ECPPM 2016

eWork and eBusiness in Architecture, Engineering and Construction

07 - 09 SEPTEMBER 2016

LIMASSOL, CYPRUS

Conference Handbook
& Book of Abstracts

ECPPM 2016

Contents

Dear Reader,

Nowadays, amidst global and prolonged economic slowdown, climatic change, increased urbanization, rapidly evolving technology, and fierce competition in the architectural, engineering and construction (AEC) industry, the development and implementation of scientific and applied knowledge for improved product and process modelling is of paramount importance to not only national agencies and firms but also to transnational networks.

Such scientific knowledge and policies should cover a myriad of issues related to product and process modelling including, but not limited to, building information models (BIM), energy efficiency at the building and urban scales, information and communication technology (ICT) applications in the AEC/FM domains, information and knowledge management, ontologies, data models and interoperability, smart cities, human requirements and human factors.

The following sections discuss most of the aforementioned important components of product and process modelling, as presented at the **Eleventh European Conference on Product and Process Modelling (ECPPM2016)**, held in Limassol, Cyprus (7-9 Sep. 2016). ECPPM is the flagship conference event of the European Association of Product and Process Modelling (EAPPM), with a long standing history of excellence in product and process modelling in the building industry, which is currently known as building information modelling (BIM).

The conference aimed to provide an international forum for the exchange of scientific information and knowledge-sharing on state-of-the-art research efforts and on contemporary product and process modelling issues, covering a large spectrum of topics pertaining to ICT deployment instances in AEC/FM, attracting high quality research papers and providing a platform for the cross fertilization of new ideas and know-how in relation to the special conference themes.

The work presented and included in the conference proceedings constitutes an excellent blending of cutting-edge research, of scientific and applied knowledge, and of case-studies across the globe which should be of great interest to both researchers and practitioners since it offers the European and the international community of product and process modelling professionals a great opportunity to experience the latest achievements in research, science, practice and management related to ECPPM. The proceedings include work from researchers from a total of 25 countries across the globe, and on topics covering the full spectrum of the conference's thematic areas. Further, the conference hosted two special sessions, titled *"Modelling and Simulation for Energy Efficient-Neighbourhoods (ee-Neighborhoods)"* and *"Use Case Data Requirements for Product Models to Enable Building Energy Simulation"*, as well as research outputs from several EU-funded projects.

This great experience starts with your participation in a state-of-the-art technical programme and culminates in a unique opportunity to, not only immerse yourself in cutting-edge ECPPM-related science, but also to engage other professionals in discussions, possible collaborations and future scientific endeavors for the advancement of knowledge in product and process modelling.

Finally, a great venue and an even greater host-city can only add value to the conference and guarantee the success and fun of it. We are definite that the city and the people of Limassol will make this a memorable experience to all participants and we invite you all to take full advantage of the country's historical, cultural, urban and tourist assets. Conference delegates, family and friends alike should take advantage of the great

opportunities the city provides and the ideal weather conditions to not only enjoy the sun and the sandy beaches of Limassol, but to also experience the full range of activities and excursions in Cyprus.

For all the above reasons and many more, we warmly invite you to Limassol, Cyprus, for the 11th International European Conference on Product and Process Modelling (ECPPM2016) and wish you the best and most memorable stay.

S.E. Christodoulou, PhD
Conference Host and Chair

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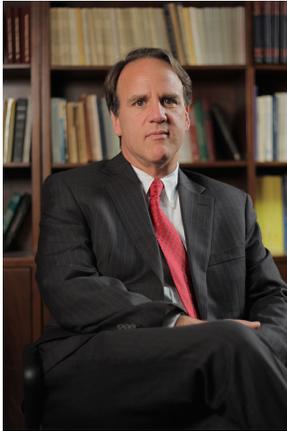
Lucio Soibelman, PhD

Professor and Chair of the Astani Civil and Environmental Department
University of Southern California, USA

Title: Data Rich Design, Construction, and Operations of Sustainable
Buildings and Infrastructure Systems

Abstract:

It is certainly no surprise that construction and operations of buildings and infrastructure systems require a huge amount of information from specifications, plans, construction documents, inventory management, cost estimating, and scheduling, for the design and construction phase and maintenance records, inspections and sensor data for the operations phase. As the AEC industry adopts new computer technologies like laser scanners, sensor networks, RFIDs, digital cameras, among many other data acquisition technologies computerized construction/operations data are becoming more and more available. There exist numerous opportunities to exploit this vast amount of data. Unlike much previous data management research that has been successfully applied in several domains, in the AEC domain, however, the data are of multiple types and from many different sources, some with very low quality.

