.; Jones, Simon; Shi, Lei; Hicks, Ben</i> .....	3-65
<b>Implementation of R&amp;D Management Models in Global Organisations</b> <i>Johansson, Glenn; Säfsten, Kristina; Adolfsson, Ann-Cathrine</i> .....	3-75
<b>An Agent-Based Approach to Support Planning for Change During Early Design</b> <i>Fernandes, João; Henriques, Elsa; Silva, Arlindo; Pimentel, César</i> .....	3-83
<b>Considering Risk Attitude in a Value of Information Problem</b> <i>Hsiao, Chuck; Malak, Richard</i> .....	3-93
<b>Crisis Situations in Engineering Product Development - A Method to Identify Crisis</b> <i>Muenzberg, Christopher; Venkataraman, Srinivasan; Hertrich, Nicolas; Fruehling, Carl; Lindemann, Udo</i> .....	3-103
<b>Safety of Individual Products – Perspectives in the Context of Current Practices and Challenges</b> <i>Roth, Michael; Gehrlicher, Steffi; Lindemann, Udo</i> .....	3-113
<b>Utilizing Failure Information for Mission Analysis for Complex Systems</b> <i>DeStefano, Charlie; Jensen, David</i> .....	3-123
<b>Framing in Design: A Formal Analysis and Failure Modes</b> <i>Vermaas, Pieter; Dorst, Kees; Thurgood, Clementine</i> .....	3-133
<b>Design Driven Startups</b> <i>Petersen, Søren Ingomar</i> .....	3-143

<b>Characteristics and Enablers of Transparency in Product Development Risk Management</b>	
<i>Shaffer, Ryan M.; Olechowski, Alison L.; Seering, Warren P.; Ben-Daya, Mohammad</i> .....	3-153
<b>Actor-Based Signposting: A Modeling Tool to Improve the Socio-Technical Design Processes</b>	
<i>Hassannezhad, Mohammad; Cantamessa, Marco; Montagna, Francesca</i> .....	3-165
<b>The Impact of Technology Uncertainty on Early Supplier Integration in Product Development</b>	
<i>Geissmann, Lukas; Rebentisch, Eric Scott</i> .....	3-175
<b>Impact of Architecture Types and Degree of Modularity on Change Propagation Indices</b>	
<i>Colombo, Edoardo Filippo; Cascini, Gaetano; De Weck, Olivier L.</i> .....	3-187
<b>Dependency Identification for Engineering Change Management (ECM): An Example of Computer-Aided Design (CAD)-Based Approach</b>	
<i>Masmoudi, Mahmoud; Leclaire, Patrice; Zolghadri, Marc; Haddar, Mohamed</i> .....	3-199
<b>An Intelligent Design Environment for Changeability Management - Application To Manufacturing Systems</b>	
<i>Benkamoun, Nadège; Kouiss, Khalid; Huyet, Anne-Lise</i> .....	3-205
<b>Changes on Changes: Towards an Agent-Based Approach for Managing Complexity in Decentralized Product Development</b>	
<i>Kehl, Stefan; Stiefel, Patrick; Müller, Jörg P.</i> .....	3-215
<b>How to Integrate Information about Past Engineering Changes in New Change Processes?</b>	
<i>Wickel, Martina Carolina; Lindemann, Udo</i> .....	3-229
<b>Envisioning Products to Support the Agile Management of Innovative Design</b>	
<i>Carvalho, Fábio Henrique Trovon De; Costa, Janaína Hornos Mascarenhas Da; Amaral, Daniel Capaldo</i> .....	3-239
<b>Exploring Tensions Between Creativity and Control in Product Development Projects</b>	
<i>Bojesson, Catarina; Backström, Tomas; Bjurström, Erik</i> .....	3-249
<b>Constant Dripping Wears Away the Stone: Linking Design Thinking and Effectual Action in Designing New Ventures</b>	
<i>Niedworok, Anja; Schloegl, Stephan; Mirski, Peter J.; Greger, Rudolf; Ambrosch, Marcus</i> .....	3-259
<b>Constructing a Multi-Dimensional Model to Understand Team Design through Language</b>	
<i>Xu, Jiang; Guo, Feng; Gan, Xiang; Wang, Xiuyue</i> .....	3-269
<b>The Use and Value of Different Co-Creation and Tools in the Design Process.</b>	
<i>Ali, Abu; Liem, Andre</i> .....	3-279

<b>Physical Interaction Mappings: Utilizing Cognitive Load Theory in order to Enhance Physical Product Interaction</b> <i>Young, Bryan Gough; Wodehouse, Andrew; Sheridan, Marion</i>	3-289
<b>An Exploratory Study of the Specifications Process in a Customer-Supplier Collaborative New Product Development</b> <i>Yager, Matthieu; Le Dain, Marie-Anne; Merminod, Valéry</i>	3-299
<b>Correlations Between Successful Consumer Goods in the Market and Creativity in Form And Function Attributes</b> <i>Sehn, Cristina Morandi; Bernardes, Mauricio Moreira E Silva; Jacques, Jocelise Jacques De</i>	3-309
<b>Meetings in The Product Development Process: Applying Design Methods to Improve Team Interaction and Meeting Outcomes</b> <i>Bavendiek, Ann-Kathrin; Thiele, Lisa; Meyer, Patrick; Vietor, Thomas; Kauffeld, Simone; Fingscheidt, Tim</i>	3-319
<b>Modelling of Immersive Systems for Collaborative Design</b> <i>Rohmer, Serge</i>	3-329
<b>Online Ways of Sharedness: A Syntactic Analysis of Design Collaboration in OpenIDEO</b> <i>Bianchi, Joost; Knopper, Yuri; Eris, Ozgur; Badke-Schaub, Petra; Roussos, Lampros</i>	3-339
<b>Can Algorithms Calculate The “Real” Sharedness in Design Teams?</b> <i>Yamada, Kaori; Badke-Schaub, Petra; Eris, Ozgur</i>	3-349
<b>How an Open Source Design Community Works: The Case of Open Source Ecology</b> <i>Macul, Victor; Rozenfeld, Henrique</i>	3-359
<b>A Framework of Working across Disciplines in Early Design and R&amp;D of Large Complex Engineered Systems</b> <i>McGowan, Anna-Maria Rivas; Papalambros, Panos; Baker, Wayne</i>	3-367
<b>Identifying and Visualising KPIs for Collaborative Engineering Projects: A Knowledge Based Approach</b> <i>Shi, Lei; Newnes, Linda; Culley, Steve; Gopsill, James; Jones, Simon; Snider, Chris</i>	3-377
<b>The Sensory Delivery Rooms of The Future: Translating Knowlege across Boundaries in a Public-Private Innovation Partnership</b> <i>Pedersen, Signe</i>	3-387
<b>Meaning Making in the Intersection between Sketches and 3D Mock-Up</b> <i>Ali, Abu; Liem, Andre</i>	3-397
<b>Argumentation Analysis in an Upstream Phase of an Innovation Project</b> <i>Abou Eddahab, Fatima-Zahra; Prudhomme, Guy; Masclet, Cedric; Lund, Kris; Boujut, Jean-François</i>	3-407
<b>Rethinking Operating Models for Intangible Services: From a Mechanistic Structure to a Sustainable Model</b> <i>Minzoni, Angela; Mounoud, Eleonore</i>	3-417

**Pragmatic Team Compositions in Scrum-Based Development Projects**  
*Ovesen, Nis* ..... 3-427

**A Longitudinal Study of Globally Distributed Design Teams:  
The Impacts on Product Development.**  
*Taylor, Thomas Paul; Ahmed-Kristensen, Saeema* ..... 3-437

**Boundary Objects in Open Source Design: Experiences from OSE Community**  
*Affonso, Claudia Andressa Cruz; Amaral, Daniel Capaldo* ..... 3-447

**Work Sampling Approach for Measuring Intellectual Capital Elements  
in Product Development Context**  
*Škec, Stanko; Štorga, Mario; Tečec Ribarić, Zlatka; Marjanović, Dorian* ..... 3-457



