

# **9th CIRP IPSS Conference (IPSS 2017)**

## **Circular Perspectives on Product/Service-Systems**

Procedia CIRP Volume 64

Kongens Lyngby, Denmark  
19 – 21 June 2017

### **Editors:**

**Tim C. McAloone**  
**Daniela C.A. Pigosso**

**Niels Henrik Mortensen**  
**Yoshiki Shimomura**

ISBN: 978-1-5108-4235-9

**Printed from e-media with permission by:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.**

Copyright© by Elsevier B.V.  
All rights reserved.

Printed by Curran Associates, Inc. (2017)

For permission requests, please contact Elsevier B.V.  
at the address below.

Elsevier B.V.  
Radarweg 29  
Amsterdam 1043 NX  
The Netherlands

Phone: +31 20 485 3911  
Fax: +31 20 485 2457

<http://www.elsevierpublishingsolutions.com/contact.asp>

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2633  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

# TABLE OF CONTENTS

## **EDITORIAL**

<b>EDITORIAL</b> .....	1
<i>T. C. McAlloone, D. C. A. Pigosso, N. H. Mortensen, Y. Shimomura</i>	

## **SESSION 1: PSS AS ENABLERS FOR CIRCULAR ECONOMY IN A SUSTAINABILITY CONTEXT**

<b>FROM LINEAR TO CIRCULAR ECONOMY: PSS CONDUCTING THE TRANSITION</b> .....	2
<i>Gustavo Michelin, Renato N. Moraes, Renata N. Cunha, Janaina M. H. Costa, Aldo R. Ometto</i>	
<b>BARRIERS TO THE CIRCULAR ECONOMY – INTEGRATION OF PERSPECTIVES AND DOMAINS</b> .....	7
<i>Sofia Ritzén, Gunilla Ölundh Sandström</i>	
<b>TOWARDS CIRCULAR LEAN PRODUCT-SERVICE SYSTEMS</b> .....	13
<i>David Romero, Monica Rossi</i>	
<b>THE EMERGENT ROLE OF DIGITAL TECHNOLOGIES IN THE CIRCULAR ECONOMY: A REVIEW</b> .....	19
<i>Aris Pagoropoulos, Daniela C. A. Pigosso, Tim C. McAlloone</i>	
<b>SIMULATION-DRIVEN DESIGN FOR ASSESSING STRATEGIC DECISIONS IN THE CONCEPTUAL DESIGN OF CIRCULAR PSS BUSINESS MODELS</b> .....	25
<i>Massimo Panarotto, Johan Wall, Tobias Larsson</i>	
<b>LIFECYCLE MANAGEMENT OF PRODUCT-SERVICE SYSTEMS: A PRELIMINARY INVESTIGATION OF A WHITE GOODS MANUFACTURER</b> .....	31
<i>Thayla T. Sousa-Zomer, Lucas Magalhães, Eduardo Zancul, Paulo A. Cauchick-Miguel</i>	
<b>A CIRCULAR ECONOMY TOOLKIT AS AN ALTERNATIVE TO IMPROVE THE APPLICATION OF PSS METHODOLOGIES</b> .....	37
<i>Carolina Rodrigues Reigado, Sânia Da Costa Fernandes, Yovana Maria Barrera Saavedra, Aldo Roberto Ometto, Janaina Mascarenhas Hornos Da Costa</i>	
<b>RESHAPING THE WASHING MACHINE INDUSTRY THROUGH CIRCULAR ECONOMY AND PRODUCT-SERVICE SYSTEM BUSINESS MODELS</b> .....	43
<i>Gianmarco Bressanelli, Marco Perona, Nicola Saccani</i>	
<b>SUPPORTING CIRCULAR ECONOMY THROUGH USE-BASED BUSINESS MODELS: THE WASHING MACHINES CASE</b> .....	49
<i>Maria Grazia Gnoni, Giorgio Mossa, Giovanni Mummolo, Fabiana Tornese, Rossella Verriello</i>	
<b>OPTIMIZING RECYCLING MANAGEMENT USING INDUSTRIAL INTERNET SUPPORTING CIRCULAR ECONOMY: A CASE STUDY OF AN EMERGING IPS<sup>2</sup></b> .....	55
<i>John Lindström, Anders Hermanson, Mats Hellis, Petter Kyösti</i>	
<b>IMPLEMENTING SUSTAINABLE PRODUCT-SERVICE SYSTEMS UTILIZING BUSINESS MODEL ACTIVITIES</b> .....	61
<i>Wiebke Reim, Sambit Lenka, Johan Frishammar, Vinit Parida</i>	
<b>PSS DESIGN PROCESS MODELS: ARE THEY SUSTAINABILITY-ORIENTED?</b> .....	67
<i>Marina De Pádua Pieroni, Caio Augusto Nunes Marques, Renato Nunes Moraes, Henrique Rozenfeld, Aldo Roberto Ometto</i>	
<b>REINTERPRETING THE LCA STANDARD PROCEDURE FOR PSS</b> .....	73
<i>Marco Dal Lago, Donatella Corti, Stefan Wellsandt</i>	
<b>TOWARDS SUSTAINABILITY: PSS, DIGITAL TECHNOLOGY AND VALUE CO-CREATION</b> .....	79
<i>Ai Qiang Li, Pauline Found</i>	
<b>PROPOSAL OF A HOTSPOT-BASED APPROACH TO IDENTIFYING SOCIAL IMPACTS ALONG THE PRODUCT-SERVICE SYSTEMS LIFE CYCLE IN THE EARLY DESIGN PHASES</b> .....	85
<i>Thayla T. Sousa-Zomer, Paulo A. Cauchick-Miguel</i>	