At the same time that we have increasing access to data, infrastructure systems, broadly defined to include buildings and other facilities, transportation infrastructure, telecommunication networks, the power grid and natural environmental systems will require more and more that engineers provide a continuous state awareness, assessment and proactive decision making for the complete life-cycle of the systems and processes they create. Such continuous state awareness and proactive decision making will allow these systems to be more efficiently and effectively managed in both normal and abnormal conditions.

There are many technological developments and research projects that already support, or begin to support this vision. At this talk professor Soibelman will introduce his vision and work developed within his research group focus on the application and exploration of emerging Information and Communication Technologies (ICT), to a broadly defined set of infrastructure systems and associated processes, such as planning, design, construction, facility/infrastructure management, and environmental monitoring, so as to improve their sustainability, efficiency, maintainability, durability, and overall performance of these systems.

Biography:

Professor Soibelman obtained his Bachelor and Masters Degrees from the Civil Engineering De-partment of the Universidade Federal do Rio Grande do Sul, Brazil. He worked as a construction manager for 10 years before moving in 1993 to the US where he obtained in 1998 his PhD in Civil Engineering Systems from the Civil and Environmental Engineering Department at the Massachusetts Institute of Technology (MIT).

In 1998 he started as an Assistant Professor at the University of Illinois at Urbana Champaign. In 2004 he moved as an Associate Professor to the Civil and Environmental Engineering Department at Carnegie Mellon University (CMU) and in 2008 was promot-ed to Professor. In January 2012 he joined the Uni-versity of Southern California as the Chair of the Sonny Astani Department of Civil and Environmen-tal Engineering.

During the last 23 years he focused his research on advanced data acquisition, management, visuali-zation, and mining for construction and operations of advanced infrastructure systems. He published over 100 books, books chapters, journal papers, con-ference articles, and reports and performed research with funding from NSF (NSF career award and sev-eral other NSF grants), NASA, DOE, US Army, NIST, IBM, Bosch, IDOT, RedZone Robotics among many others funding agencies. He is the for-mer chief editor of the American Society of Civil Engineers Computing in Civil Engineering Journal. In 2010 he received the ASCE Computing in Civil Engineering Award, in 2012 received the 2011 FIATECH Outstanding Researcher Celebration of Engineering & Technology Innovation, or CETI, Award, in 2013 he was elected an ASCE fellow and in 2016 his was appointed a Distinguished 1,000 tal-ent Professor at Tsinghua University.

His areas of interest are: Use of information tech-nology for economic development, information technology support for construction management, process integration during the development of large-scale engineering systems, information logistics, ar-tificial intelligence, data mining, knowledge discov-ery, image reasoning, text mining, machine learning, advanced infrastructure systems, sensors, streaming data, and Multi-reasoning Mechanisms.

Ioannis Brilakis, PhD

Laing O'Rourke Lecturer of Construction Engineering,
University of Cambridge, UK

Title: Virtualizing Infrastructure

Abstract:

Vertical and horizontal infrastructure is comprised of large assets that need sizable budgets to design, construct and operate/maintain them. Cost reductions throughout their lifecycle can generate significant savings to all involved parties. Such reductions can be derived directly through productivity improvements or indirectly through safety and quality control improvements. Creating and maintaining an up-to-date electronic record of these assets in the form of rich Bridge Information Models (BIM) can help generate such improvements. New research is being conducted at the University of Cambridge on inexpensive methods for generating object-oriented infrastructure geometry, detecting and mapping visible defects on the resulting BIM, automatically extracting defect spatial measurements, and sensor and sensor data modelling. The results of these methods are further exploited through their application in design for manufacturing and assembly (DfMA), augmented-reality-enabled mobile inspection, and proactive asset protection from accidental dam-age. Virtualization methods can produce a reliable digital record of infrastructure and enable owners to reliably protect, monitor and maintain the condition of their asset.