## **VOLUME 4: Proceedings of the 20th International Conference on Engineering Design (ICED15)**

### **DESIGN FOR X, DESIGN TO X**

Approach to Consider Rapid Manufacturing in the Early Phases of Product Development <i>Weiss, Florian; Binz, Hansgeorg; Roth, Daniel</i> .....	4-1
Result Visualization and Documentation of Tolerance Simulations of Mechanisms <i>Walter, Michael Simon Josef; Pribek, Michael; Spruegel, Tobias Constantin; Wartzack, Sandro</i> .....	4-11
The Design and Manufacture of Individualised Perfect-Fit Packaging Solutions <i>Dhokia, Vimal; Newman, Stephen Thomas</i> .....	4-21
Assembly Sequence Planning with the Principles of Design for Assembly <i>Sąsiadek, Michał</i> .....	4-31
Handling Product Variety in a Mixed-Product Assembly Line: A Case Study <i>Asadi, Narges; Jackson, Mats; Fundin, Anders</i> .....	4-41
Design for Recovery - Applying Multivariate Statistics to Define Groupings of French WEEE Pre-Treatment Operators <i>Alonso Movilla, Natalia; Zwolinski, Peggy</i> .....	4-51
Design for Retrofitting <i>Coenen, Jenny; Ruiz, Valentina; Fernandez Hernando, Jose Manuel; Frouws, Koos</i> .....	4-61
The Realization of an Engineering Assistance System for the Development of Noise-Reduced Rotating Machines <i>Küstner, Christof; Wartzack, Sandro</i> .....	4-71
Development of Portability Design Heuristics <i>Hwang, Dongwook; Park, Woojin</i> .....	4-81
Dealing with Non-Trade-Offs for Frugal Design <i>Lecomte, Chloé; Blanco, Eric</i> .....	4-91
Exploring Benefits of Using Augmented Reality for Usability Testing <i>Choi, Young Mi; Mittal, Sanchit</i> .....	4-101
Development of an Interface Analysis Template for System Design Analysis <i>Uddin, Amad; Campean, Felician; Khan, Mohammed Khurshid</i> .....	4-111
The Application of Crowdsourcing for 3D Interior Layout Design <i>Wu, Hao; Corney, Jonathan; Grant, Michael</i> .....	4-123
Assessing Time-Varying Advantages of Remanufacturing: A Model for Products with Physical and Technological Obsolescence <i>Kwak, Minjung; Kim, Harrison</i> .....	4-135

<b>Product Development in Low-Volume Manufacturing Industries: Characteristics and Influencing Factors</b>	
<i>Javadi, Siavash; Bruch, Jessica; Bellgran, Monica</i>	4-145
<b>Methodical Support for Concurrent Engineering across Product and Production (System) Development</b>	
<i>Stoffels, Pascal; Vielhaber, Michael</i>	4-155
<b>Modeling Factory Systems Using Graphs - Ontology-Based Design of a Domain Specific Modeling Approach</b>	
<i>Plehn, Christian; Stein, Florian; Reinhart, Gunther</i>	4-163
<b>Tasks and Challenges in Prototype Development with Novel Technology – An Empirical Study</b>	
<i>Ravn, Poul Martin; Guðlaugsson, Tómas Vignir; Mortensen, Niels Henrik</i>	4-173
<b>Design-For-Manufacture of Sheet-Bulk Metal Formed Parts</b>	
<i>Breitsprecher, Thilo; Sauer, Christopher; Sperber, Christian; Wartzack, Sandro</i>	4-183
<b>Digital Aesthetic of New Products Obtained by Selective Laser Melting Process</b>	
<i>Galimberti, Giorgia; Guagliano, Mario; Previtali, Barbara; Rampino, Lucia</i>	4-193
<b>Additive Manufacturing Design Feature Selection for Variable Product Platforms</b>	
<i>Yao, Xiling; Moon, Seung Ki; Bi, Guijun</i>	4-205
<b>Approach for a Comparatively Evaluation of the Sustainability for Additive Manufactured Aluminum Components</b>	
<i>Lachmayer, Roland; Gottwald, Philipp; Lippert, Rene Bastian</i>	4-215
<b>Indicators and Design Strategies for Direct Part Production by Additive Manufacturing</b>	
<i>Leutenecker, Bastian; Klahn, Christoph; Meboldt, Mirko</i>	4-225
<b>Design Method and Taxonomy of Optimized Regular Cellular Structures for Additive Manufacturing Technologies</b>	
<i>Savio, Gianpaolo; Gaggi, Flavio; Meneghello, Roberto; Concheri, Gianmaria</i>	4-235
<b>Design for Mass Customization Using Additive Manufacture: Case-Study of a Balloon-Powered Car</b>	
<i>Chen, Tian; Fritz, Stöckli; Shea, Kristina</i>	4-245
<b>A Call for FDM Design Rules to Include Road Deposition</b>	
<i>Fornasini, Giacomo; Schmidt, Linda C.</i>	4-255
<b>Redefining Product Family Design for Additive Manufacturing</b>	
<i>Lei, Ningrong; Moon, Seung Ki; Rosen, David W.</i>	4-267
<b>Combining Additive Manufacturing with CFRP Composites: Design Potentials</b>	
<i>Türk, Daniel-Alexander; Züger, Andreas; Klahn, Christoph; Meboldt, Mirko</i>	4-279
<b>Crowdsourced Design Principles for Leveraging the Capabilities of Additive Manufacturing</b>	
<i>Perez, K Blake; Anderson, David S; Holtta-Otto, Katja; Wood, Kristin L</i>	4-291

<b>Exploring the Significance of In-Process Knowledge to Composites Design and Production</b>	
<i>Jones, Helene Victoria; Chatzimichali, Anna; Potter, Kevin; Ward, Carwyn</i>	4-301
<b>Natural Fibre-Reinforced, Injection Moulded Polymers for Light Weight Constructions – Simulation of Sustainable Materials for the Automotive Industry –</b>	
<i>Albrecht, Katharina; Osswald, Tim; Wartzack, Sandro; Müssig, Jörg</i>	4-313
<b>Energy Efficiency Oriented Development of Production Systems</b>	
<i>Stoffels, Pascal; Vielhaber, Michael</i>	4-323
<b>Evaluation of a Strategic Method to Improve Prototype Performance with Reduced Cost and Fabrication Time</b>	
<i>Camburn, Bradley Adam; Jensen, Daniel; Crawford, Richard; Otto, Kevin; Wood, Kristin</i>	4-333
<b>A Generic Approach to Sensitivity Analysis in Geometric Variations Management</b>	
<i>Schleich, Benjamin; Wartzack, Sandro</i>	4-343