## **SESSION 2: ORGANISATIONAL CAPABILITIES FOR PSS IMPLEMENTATION**

<b>DEVELOPING A CONCEPTUAL FRAMEWORK FOR PSS BUSINESS MODELS</b> .....	91
<i>Andrew Lahy, Pauline Found</i>	

<b>BUSINESS MODEL CONFIGURATION FOR PSS: AN EXPLORATIVE STUDY</b> .....	97
<i>Martha Orellano, Gilles Neubert, Lilia Gzara, Marie-Anne Le-Dain</i>	
<b>BUSINESS MODEL INNOVATION: PROCESS AND TOOLS FOR SERVICE TRANSFORMATION OF INDUSTRIAL FIRMS</b> .....	103
<i>Federico Adrodegari, Theoni Pashou, Nicola Saccani</i>	
<b>A REVIEW OF BUSINESS MODELS TOWARDS SERVICE-ORIENTED ELECTRICITY SYSTEMS</b> .....	109
<i>Michael Hamwi, Iban Lizarralde</i>	
<b>BUSINESS MODEL GAMING: A GAME-BASED METHODOLOGY FOR E-MOBILITY BUSINESS MODEL INNOVATION</b> .....	115
<i>Katja Laurischkat, Arne Viertelhausen</i>	
<b>A GENERAL OVERVIEW OF MANUFACTURING SERVICITIZATION IN ITALY</b> .....	121
<i>Luca Mastrogiacomo, Federico Barravecchia, Fiorenzo Franceschini</i>	
<b>SERVICES EXTENDING PRODUCTS: A COMPARATIVE ANALYSIS IN EMERGING AND DEVELOPED COUNTRIES</b> .....	127
<i>Carolline Amaral Paslauski, Carolina Gazal De Alencastro, Néstor Fabián Ayala, Paolo Gaiardelli, Giuditta Pezzotta, Alejandro Germán Frank</i>	
<b>IMPACT OF SERVICE TRANSITION ON AFTER SALES SERVICE STRUCTURES OF MANUFACTURING COMPANIES</b> .....	133
<i>Uwe Dombrowski, Simon Fochler</i>	
<b>ENABLERS AND INHIBITORS OF SERVICITISATION: A CASE STUDY IN THE BRAZILIAN ROAD TRANSPORT</b> .....	139
<i>Gilmerson Inácio Gonçalves, Glauco Henrique De Sousa Mendes, Maicon Gouvêa De Oliveira</i>	
<b>PRODUCT SERVICE DEMAND FORECASTING IN HIERARCHICAL SERVICE STRUCTURE</b> .....	145
<i>Zhitao Xu, Wenyan Song, Qin Zhang, X. G. Ming, Lina He, Wenjie Liu</i>	
<b>ONTOLOGY FOR THE PSS LIFECYCLE MANAGEMENT</b> .....	151
<i>Azadeh Hajimohammadi, Juliana Cavalcante, Lilia Gzara</i>	
<b>PRODUCT/SERVICE-SYSTEM ORIGINS AND TRAJECTORIES: A SYSTEMATIC LITERATURE REVIEW OF PSS DEFINITIONS AND THEIR CHARACTERISTICS</b> .....	157
<i>Ronja P. Haase, Daniela C. A. Pigosso, Tim C. McAloone</i>	
<b>OVERCOMING THE PRODUCT-SERVICE MODEL ADOPTION OBSTACLES</b> .....	163
<i>Marcus Vinicius Pereira Pessôa, Juan Manuel Jauregui Becker</i>	
<b>RISK MANAGEMENT CHALLENGES IN LARGE-SCALE ENERGY PSS</b> .....	169
<i>Miroslava Tegeltija, Josef Oehmen, Igor Kozin</i>	
<b>MATURITY MODEL AND ACTION RECOMMENDATION: A PSS CAPABILITY SELF-ASSESSMENT TOOL FOR COMPANIES</b> .....	175
<i>Konrad Exner, Raphael Zimpfer, Rainer Stark</i>	
<b>STATUS REVIEW AND FUTURE PERSPECTIVES ON THE FRAMEWORK OF SMART PRODUCT SERVICE ECOSYSTEM</b> .....	181
<i>Maokuan Zheng, Xinguo Ming, Liya Wang, Dao Yin, Xianyu Zhang</i>	
<b>A FRAMEWORK TO MANAGE CO-CREATION PROCESS FOR PSS CONSIDERING THE NETWORK AND TECHNOLOGY</b> .....	187
<i>Widha Kusumaningdyah, Tezuka Tetsuo</i>	
<b>CAN SOCIAL SUSTAINABILITY VALUES BE INCORPORATED IN A PRODUCT SERVICE SYSTEM FOR TEMPORARY PUBLIC BUILDING MODULES?</b> .....	193
<i>Martin Kurdve, Heleen De Goey</i>	
<b>THE CITIZEN FUNDING: AN ALTERNATIVE TO FINANCE RENEWABLE ENERGY PROJECTS</b> .....	199
<i>Benjamin Tyl, Iban Lizarralde</i>	

### **SESSION 3: ENGINEERING DESIGN APPROACHES AND METHODS FOR PSS**

<b>SYSTEMS ENGINEERING AS A FOUNDATION FOR PSS DEVELOPMENT PROJECT: MOTIVATIONS AND PERSPECTIVES</b> .....	205
<i>Elaheh Maleki, Farouk Belkadi, Alain Bernard</i>	
<b>SYSTEM DESIGN OF E-MARKETS FOR IPSS PURCHASING</b> .....	211
<i>Wolfgang Bauer, Jürgen Dorn</i>	
<b>NEW PERSPECTIVES FOR GENERATING SMART PSS SOLUTIONS – LIFE CYCLE, METHODOLOGIES AND TRANSFORMATION</b> .....	217
<i>Bernd Kuhlenkötter, Uta Wilkens, Beate Bender, Michael Abramovici, Thomas Süße, Jens Göbel, Michael Herzog, Alfred Hypki, Kay Lenkenhoff</i>	

<b>AN ECOSYSTEM APPROACH AS A DESIGN PRINCIPLE FOR A PSS-SPECIFIC BUSINESS SIMULATION</b> .....	223
<i>Janis Cibat, Thomas Süße, Uta Wilkens</i>	
<b>A DESIGN APPROACH WITH METHOD AND TOOLS TO SUPPORT SMES IN DESIGNING AND IMPLEMENTING DISTRIBUTED RENEWABLE ENERGY (DRE) SOLUTIONS BASED ON SUSTAINABLE PRODUCT-SERVICE SYSTEM (S.PSS)</b> .....	229
<i>Elisa Bacchetti</i>	
<b>GENERIC CONCEPTUAL MODEL TO SUPPORT PSS DESIGN PROCESSES</b> .....	235
<i>Nawfal Anka Idrissi, Xavier Boucher, Khaled Medini</i>	
<b>PSS IN HEALTHCARE: AN UNDER-EXPLORED FIELD</b> .....	241
<i>Ke Xing, Mario Rapaccini, Filippo Visintin</i>	
<b>REPRESENTING A CASE-BASED INTERPRETATION OF THE PSS DESIGN TOOLKIT</b> .....	247
<i>Ivo Dewit, Bram Cobben, Ben Goovaerts, Cedric Van Steenkiste, Alexis Jacoby</i>	
<b>COMMONALITIES AND PARTICULARITIES OF PSS DESIGN PROCESS AND DESIGN THINKING</b> .....	253
<i>Maiara Rosa, Caio Augusto Nunes Marques, Henrique Rozenfeld</i>	
<b>TOWARDS A REFERENCE MODEL FOR AGILE NEW SERVICE DEVELOPMENT USING THE EXAMPLE OF E-MOBILITY SERVICE SYSTEMS</b> .....	259
<i>Sabrina Lamberth-Cocca, Thomas Meiren</i>	
<b>TESTING THE METHODOLOGY TO GENERATE DESIGN FOR PRODUCT SERVICE SUPPORTABILITY (DFPSS) GUIDELINES AND RULES: AN APPLICATION CASE</b> .....	265
<i>Claudio Sassanelli, Giuditta Pezzotta, Roberto Sala, Ana Correia, Sergio Terzi</i>	
<b>EXPLORATION OF SIMULATION-DRIVEN SUPPORT TOOLS FOR SUSTAINABLE PRODUCT DEVELOPMENT</b> .....	271