## **VOLUME 5: Proceedings of the 20th International Conference on Engineering Design (ICED15)**

### **DESIGN METHODS AND TOOLS – PART 1**

<b>A Framework for Quantitative Analysis of Government Policy Influence on Electric Vehicle Market</b> <i>Kang, Namwoo; Emmanoulopoulos, Manos; Ren, Yi; Feinberg, Fred M.; Papalambros, Panos Y.</i> .....	5-1
<b>A Comparison of Conjoint Analysis and Interactive Genetic Algorithms for the Study of Product Semantics</b> <i>Petiot, Jean-François; Francisco, Cervantes Chavez; Ludivine, Boivin</i> .....	5-11
<b>Stakeholders' Diverging Perceptions of Product Requirements: Implications in the Design Practice</b> <i>Borgianni, Yuri; Rotini, Federico</i> .....	5-21
<b>The Malicious Labyrinth of Requirements - Three Types of Requirements for a Systematic Determination of Product Properties</b> <i>Mattmann, Ilyas; Gramlich, Sebastian; Kloberdanz, Hermann</i> .....	5-31
<b>Requirements Checklists: Benchmarking the Comprehensiveness of the Design Specification</b> <i>Becattini, Niccolo; Cascini, Gaetano; Rotini, Federico</i> .....	5-41
<b>Considering User's Impact in Validation Activities – An Approach for the Determination of Requirements</b> <i>Pinner, Tobias; Jost, Franz; Schmid, Daniel; Albers, Albert</i> .....	5-51
<b>Understand the Design Requirement in Companies</b> <i>Li, Xuemeng; Ahmed-Kristensen, Saeema</i> .....	5-63
<b>A Product Planning of E-Sports Headphone by Blending Replication ZMET with QFD</b> <i>Wang, Hung-Hsiang</i> .....	5-75
<b>Quality Function Deployment Using Multispace Design Model and its Application</b> <i>Kato, Takeo; Horiuchi, Shigehiro; Miwa, Toshiharu; Matsuoka, Yoshiyuki</i> .....	5-83
<b>The Potential of Design-By-Analogy Methods to Support Product, Service and Product Service Systems Idea Generation</b> <i>Moreno Grandas, Diana Paola; Blessing, Lucienne; Yang, Maria; Wood, Kristin</i> .....	5-93
<b>A Qualitative Investigation of Ideation Practices in Engineering and Product Design</b> <i>Currano, Rebecca; Henriksson, Emily</i> .....	5-105
<b>Synthesis of Conceptual Designs for Sensors Using SAPPhIRE-lite</b> <i>Sarkar, Biplob; Chakrabarti, Amaresh; Ananthasuresh, G.K</i> .....	5-115
<b>When Costs from Being a Constraint Become a Driver for Concept Generation</b> <i>Altavilla, Stefania; Montagna, Francesca</i> .....	5-125

<b>Form Follows Data: A Method to Support Concept Generation</b>	
<b>Coupling Experience Design with Motion Capture.</b>	
<i>Camere, Serena; Caruso, Giandomenico; Bordegoni, Monica;</i>	
<i>Di Bartolo, Carmelo; Mauri, Duccio; Pisino, Enrico</i>	5-135
<b>Integrated Function Modelling: Comparing the IFM Framework with SysML</b>	
<i>Eisenbart, Boris; Mandel, Constantin; Gericke, Kilian; Blessing, Lucienne</i>	5-145
<b>Capture of Actual Development Processes of Hybrid Intelligent</b>	
<b>Design Elements in Order to Define a Target Development Process</b>	
<i>Crostack, Alexander; Binz, Hansgeorg; Roth, Daniel</i>	5-157
<b>Improving Generative Grammar Development and Application</b>	
<b>through Network Analysis Techniques</b>	
<i>Königseder, Corinna; Stanković, Tino; Shea, Kristina</i>	5-167
<b>Management and Visualization of Relationships Between Engineering Objects</b>	
<i>Pavkovic, Neven; Martinec, Tomislav; Rohde, Danijel; Sikic, Bruno</i>	5-177
<b>Evaluating the Need for Traceability in Product Development:</b>	
<b>A Preliminary Study</b>	
<i>Koehler, Nico; Naumann, Thomas; Vajna, Sandor</i>	5-187
<b>Building Brands Through Design: A Systematic Bibliographical Review</b>	
<i>Michellini, Gustavo; Amaral, Daniel Capaldo</i>	5-197
<b>On the Development of Visualisation Concepts as Tools in Product Design</b>	
<i>Gebhardt, Nicolas; Krause, Dieter</i>	5-205
<b>Evaluation of Clay Modelling and Surfacing Cycles From Designers Perspective</b>	
<i>Chandra, Sushil</i>	5-215
<b>Determining the Similarity of Products Using Pairwise Comparisons</b>	
<b>and Eye Tracking</b>	
<i>Boa, Duncan R; Ranscombe, Charlie; Hicks, Ben</i>	5-225
<b>The Value of Prototypes in the Early Design and Development Process</b>	
<i>Isa, Siti Salwa; Liem, Andre; Steinert, Martin</i>	5-235
<b>An Automated Function Decomposition Method Based on a</b>	
<b>Formal Representation of Solid Material's Shape</b>	
<i>Yuan, Lin; Zhang, Zhinan; Liu, Yusheng</i>	5-243
<b>A Bayesian Network Approach to Improve Change Propagation Analysis</b>	
<i>Lee, Jihwan; Hong, Yoo S.</i>	5-253
<b>Digital Intermediary Objects: The (Currently) Unique Advantage</b>	
<b>of Computer-Supported Design Tools</b>	
<i>Guerra, Andrea Luigi; Gidel, Thierry; Vezzetti, Enrico</i>	5-265
<b>An Approach to the Property-Based Planning of Simulations</b>	
<i>Reitmeier, Jochen; Chahin, Abdo; Paetzold, Kristin</i>	5-275
<b>Applying Matrix-Based Methods for Improving User Experience</b>	
<b>of a Driver Advisory System</b>	
<i>Michailidou, Ioanna; Diergarten, Lorenz; Lindemann, Udo</i>	5-287
<b>Eco-Evaluation of Technical Systems in the Conceptual Phase</b>	
<i>Midžić, Ida; Štorga, Mario; Marjanović, Dorian</i>	5-299

Designing of Hybrid Joints at the Early Embodiment Design Stage  
*Kellermeyer, Markus; Klein, Daniel; Wartzack, Sandro* ..... 5-309

Extension of the Lightweight Design Thinking Tools for the Application  
on More Complex Problems  
*Posner, Benedikt; Binz, Hansgeorg; Roth, Daniel* ..... 5-319

A Methodical Approach to Model and Map Interconnected Decision Making  
Situations and their Consequences  
*Luft, Thomas; Schneider, Samuel; Wartzack, Sandro* ..... 5-329

Using Balance Variables to Describe System Interfaces  
and Assess In-Progress Designs  
*Salustri, Filippo Arnaldo; Rogers, Damian* ..... 5-341

Real-Time Product Recovery Decision Making Algorithm  
for Sustainability  
*Kanchanasri, Passaporn; Moon, Seung Ki; Ng, Gary Ka Lai* ..... 5-351

## **VOLUME 6: Proceedings of the 20th International Conference on Engineering Design (ICED15)**

### **DESIGN METHODS AND TOOLS – PART 2**

<b>A Visual Interface Diagram for Mapping Functions in Integrated Products</b> <i>Ingerslev, Mattias; Jespersen, Mikkel Oliver; Göhler, Simon Moritz;</i> <i>Howard, Thomas J. ....</i>	<b>6-1</b>
<b>How to Define a Sustainability Design Space</b> <i>Hallstedt, Sophie ....</i>	<b>6-11</b>
<b>Highlighting the Importance of Testing in the Product Development Process</b> <i>Tahera, Khadija; Eckert, Claudia; Earl, Chris ....</i>	<b>6-21</b>
<b>Rerouting Failure Flows Using Logic Blocks in Functional Models for Improved System Robustness: Failure Flow Decision Functions</b> <i>Short, Adam R.; Van Bossuyt, Douglas Lee ....</i>	<b>6-31</b>
<b>Integrated Approach for Efficient Tolerance Optimization on Sheet Metal Parts</b> <i>Litwa, Frank; Gottwald, Martin; Vielhaber, Michael ....</i>	<b>6-41</b>
<b>An Approach to Analysing Interface Uncertainty Using the Contact and Channel Model</b> <i>Freund, Tillmann; Kloberdanz, Hermann; Lotz, Julian; Würtenberger, Jan ....</i>	<b>6-53</b>
<b>A Robust Design Applicability Model</b> <i>Ebro, Martin; Krogstie, Lars; Howard, Thomas J. ....</i>	<b>6-63</b>
<b>Measuring Functional Robustness With Network Topological Robustness Metrics</b> <i>Haley, Brandon; Dong, Andy; Tumer, Irem ....</i>	<b>6-75</b>
<b>Design Roadmapping: Challenges and Opportunities</b> <i>Kim, Euiyoung; Yao, Shun; Agogino, Alice Merner ....</i>	<b>6-85</b>
<b>Avoiding Resonant Frequencies in a Pipeline Application by Utilising the Concept Design Analysis Method</b> <i>Khamuknin, Alexander; Bertoni, Marco; Eres, Murat Hakki ....</i>	<b>6-95</b>
<b>Introduction of a Computational Approach for the Design of Composite Structures at the Early Embodiment Design Stage</b> <i>Klein, Daniel; Malezki, Waldemar; Wartzack, Sandro ....</i>	<b>6-105</b>
<b>Assessing the Differences Between Numerical Methods, CAD Evaluations and Real Experiments for the Assessment of Reach Envelopes of the Human Body</b> <i>Delangle, Mathieu; Petiot, Jean-François; Poirson, Emilie ....</i>	<b>6-115</b>
<b>Efficient Design Evaluation Through the Combination of Numerical and Physical Computations</b> <i>Foehr, André G. C.; Stücheli, Marius; Meboldt, Mirko ....</i>	<b>6-125</b>
<b>Simultaneous Optimisation: Strategies for Using Parallelization Efficiently</b> <i>Wünsch, Andreas; Jordan, André; Vajna, Sándor ....</i>	<b>6-133</b>