<i>Yasmeen Jaghbeer, Sophie I. Hallstedt, Tobias Larsson, Johan Wall</i>	
<b>AN IPA BASED METHOD FOR PSS DESIGN CONCEPT ASSESSMENT</b> .....	277
<i>Alice Rondini, Marco Bertoni, Giuditta Pezzotta</i>	
<b>SIMULATION-BASED BUSINESS CASE FOR PSS: A SYSTEM DYNAMICS FRAMEWORK</b> .....	283
<i>Vinicius P. Rodrigues, Daniela C. A. Pigosso, Tim C. McAloone</i>	
<b>A SYSTEMATIC REVIEW OF VALUE METRICS FOR PSS DESIGN</b> .....	289
<i>Marco Bertoni, Alice Rondini, Giuditta Pezzotta</i>	
<b>PREDICTING THE VALUE OF PRODUCT SERVICE-SYSTEMS FOR POTENTIAL FUTURE IMPLEMENTERS: RESULTS FROM MULTIPLE INDUSTRIAL CASE STUDIES</b> .....	295
<i>Alessandro Annarelli, Cinzia Battistella, Yuri Borgianni, Fabio Nonino</i>	
<b>MODULARIZATION OF PRODUCT SERVICE SYSTEM BASED ON FUNCTIONAL REQUIREMENT</b> .....	301
<i>Jian Sun, Nana Chai, Gang Pi, Zaifang Zhang, Beibei Fan</i>	
<b>DATA MINING IN PRODUCT SERVICE SYSTEMS DESIGN: LITERATURE REVIEW AND RESEARCH QUESTIONS</b> .....	306
<i>Alessandro Bertoni, Tobias Larsson</i>	
<b>A CONTEXT EXTRACTING METHOD FOR VALUE-IN-USE ENHANCEMENT</b> .....	312
<i>Yuya Mitake, Yuichi Noto, Koji Kimita, Yoshiki Shimomura</i>	
<b>GOVERNANCE: A NEW PERSPECTIVE TO SERVICE DESIGN PROCESS</b> .....	318
<i>Saed Imran, Dieter Haeberle, Christian Van Husen</i>	
<b>SERVICE PLANNING AS SUPPORT PROCESS FOR A LEAN AFTER SALES SERVICE</b> .....	324
<i>Uwe Dombrowski, Constantin Malorny</i>	
<b>PROACTIVE MAINTENANCE AS SUCCESS FACTOR FOR USE-ORIENTED PRODUCT-SERVICE SYSTEMS</b> .....	330
<i>Konrad Exner, Christian Schnürmacher, Sebastian Adolphy, Rainer Stark</i>	
<b>APPROACH TO TEST A PRODUCT-SERVICE SYSTEM DURING SERVICE ENGINEERING</b> .....	336
<i>Mike Freitag, Christian Schiller</i>	
<b><u>SESSION 4: PSS AND THE DIGITAL TRANSFORMATION</u></b>	
<b>A NOVEL CONCEPT FOR THE DEVELOPMENT OF AVAILABILITY-ORIENTED BUSINESS MODELS</b> .....	340
<i>P. Kölsch, C. F. Herder, V. Zimmermann, J. C. Aurich</i>	
<b>DESIGN FOR CUSTOMIZATION: A NEW PARADIGM FOR PRODUCT-SERVICE SYSTEM DEVELOPMENT</b> .....	345
<i>Amal Elgammal, Mike Papazoglou, Bernd Krämer, Carmen Constantinescu</i>	