<b>Stack-Up Analysis of Statistical Tolerance Indices for Linear Function Model Using Monte Carlo Simulation</b>	
<i>Otsuka, Akimasa; Nagata, Fusaomi</i>	6-143
<b>Taking Into Account the Change of Geometry in System Simulation Processes</b>	
<i>Mauser, Kristian; Breitsprecher, Thilo; Hasse, Alexander; Wartzack, Sandro</i>	6-153
<b>Functional Assembly Using Synaptic Networks: Theory and a Demonstration Case Study</b>	
<i>Mavrikas, Georgios; Spitas, Vasilios; Spitas, Christos</i>	6-163
<b>Integrating the Ability for Topology Optimization in a Commercial CAD-System</b>	
<i>Schmelcher, Johannes; Stetter, Ralf; Till, Markus</i>	6-173
<b>Concept and Application of Automatic Part-Recognition with Artificial Neural Networks for FE Simulations</b>	
<i>Spruegel, Tobias C.; Wartzack, Sandro</i>	6-183
<b>Simulation Ready CAD-Models as a Means for Knowledge Transfer Between Technology Development and Product Development</b>	
<i>Johansson, Joel; André, Samuel; Elgh, Fredrik</i>	6-195
<b>Definition of the Collaborative Simulation System (CM&amp;SS) from a Systemic Perspective in Vehicle Industry Context</b>	
<i>Roa Castro, Laura; Stal-Le Cardinal, Julie</i>	6-205
<b>Graphical Support Adapted to Designers for the Selection of an Optimal Solution in Design By Shopping</b>	
<i>Abi Akle, Audrey; Minel, Stéphanie; Yannou, Bernard</i>	6-215
<b>Heterogeneous Simulated Annealing Teams: An Optimizing Search Algorithm Inspired by Engineering Design Teams</b>	
<i>McComb, Christopher; Cagan, Jonathan; Kotovsky, Kenneth</i>	6-225
<b>Feature Based Interpretation and Reconstruction of Structural Topology Optimization Results</b>	
<i>Stangl, Thomas; Wartzack, Sandro</i>	6-235
<b>From Simulation to Invention, Beyond the Pareto-Frontier</b>	
<i>Dubois, Sebastien; Lin, Lei; De Guio, Roland; Rasovska, Ivana</i>	6-245
<b>Design for Scalability and Strength Optimisation for Components Created Through FDM Process</b>	
<i>Qureshi, A.J.; Mahmood, Shahrain; Wong, W.L.E.; Talamona, Didier</i>	6-255
<b>Fairness and Manipulation: An Empirical Study of Arrow's Impossibility Theorem</b>	
<i>McComb, Christopher; Goucher-Lambert, Kosa; Cagan, Jonathan</i>	6-267
<b>Proposal of a Framework for Characterizing Virtual Collectives in the Engineering Design Field</b>	
<i>El Badawi El Najjar, Rachad; Blanco, Eric; Pourroy, Franck; Prudhomme, Guy; Maussang-Detaille, Nicolas</i>	6-277



<b>Bridging the ‘Valley of Death’ in Product Development: A Case Study of the Drill Cover Project</b>	
<i>Gheorghe, Florin; Hodgson, Antony J.; Van Der Loos, H.F. Machiel</i> .....	6-287
<b>Interactive Immersive Engineering System for Distant Collaboration</b>	
<i>Fechter, Marius; Damgrave, Roy Gerhardus Johannes; Wartzack, Sandro</i> .....	6-297
<b>Subject Lines as Sensors: Co-Word Analysis of Email to Support the Management of Collaborative Engineering Work</b>	
<i>Jones, Simon L.; Payne, Stephen J.; Hicks, Ben J.; Gopsill, James A.; Snider, Chris; Shi, Lei</i> .....	6-307

## **VOLUME 7: Proceedings of the 20th International Conference on Engineering Design (ICED15)**

### **PRODUCT MODULARISATION AND ARCHITECTURE, SYSTEMS ENGINEERING, PRODUCT-SERVICE SYSTEMS**

#### **PRODUCT MODULARISATION AND ARCHITECTURE**

<b>Assessing Modularisation Transition with Metrics</b> <i>Heilemann, Markus; Steve, Culley; Meike, Schlueter; Vera, Lindemer</i> .....	7-1
<b>Cost Prognosis of Modular Product Structure Concepts</b> <i>Ripperda, Sebastian; Krause, Dieter</i> .....	7-13
<b>Towards Product Platform Introduction: Optimising Commonality of Components.</b> <i>Zapico, Miguel; Eckert, Claudia; Jowers, Iestyn; Earl, Christopher</i> .....	7-23
<b>Structuring Perceived Quality Attributes for Use in the Design Process</b> <i>Stylidis, Konstantinos; Landahl, Jonas; Wickman, Casper; Johannesson, Hans; Söderberg, Rikard</i> .....	7-33
<b>Towards a Decision Support Framework for System Architecture Design</b> <i>Ben Hamida, Sonia; Jankovic, Marija; Callot, Martine; Monceaux, Anne; Eckert, Claudia</i> .....	7-43
<b>Framework for Diagnosing Standardization Potential in Current Product Range</b> <i>Chandra, Sushil</i> .....	7-53
<b>Conceiving Modular Solutions in Early Conceptual Design Activities</b> <i>Fiorineschi, Lorenzo; Rotini, Federico; Rissone, Paolo</i> .....	7-63
<b>Platform Concept Development within the Integrated PKT-Approach</b> <i>Kruse, Moritz; Ripperda, Sebastian; Krause, Dieter</i> .....	7-73
<b>A Revision of Product Architecture Design for Multi-Modal Products</b> <i>Liu, Cong; Hildre, Hans Petter; Zhang, Houxiang; Rølvåg, Terje</i> .....	7-83
<b>The Impact of Criteria in System Architecture Selection: Observation from Industrial Experiment</b> <i>Moullec, Marie-Lise; Jankovic, Marija; Eckert, Claudia</i> .....	7-93
<b>Portfolio Management for Electric Drives in Powertools at Hilti: Challenges and Solution Approaches</b> <i>Ponn, Josef</i> .....	7-105
<b>An Engineering Design Approach to Lithium-Ion Cells - Modular Kit Configuration for an Innovative Technology Application</b> <i>Tschech, Matthias; Vietor, Thomas</i> .....	7-115
<b>Developing an Objective Formulation for Motorcycle Architecture</b> <i>Chandra, Sushil</i> .....	7-125
<b>Brownfield Process for the Rationalisation of Existing Product Variety Towards a Modular Product Family</b> <i>Pakkanen, Jarkko; Juuti, Tero; Lehtonen, Timo</i> .....	7-135

<b>Index-Based Metrics for the Evaluation of Effects of Custom Parts on the Standardization of Mechanical Systems</b>	
<i>Sinigalias, Pavlos Christoforos; Dentsoras, Argyris</i>	7-145
<b>Design for Embodiment through Smart Archives</b>	
<i>Rosa, Francesco; Viganò, Roberto; Roviða, Edoardo</i>	7-155
<b>Exploratory Research about the Customization or Personalization of Assistive Products for Walking</b>	
<i>Gois, Marcel; Thomann, Guillaume; Autreau, Jeremiah</i>	7-165
<b>Product Architecture Design Methodology for Developing Standardized Modules</b>	
<i>Thumm, Benjamin Roland; Göhlich, Dietmar</i>	7-175
<b>Sustainability of Modular Product Families</b>	
<i>Bahns, Tammo; Beckmann, Gregor; Gebhardt, Nicolas; Krause, Dieter</i>	7-185
<b>Higher Order Interactions: Product and Configuration Study on DSM Saturation</b>	
<i>Phelan, Keith; Summers, Joshua David; Pearce, Brian; Kurz, Mary E.</i>	7-195
<b>Harnessing Social Media and Cloud-Computing Technologies for Co-Design in Open Collaborative Innovation: The Case of 24 Hours of Innovation</b>	
<i>Jimenez-Narvaez, Luz-Maria; Dalkir, Kimiz; Gelinas, Valerie; Gardoni, Mickael</i>	7-207

## **SYSTEMS ENGINEERING**

<b>An Algorithm for Behaviour Prediction of Complex Technical Systems</b>	
<i>Osman, Krešimir; Štorga, Mario; Marjanović, Dorian</i>	7-217
<b>Cost-Benefit Analysis in Model-Based Systems Engineering: State of the Art and Future Potentials</b>	
<i>Eigner, Martin; Huwig, Christian; Dickopf, Thomas</i>	7-227
<b>Improving Order Fulfillment Processes with MBSE</b>	
<i>Westermann, Thorsten; Anacker, Harald; Dumitrescu, Roman</i>	7-237
<b>Industrial Application of a Mechatronic Framework</b>	
<i>Torry-Smith, Jonas Mørkeberg; Mortensen, Niels Henrik; Ploug, Ole; Achiche, Sofiane</i>	7-247

## **PRODUCT-SERVICE SYSTEMS**

<b>A Tool for Facilitating Semantic Reframing of Service Design Insight Discovery</b>	
<i>Yuan, Soe-Tsyr Daphne; Hsieh, Pei-Kang</i>	7-259
<b>A Model to Describe use Phase of Socio-Technical Sphere of Product-Service Systems</b>	
<i>Hollauer, Christoph; Venkataraman, Srinivasan; Omer, Mayada</i>	7-271
<b>Potential of Nature-Inspired Approach for Organisation Design in Product-Service System</b>	
<i>Kim, Sojung; Baek, Joon Sang</i>	7-281

**Product-Service System (PSS) Design Process Methodologies:  
A Systematic Literature Review**  
*Mendes, Glauco H. S.; Oliveira, Maicon Gouvea; Rozenfeld, Henrique;  
Marques, Caio Augusto Nunes; Costa, Janaina Mascarenhas Hornos* .....7-291

**Facilitating Industrial Adoption of Design Methods for  
Product-Service Systems**  
*Matschewsky, Johannes; Lindahl, Mattias; Sakao, Tomohiko* .....7-301

**An Exploratory Study to Evaluate the Practical Application  
of PSS Methods and Tools Based on Text Mining**  
*Marques, Caio Augusto Nunes; Matsuno, Ivone Penque;  
Sinoara, Roberta Akemi; Rezende, Solange Oliveira; Rozenfeld, Henrique* .....7-311

**Product-Service Systems Representation and Repository for  
a Design Support Tool**  
*Kim, Yong Se; Kim, Sohui; Roh, Eunrae* .....7-321

## **VOLUME 8: Proceedings of the 20th International Conference on Engineering Design (ICED15)**

### **INNOVATION AND CREATIVITY**

#### **INNOVATION**

<b>Risk and Innovation Balance in Crowdfunding New Products</b> <i>Song, Chaoyang; Luo, Jianxi; Hölttä-Otto, Katja; Seering, Warren; Otto, Kevin</i> .....	8-1
<b>Open Design Platforms for Open Source Product Development: Current State and Requirements</b> <i>Bonvoisin, Jérémy; Boujut, Jean-François</i> .....	8-11
<b>How to Search for Open Innovation Partners?</b> <i>Guertler, Matthias R.; Von Saucken, Constantin; Schneider, Maria; Lindemann, Udo</i> .....	8-21
<b>Open Innovation Ecosystem: Towards Collaborative Innovation</b> <i>Böhmer, Annette Isabel; Lindemann, Udo</i> .....	8-31
<b>Using Crowds in Engineering Design – Towards a Holistic Framework</b> <i>Panchal, Jitesh H</i> .....	8-41
<b>Supporting Need Seeker Innovation: The Radical Innovation Design Methodology</b> <i>Yannou, Bernard</i> .....	8-51
<b>Design Innovation for Societal and Business Change</b> <i>Thurgood, Clementine; Dorst, Kees; Bucolo, Sam; Van Der Bijl-Brouwer, Mieke; Vermaas, Pieter</i> .....	8-61
<b>Socio-Technical Design for Resilience: A Case Study of Designing Collaborative Services for Community Resilience</b> <i>Baek, Joon Sang</i> .....	8-71
<b>The Role of Ambiguity and Discrepancy in Early Phases of Innovation</b> <i>Laurson, Linda Nhu; Tollestrup, Christian</i> .....	8-81
<b>Innovative and Sustainable Design: Perceptions of Experts</b> <i>Telenko, Cassandra; Wood, Kristin</i> .....	8-91
<b>Design Methodology Applied for Product Innovation in a Multi-Disciplinary Project – A Case Study</b> <i>Almefelt, Lars; Claesson, Anders</i> .....	8-101
<b>A New Knowledge Sourcing Framework to Support KBE Development</b> <i>Quintana-Amate, Santiago; Bermell-García, Pablo; Balcazar, Luis; Tiwari, Ashutosh</i> .....	8-111
<b>An Idea Generation Method for the Late Phases of Engineering Design</b> <i>Meyer, Andreas Wilhelm; Wünsch, Andreas; Vajna, Sándor; König, Oliver</i> .....	8-121
<b>The Characteristics of Excellent Designers – Findings from an Interview Study with Swedish Innovators</b> <i>Axelsson, Louise; Blome, Simon; Nourbarpour, Dennis; Nänzen, Johan; Yvonne, Platon; Malmqvist, Johan Lars</i> .....	8-131

<b>Idea Development and its Constituting Elements</b>	
– An Empirical Investigation	
<i>Karlsson, Anna</i> .....	8-141
<b>Design Driven Innovation – Minimum Viable Products for Local</b>	
<b>Entrepreneurship In Nepal</b>	
<i>Keitsch, Martina Maria</i> .....	8-151
<b>A Water Saving Solution with a TRIZ Based Method</b>	
<i>Russo, Davide; Spreafico, Christian; Mores, Nicola</i> .....	8-163
<b>Production Innovation in Manufacturing Firms:</b>	
<b>The Case of Swedish SMEs</b>	
<i>Viveros-Eulogio, Brenda; Öhrwall Rönnbäck, Anna; Ramirez-Portilla, Andres</i> .....	8-173
<b>Investigation and Support of Evolutionary Design</b>	
<i>Stetter, Ralf; Möhringer, Stefan; Günther, Joachim; Pulm, Udo</i> .....	8-183
<b>A Model of Idea Evaluation and Selection for Product Innovation</b>	
<i>Stevanovic, Milan; Marjanovic, Dorian; Storga, Mario</i> .....	8-193
<b>A Method Model for Distinguishing and Selecting Open Innovation Methods</b>	
<i>Von Saucken, Constantin; Gürtler, Matthias; Schneider, Maria; Lindemann, Udo</i> .....	8-203
<b>The Implementation of Innovation Metrics: A Case Study</b>	
<i>Benaim, Andre; Elfsberg, Jenny; Larsson, Tobias C.; Larsson, Andreas</i> .....	8-213
<b>Innovation Ambidexterity in Medium Size Enterprises</b>	
<i>Lavayssière, Pierre; Blanco, Eric; Le Dain, Marie-Anne; Chévrier, Pierre</i> .....	8-225
<b>Enabling Front End of Innovation in a Mature Development Company</b>	
<i>Broennum, Louise; Clausen, Christian</i> .....	8-235
<b>Inverse Technology C-K in Environment C-K to Overcome Design Fixation</b>	
<i>Jean, Fabien; Le Masson, Pascal; Weil, Benoît</i> .....	8-245
<b>Maslow Meets the Stonecutter</b>	
<i>Winkelman, Paul Martin</i> .....	8-255
<b>Design Acumen</b>	
<i>Petersen, Søren Ingomar</i> .....	8-265
<b>Formulations of Paradigms of Technical Inheritance</b>	
<i>Mozgova, Iryna; Lachmayer, Roland; Gottwald, Philipp</i> .....	8-271
<b>The Impact of Design Methods on The Creativity of 1st-Year</b>	
<b>Engineering Student Projects: The Case Of Computer Programming</b>	
<i>Beghelli, Alejandra; Prieto, Pablo</i> .....	8-279
<b>Fusion of Old and New, Creativity In Educational and Historical Way:</b>	
<b>Board Game with Servicescape Concept in Taipei Tech University Town.</b>	
<i>Wang, Sheng-Ming; Huang, Chieh Ju</i> .....	8-289
<b>Reggio Emilia Engineering Education</b>	
<i>Vignoli, Matteo; D'Onghia, Francesco</i> .....	8-297