<b>INTEGRATING REQUIREMENTS ENGINEERING FOR DIFFERENT DOMAINS IN SYSTEM DEVELOPMENT – LESSONS LEARNT FROM INDUSTRIAL SME CASES</b> .....	351
<i>Stefan Wiesner, Sara Nilsson, Klaus-Dieter Thoben</i>	
<b>FROM PSS TO CPS DESIGN: A REAL INDUSTRIAL USE CASE TOWARD INDUSTRY 4.0</b> .....	357
<i>Eugenia Marilungo, Alessandra Papetti, Michele Germani, Margherita Peruzzini</i>	
<b>POTENTIALS OF THE ASSET ADMINISTRATION SHELL OF INDUSTRIE 4.0 FOR SERVICE-ORIENTED BUSINESS MODELS</b> .....	363
<i>Erdal Tantik, Reiner Anderl</i>	
<b>A BIG DATA ANALYTICAL ARCHITECTURE FOR THE ASSET MANAGEMENT</b> .....	369
<i>Jaime Campos, Pankaj Sharma, Unai Gorostegui Gabiria, Erkki Jantunen, David Baglee</i>	
<b>SUPPORTING SUSTAINABLE PRODUCT-SERVICE SYSTEM IMPLEMENTATION THROUGH DISTRIBUTED MANUFACTURING</b> .....	375
<i>Aine Petruaityte, Fabrizio Ceschin, Eujin Pei, David Harrison</i>	
<b>PROVIDER-DRIVEN KNOWLEDGE ALLOCATION CONCEPT FOR IMPROVING TECHNICAL REPAIR TASKS IN IPS<sup>2</sup> NETWORKS</b> .....	381
<i>Michael Abramovici, Philip Gebus, Jens Christian Göbel, Philipp Savarino</i>	
<b>REFERENCE PRODUCT-SERVICE SYSTEM LIFECYCLE MODELS IN VIRTUAL ENTERPRISE CONTEXT</b> .....	387
<i>Hao Guan, Thècle Alix, Jean-Paul Bourrières</i>	
<b>PROCEDURE FOR GENERATING A BASIS FOR PPC SYSTEMS TO SCHEDULE THE PRODUCTION CONSIDERING ENERGY DEMAND AND AVAILABLE RENEWABLE ENERGY</b> .....	393
<i>Agnes Pechmann, Maximilian Zarte</i>	

## **SESSION 5: PSS CASES AND SUCCESS STORIES**

<b>EMPIRICAL STUDIES ON PRODUCT-SERVICE SYSTEMS – A SYSTEMATIC LITERATURE REVIEW</b> .....	399
<i>Yan Xin, Ville Ojanen, Janne Huiskonen</i>	
<b>PSS CREATING BUSINESS FOR SUSTAINABILITY: THE BRAZILIAN OLIVE OIL CASE IN MANTIQUEIRA COMMUNITY</b> .....	405
<i>Aline Sacchi Homrich, Daniel Sattler Theodoro, Marly Monteiro De Carvalho</i>	
<b>PRODUCT-SERVICE SYSTEMS FOR FUNCTIONAL OFFERING OF AUTOMOTIVE FIXTURES: USING DESIGN AUTOMATION AS ENABLER</b> .....	411
<i>Christian Johansson, Tobias Larsson, Sravan Tatipala</i>	
<b>A COST-ENGINEERING METHOD FOR PRODUCT-SERVICE SYSTEMS BASED ON STOCHASTIC PROCESS MODELLING: BERGAMO'S BIKE-SHARING PSS</b> .....	417
<i>Arturo Estrada, David Romero, Roberto Pinto, Giuditta Pezzotta, Alexandra Lagorio, Alice Rondini</i>	
<b>BICYCLE SHARING BASED ON PSS-EPR COUPLING MODEL: EXEMPLIFIED BY BICYCLE SHARING IN CHINA</b> .....	423
<i>Yi Wu, Dajian Zhu</i>	
<b>Author Index</b>	