## CREATIVITY

### Supporting Idea Generation through Functional Decomposition:

#### An Alternative Framing for Design Heuristics

*Gray, Colin M.; Yilmaz, Seda; Daly, Shanna; Seifert, Colleen M.; Gonzalez, Richard* ..... 8-309

### A Cross-Functional Approach for the Fuzzy Front End: Highlights

#### from a Conceptual Project

*Figueiredo, João Filipe; Correia, Nuno C.; Ruivo, Inês Secca; Alves, Jorge Lino* ..... 8-319

### Strategies to Employ Social Networks in Early Design Phases (Idea Generation)

*Escandon-Quintanilla, Ma-Lorena; Jimenez-Narvaez, Luz-Maria; Gardoni, Mickael* ..... 8-329

### Modulation of Ambiguity, A Cognitive Function of Representations

#### During Idea Generation

*Kasatkina, Olga; De Vries, Erica; Masclet, Cédric; Boujut, Jean-François* ..... 8-339

### Using Idea Materialization to Enhance Design Creativity

*Georgiev, Georgi V.; Taura, Toshiharu* ..... 8-349

### Creativity Tool Selection for Design Engineers in Idea Generation.

*Yan, Yanliuxing; Childs, Peter R N* ..... 8-359

### Inspirational Design Briefing Performance

*Petersen, Søren Ingomar; Joo, Jaewoo; Takahashi, Shelley* ..... 8-371

### Evaluation Method which Promote Creativity: Case Study about

#### Ergonomic Design in Pointing Devices

*Namayandegi, Mohammad Hossein* ..... 8-379

## **VOLUME 9: Proceedings of the 20th International Conference on Engineering Design (ICED15)**

### **USER-CENTRED DESIGN**

### **DESIGN OF SOCIO-TECHNICAL SYSTEMS**

#### **USER-CENTRED DESIGN**

Empathic-Design Assisted by the Kano Method – A Human-Centered Design Method for Medical Devices Considering Patients <i>Ahrens, Martin; Hehenberger, Peter</i> .....	9-1
Navigation System Based on Humane Engineering for Wheelchair Users <i>Nagai, Yukari; Kihara, Hironori</i> .....	9-11
A Capability Approach Based Stakeholder Analysis for the Base of the Pyramid: A Case Study Of The Firewood Based Cook-Stoves <i>Khadilkar, Pramod Ratnakar; Mani, Monto</i> .....	9-23
User Involvement in Product Design Practices: A Case Study on Technologies for Older Adults <i>Lee, Chaiwoo; Coughlin, Joseph F.</i> .....	9-33
Inclusive Design; From Physical to Psychosocial - A Literature Analysis Toward a Definition of Psychosocial Dimensions in Design <i>Lim, Yonghun; Dr. Nickpour, Farnaz</i> .....	9-45
Description of a Competence Oriented Approach for Designing Technical Assistance Systems <i>Walter, Johanna; Paetzold, Kristin; Nitsch, Verena</i> .....	9-57
Design Towards Better Life Experience: Closing the Gap between Pharmaceutical Packaging Design and Elderly People <i>Carli Lorenzini, Giana; Olsson, Annika</i> .....	9-65
Design for Assistive Technology Applications: Usefulness of Re-Use? <i>Walsh, Edwin Peter; Daems, Walter; Steckel, Jan; Peremans, Herbert; Baelus, Christiaan</i> .....	9-77
Dynamic Products: An Instrument for Saving Resources. Improve User's Awareness through Designing Product Experiences. <i>Bergamaschi, Sara</i> .....	9-87
A Study on Consumer Trend and Service Innovation in Korean Market <i>Ahn, Kyungmi; Kim, Kee-Ok; Sung, Hyunjin</i> .....	9-97
Behaviour-Attentive Prototyping of a Design and Simulation System for IC Chambers <i>Hou, Yuemin; Horvath, Imre; Rusak, Zoltan; Ji, Linhong; Sun, Yunchun; Lin, Jia</i> .....	9-109
Identifying the Factors to Influence Product Attachment through Product Fandom Phenomenon <i>Bae, Jieun; Kim, Chajoon</i> .....	9-119



<b>Experimental Setup for Visual and Tactile Evaluation of Materials and Products through Napping® Procedure</b>	
<i>Faucheu, Jenny; Caroli, Antonio; Del Curto, Barbara; Delafosse, David</i>	9-129
<b>Product Design of Novel Technology-Based Products</b>	
- The Importance of Users	
<i>Sampaio, Álvaro M.; Pontes, António J.</i>	9-139
<b>How Does Expectation Change Perception? : A Simulation Model of Expectation Effect</b>	
<i>Yanagisawa, Hideyoshi; Mikami, Natsu</i>	9-149
<b>Towards Improvement of Interaction Aesthetics of Mobile Music Listening Journeys</b>	
<i>Sen, Güzin; Sener, Bahar</i>	9-159
<b>Collective Brand Imagery Weave: Connecting Brand Values to Product Characteristics using Physical Complex Installation</b>	
<i>Mulder-Nijkamp, Maaik; Chueng-Nainby, Priscilla</i>	9-169
<b>Aiding Designers to Make Practitioner-Like Interpretations of Life Cycle Assessment Results</b>	
<i>Uchil, Praveen; Chakrabarti, Amaresh; Fantke, Peter</i>	9-179
<b>A Model of Lost Habits: Towards a Strategy to Improve the Acceptance of Product Service Systems</b>	
<i>Schotman, Hendrikus; Ludden, Geke D.S.</i>	9-189
<b>Integration of User Knowledge across the Lifecycle of Integrated Product-Service Systems – An Empirical Analysis of the Relevance for PSS Development and Management</b>	
<i>Schmidt, Danilo Marcello; Preißner, Stephanie; Hermosillo Martínez, José Alonso; Quiter, Michael; Mörtl, Markus; Raasch, Christina</i>	9-199
<b>An Investigation of Diet Apps for Enhancing People's Health and Wellbeing.</b>	
<i>Tuna, Nur Nagihan; Şener, Bahar</i>	9-209
<b>The Shape of Light: An Interactive Approach to Smart Materials</b>	
<i>Piselli, Agnes; Garbagnoli, Paola; Cavarretta, Giorgia; Del Curto, Barbara</i>	9-219
<b>HCI/HMI Pleasure: Push Your Buttons</b>	
<i>Wendrich, Robert E.</i>	9-229
<b>Principles for Designing for Perception</b>	
<i>Perez Mata, Marta; Ahmed-Kristensen, Saeema</i>	9-239
<b>The “Ideal” User Innovation Toolkit - Benchmarking and Concept Development</b>	
<i>Roth, Michael; Harmeling, Jonas; Michailidou, Ioanna; Lindemann, Udo</i>	9-249
<b>A V-Model for More. An Inclusive Design Model Supporting Interaction Between Designer and User.</b>	
<i>lelegems, Elke; Herzsens, Jasmien; Vanrie, Jan</i>	9-259
<b>Integration of End-User Needs into Building Design Projects: Use of Boundary Objects to Overcome Participatory Design Challenges</b>	
<i>Latortue, Xavier; Minel, Stéphanie; Pompidou, Stéphane; Perry, Nicolas</i>	9-269

Photography - A New Tool in Needfinding <i>Wulvik, Andreas; Balters, Stephanie; Steinert, Martin</i> .....	9-279
Integration of Universal Design Principles into Early Phases of Product Design - A Case Study <i>Kett, Susan Gretchen; Wartack, Sandro</i> .....	9-289
The Role of the Inner Child in Process of Decision Making for Product Selection <i>Sepahpour, Ghazaleh</i> .....	9-301
Analysis of the Perception of Future Designers about Usage Scenario Integration In Product Design (SIPD) <i>Royo, Marta; Mulet, Elena; Galán, Julia; Felip, Francisco; García-García, Carlos</i> .....	9-311
Designed for, with, and by Kids. Integrating Children's Approach into Design Teaching and Research Visualisation <i>Luccarelli, Martin; Di Iorio, Mariagiovanna</i> .....	9-321
<b>DESIGN OF SOCIO-TECHNICAL SYSTEMS</b>	
Designing for Children's Play Ground, a Social Skills Improvement Approach <i>Sepahpour, Ghazaleh; Shahabi Haghighi, Hamid Reza; Chooopankareh, Vahid</i> .....	9-331
Designing with Daylight; The Relationship between Daylight and Health <i>Hauge, Bettina</i> .....	9-341
The Design and Dimensions of Social Innovation: The Brazilian Case of the "Ecological Network" <i>Xavier, Amanda Fernandes; Naveiro, Ricardo Manfredi; Aoussat, Améziane; Mello, Carlos Henrique Pereira</i> .....	9-353
Effective Simplification for Logo Design <i>Chen, Chung-Yun; Cheung, Vien; Li, Dian; Cassidy, Thomas</i> .....	9-365

## **VOLUME 10: Proceedings of the 20th International Conference on Engineering Design (ICED15)**

### **DESIGN INFORMATION AND KNOWLEDGE MANAGEMENT**

Digital Support of Wiring Harness Development (Based on the 3D Master Method) <i>Neckenich, Jonas; Winter, Roland; Vielhaber, Michael</i> .....	10-1
Generating Hybrid Geometry Models for More Precise Simulations by Combining Parametric CAD-Models with 3D Surface Scanned Geometry Inserts <i>Katona, Sebastian; Koch, Michael; Wartzack, Sandro</i> .....	10-11
Visualisation of Biomechanical Stress Quantities within CAD Environments <i>Krüger, Daniel Benjamin; Wartzack, Sandro</i> .....	10-21
Issues in Learning Engineering Graphics Fundamentals: Shall we Blame CAD? <i>Metraglia, Riccardo; Baronio, Gabriele; Villa, Valerio</i> .....	10-31
Analyzing the Generative Effects of Sketches with Design Theory: Sketching to Foster Knowledge Reordering <i>Brun, Juliette; Le Masson, Pascal; Weil, Benoit</i> .....	10-41
A Sustainable Product Model <i>Vadoudi, Kiyan; Troussier, Nadège</i> .....	10-51
PLM Implementation: Case Study <i>Bojčević, Nenad; Salopek, Damir; Marjanovic, Dorian</i> .....	10-61
Study of the Efficiency of Product Development Teams through Combined Virtual Communities of Practice, PLM and Social Media Technologies <i>Doumit, Nancy; Fortin, Clément; Huet, Gregory</i> .....	10-71
PLM-MES Integration to Support Collaborative Design <i>D'Antonio, Gianluca; Sauza Bedolla, Joel; Chiabert, Paolo; Lombardi, Franco</i> .....	10-81
Identifying Flexible Design Opportunities: Getting from a Procedural to an Execution Model <i>Allaverdi, David; Herberg, Arne; Lindemann, Udo</i> .....	10-91
Crowdsourcing for Search of Disaster Victims: A Preliminary Study for Search System Design <i>Burnap, Alex; Barto, Charlie; Johnson-Roberson, Matthew; Ren, Max Yi; Gonzalez, Richard; Papalambros, Panos Y.</i> .....	10-103
Strength Mapping Algorithm (SMA) for Biomechanical Human Modelling Using Empirical Population Data <i>Miehling, Jörg; Wartzack, Sandro</i> .....	10-115
Systematic Online Lead User Identification - Case Study for Electrical Installations <i>Pajo, Sanjin; Vandevenne, Dennis; Duflou, Joost R.</i> .....	10-125

<b>Visualizing The Effectiveness of Product Portfolio with Respect to Product Specifications</b> <i>Oh, Gyesik; Kang, Chang Muk; Kang, Kilmo; Hong, Yoo S.</i> .....	10-133
<b>A Strategy for Artefact-Based Information Navigation in Large Engineering Organisations</b> <i>Jones, David Edward; Chanchevriar, Nicolas; McMahon, Chris; Hicks, Ben</i> .....	10-143
<b>Visual Conjoint – From Discrete to Continuous</b> <i>Orsborn, Seth; Cagan, Jonathan; Boatwright, Peter</i> .....	10-155
<b>Integrated Value Engineering - Framework for the Application of Methods for Visualization of Information</b> <i>Sadi, Tarek; Behncke, Florian G. H.; Maisenbacher, Sebastian; Kremer, Simon</i> .....	10-165
<b>Unfolding The Design Process Architecture: A Networked Perspective on Activities</b> <i>Parraguez, Pedro; Maier, Anja M.</i> .....	10-177
<b>Data Science as a New Frontier for Design</b> <i>Kazakci, Akin Osman</i> .....	10-189
<b>Supporting the Configuration of New Product Variants by Reusing the Implicit Knowledge of Past Solutions</b> <i>Malatesta, Marco; Cicconi, Paolo; Raffaeli, Roberto; Germani, Michele</i> .....	10-199
<b>Evaluating the Effectiveness of Methods for Capturing Meetings</b> <i>Hall, Mark John; Bermell-Garcia, Pablo; McMahon, Chris A; Johansson, Anders; Gonzalez-Franco, Mar</i> .....	10-209
<b>It's Not Personal: Can Logbooks Provide Insights into Engineering Projects?</b> <i>Snider, Chris; McAlpine, Hamish; Gopsill, James A.; Jones, Simon; Lei, Shi; Hicks, Ben</i> .....	10-219
<b>An Integrated RFBSE Model for Managing and Reusing Engineering Design Knowledge</b> <i>Qin, Hao; Wang, Hongwei; Liu, Yusheng</i> .....	10-231
<b>Building a Cohesive Body of Design Knowledge: Developments from a Design Science Research Perspective</b> <i>Cash, Philip; Piirainen, Kalle A</i> .....	10-241
<b>Knowledge Management in Customer Integration: A Customer Input Ontology</b> <i>Füller, Kathrin; Liu, Hanxi; Böhm, Markus; Krcmar, Helmut</i> .....	10-251
<b>A Proposal for Knowledge Formalization in Product Development Processes</b> <i>Klein, Patrick; Lützenberger, Johannes; Thoben, Klaus-Dieter</i> .....	10-261
<b>Analysing the Effects of Value Drivers and Knowledge Maturity in Preliminary Design Decision-Making</b> <i>Bertoni, Alessandro; Bertoni, Marco; Johansson, Christian</i> .....	10-273
<b>Identification of Knowledge and Processes in Design Projects</b> <i>Schmidt, Danilo Marcello; Kammerl, Daniel; Schultz, Bernhard; Schenkl, Sebastian Alexander; Mörtl, Markus</i> .....	10-283

**Knowledge Management Tools and Techniques:**

**Extent of use in Organizations and Support for Modularization**

*Stenholm, Daniel; Rossi, Monica; Bergsjö, Dag; Terzi, Sergio* .....10-293

**Proposed Evaluation of the use of K-Briefs for Knowledge Acquisition in KBE**

*Marthinusen, Ivar; Kalavrytinou, Christos; Sivertsen, Ole Ivar* .....10-305

**Digital Repository for Design Knowledge Reuse**

*Firdaus, Mochammad; Wang, Hongwei; Qin, Hao; Liu, Yusheng* .....10-315

**Approach for Modelling Knowledge Management Solutions within  
the Product Development Process using the ‘Knowledge Modeling  
and Description Language’**

*Laukemann, Alexander; Binz, Hansgeorg; Roth, Daniel* .....10-325

**Design Knowledge Representation as an Integration of Functional  
Knowledge Modelling and Design Structure Matrix**

*Zhu, Guo-Niu; Hu, Jie; Qi, Jin; Gu, Chao-Chen; Peng, Ying-Hong* .....10-337

**Knowledge Sharing in Heterogeneous Data Context: Application in PLM**

*Pham, Cong Cuong; Matta, Nada; Durupt, Alexandre;  
Eynard, Benoit; Ducellier, Guillaume* .....10-347

## **VOLUME 11: Proceedings of the 20th International Conference on Engineering Design (ICED15)**

### **HUMAN BEHAVIOUR IN DESIGN DESIGN EDUCATION**

#### **HUMAN BEHAVIOUR IN DESIGN**

Design for Behavior Change: An Elaboration-Based Approach to Persuasion in Product Design <i>Montazeri, Soodeh; Panos, Papalambros; Rich, Gonzales</i> .....	11-1
The Use of Multisensory Feedback to Make Users Behave in a Sustainable Way <i>Graziosi, Serena; Ferrise, Francesco; Costanzi, Alessandro Achille Maria; Bordegoni, Monica</i> .....	11-11
Support of the System Integration with Automatically Generated Behaviour Models <i>Köbler, Johannes; Paetzold, Kristin</i> .....	11-21
Technology-Supported Design Research <i>Thoring, Katja; Mueller, Roland M.; Badke-Schaub, Petra</i> .....	11-31
Moving Targets: How Consumers Change Value Systems through Interaction with Designed Products and Other Consumers <i>Thomas, Russell C.; Gero, John S.</i> .....	11-41
Developing a Framework of New Mixed Method, Social Networking Services Group Diary and its Application in Practice <i>Bae, Jieun; Cho, Kwangmin; Kim, Chajoong</i> .....	11-51
Physiologically Based Segmentation of Design Protocol <i>Nguyen, Philon; Nguyen, Thanh An; Zeng, Yong</i> .....	11-61
Surprise as a Situated Phenomenon <i>Becattini, Niccolo; Borgianni, Yuri; Cascini, Gaetano; Rotini, Federico</i> .....	11-71
Creativity Intervention: Using Storytelling and Math Problems as Intervening Tasks for Inducing Incubation <i>Al-Shorachi, Evan; Sasasmit, Koonlada; Gonçalves, Milene</i> .....	11-81
Influence of Information Collection Strategy in Problem Formulation on Design Creativity through Mental Stress: A Theoretical Analysis <i>Wang, Xiaoying; Nguyen, Thanh An; Zeng, Yong</i> .....	11-91
Developing a Computational Framework to Study the Effects of Use of Analogy in Design on Team Cohesion and Team Collaboration <i>Singh, Vishal; Casakin, Hernan</i> .....	11-101
Exploring Problem Decomposition in Design Team Discussions <i>Tobias, Connor; Herrmann, Jeffrey W.; Gralla, Erica</i> .....	11-111
Physiology and Sensorial Based Quantification of Human-Object Interaction – The QOSI Matrix <i>Balters, Stephanie; Bisballe Jensen, Matilde; Steinert, Martin</i> .....	11-121

<b>Provoking Iterations in Ideation Workshops – An Explorative Study</b>	
<i>Heck, Johannes; Steinert, Martin; Meboldt, Mirko</i>	11-133
<b>Novice Engineers’ Predisposition to Compassionate Design</b>	
<i>Seshadri, Priya; Reid, Tahira</i>	11-143
<b>Dynamically Capturing Engineering Team Interactions with Wearable Technology</b>	
<i>Sjöman, Heikki; Steinert, Martin; Kress, Greg; Vignoli, Matteo</i>	11-153
<b>Design Questions for Life: Connecting Engineering Design, Appreciative Inquiry, and Other Question-Based Models</b>	
<i>Lilja, Johan; Hansen, David; Richardsson, Daniel</i>	11-163
<b>The Influence of Different Media Instructions on Solving a Procedural Task</b>	
<i>Chirumalla, Koteswar; Eriksson, Yvonne; Eriksson, Pelle</i>	11-173
<b>A Sensor Design and Data Analysis for Automatic Drum Beater Winding</b>	
<i>Zhao, Yuchen; Johnson, Teegan; Goh, Yee Mey</i>	11-183
<b>Barriers to Hinder Collaboration within Product Development Teams from Designers’ Perspective and the Development of a Method to Facilitate the Collaboration</b>	
<i>Kim, Yeonghun; Kim, Chajoong; Cho, Kwangmin; Kim, Kwanmyung</i>	11-193
<b>A Comparative Study on the Role of Models and Prototypes in Human-Centered Design Versus Design-Driven Innovation Approaches</b>	
<i>Isa, Siti Salwa; Liem, Andre</i>	11-203
<b>Design As the Resolution of Paradoxes: An Exploratory Study</b>	
<i>Morgan, Thea; McMahon, Chris</i>	11-215

## DESIGN EDUCATION

<b>Academic Design</b>	
<i>Koskinen, Ilpo K; Dorst, Kees</i>	11-227
<b>Guidelines for Competence Assessment in Engineering Education an Implementation in Project Nusal</b>	
<i>Albers, Albert; Butenko, Viktoriia; Breitschuh, Jan; Walter, Benjamin; Drechsler, Sandra; Burkardt, Norbert</i>	11-235
<b>A Case Study Exploring the Use of Journals to Support Student Engagement</b>	
<i>Born, Werner Christian; Schmidt, Linda Catherine</i>	11-245
<b>New Approaches to Teaching Design for Additive Manufacturing</b>	
<i>Junk, Stefan; Matt, Rebecca</i>	11-257
<b>Do High School Students Benefit from Pre-Engineering Design Education?</b>	
<i>Kannengiesser, Udo; Gero, John; Wells, John; Lammi, Matthew</i>	11-267
<b>Concept and Structure of a New Master-Programm “Systems Engineering”</b>	
<i>Paetzold, Kristin; Roger, Förstner; Clara, Tillmanns</i>	11-277
<b>New Ways in Education with Shape Design</b>	
<i>Heimrich, Felix; Anderl, Reiner</i>	11-287

<b>A Design Course Combining Aesthetics and Engineering Knowledge in PBL Style</b>	
<i>Chang, Hsiang-Tang</i> .....	11-297
<b>Advanced Business Coaching Approach in Combination with Systemic Constellation Work to Improve the Business Engineering Process</b>	
<i>Burchardt, Carsten</i> .....	11-307
<b>Understanding the Characteristics Between Design and Non-Design Background Students in Product Development Process and its Implications</b>	
<i>Kim, Chajoong; Kim, Yeonghun</i> .....	11-319
<b>Interdisciplinary Learning through Design Activities Uniting Fundamentals of Engineering Curriculum</b>	
<i>Fu, Katherine Kai-Se; Tan, U-Xuan; Teo, Tee Hui; Soh, Gim Song; Wood, Kristin L.</i> .....	11-329
<b>Design Learning Mind-Sets</b>	
<i>Hamat, Basyarah; Badke-Schaub, Petra; Eris, Ozgur</i> .....	11-341
<b>Applying a Combined User-Centred Design Approach to Assistive Shopping Trolley Development in Design Education</b>	
<i>Mengoni, Maura; Bevilacqua, Roberta; Peruzzini, Margherita</i> .....	11-351