Biography:

Dr. Ioannis Brilakis is a Laing O'Rourke Lecturer of Construction Engineering and the Director of the Construction Information Technology Laboratory at the Division of Civil Engineering of the Department of Engineering at the University of Cambridge. He completed his PhD in Civil Engineering at the Uni-versity of Illinois, Urbana Champaign. He then worked as an Assistant Professor at the Departments of Civil and Environmental Engineering, University of Michigan, Ann Arbor (2005-2008) and Georgia Institute of Technology, Atlanta (2008-2012), and as a Visiting Associate Professor of Computer Vision at the Department of Computer Science, Stanford University (2014). He is a recipient of the NSF CA-REER award, the 2013 ASCE Collingwood Prize, the 2012 Georgia Tech Outreach Award and the 2009 ASCE Associate Editor Award. Dr. Brilakis is an author of over 150 papers in peer-reviewed jour-nals and conference proceedings, an Associate Edi-tor of the ASCE Computing in Civil Engineering, ASCE Construction Engineering and Management, Elsevier Automation in Construction, and Elsevier Advanced Engineering Informatics Journals, and a past-chair and founder of the ASCE TCCIT Data Sensing and Analysis Committee, and the TRB AFH10 (1) Information Systems in Construction Management Subcommittee.

Dr. Rafael Sacks

Assoc. Professor, Virtual Construction Lab, National Building Research Institute
Faculty of Civil and Environmental Engineering, Technion – Israel Institute of Technology

Title: What's in a model? Intelligent semantic enrichment of BIM models

Abstract:

Building Information Modeling is a powerful technology, but transferring information among applications is still limited by the diversity of their internal representation schema. The goal of real 'Open BIM' remains elusive due to the difficulty of the interoperability problem. For similar reasons, model-checking and functional simulations using building models is hampered by the need for careful tailoring of the content of model files exported for these purposes.

Semantic enrichment is a novel approach to this problem. It aims to apply expert system technology to interpret and enrich the semantic content of models so that they can be re-used for multiple purposes with minimal rework. The technique will have application in a wide variety of situations. Among those being developed in current research are precast concrete detailing, cost estimation, compilation of as-built models of bridges for bridge surveys, and acquisition of building data for facility maintenance.

In the context of the SeeBridge project, funded within the EU Infravation Program, the team is using a semantic enrichment prototype named SeeBIM 2.0 to aid in compiling building models of highway bridges from point cloud data that can be used for survey and recording of damage to the bridges. This large scale experimental application has yielded important insights into the ways in which rule sets can be compiled rigorously, to ensure that they can uniquely identify bridge components and the semantic relationships between them. The method, which uses feature vectors and feature relationship matrices, also suggests that the potential exists for an alternative approach using tools developed for computer vision that include machine learning.

Prof. Sacks' talk will explore the need for semantic enrichment, its technology aspects, the ways in which it can contribute to providing interoperability, and the promise of a more advanced approach.

Biography:

Rafael Sacks' research interests are focused on the synergies of Building Information Modeling (BIM) and Lean Construction. Prof. Sacks established the BIM and Virtual Construction Laboratories at the Technion. Research in the VC Lab includes development of BIM-enabled lean production control systems; BIM systems for earthquake search, rescue and recovery; innovative approaches to interoperability for BIM; and production system theory in lean construction. The VC Lab's ongoing KanBIM and iKAN research projects are a novel attempt to bring process and product information to the job face.

Prof. Sacks earned his BSc from the University of the Witwatersrand, his MSc from MIT, and his PhD from the Technion – all in Civil Engineering. He served as Head of Structural Engineering and Construction Management in the Faculty of Civil and Environmental Engineering from 2012-2015. He has received numerous awards for research, most recently the ASCE Thomas Fitch Rowland prize. He is a co-author of the "BIM Handbook", some 70 papers in academic journals and numerous conference papers and research reports.

Overview Programme

Time/Day	Wednesday, 7th of September			Thursday, 8th of September			Friday, 9th of September	
09:00-09:30	**Opening/"Kalos Orisate"** Dr. Symeon Christodoulou, University of Cyprus Dr. Raimar Scherer, TU Dresden			**Plenary Session** Dr. Rafael Sacks, Technion Israel Institute of Technology			**Plenary Session** Dr. Ioannis Brilakis, Cambridge University	
09:30-10:30	**Plenary Session** Dr. Lucio Soibelman, University of Southern California							
10:30-11:00	Coffee Break			Coffee Break			Coffee Break	
11:00-12:30	**[W-2.1]** Information & Knowledge Management (I) - Technologies	**[W-2.2]** Collaboration and Teamwork	**[W-2.3] Special Session:** Use Case Data Requirements for Product Models to enable Building Energy Simulation	**[R-2.1] Special Session:** Energy Efficient Neighborhoods (ee-Neighborhoods, I)	**[R-2.2]** BIM Implementation and Deployment (I) - Principles and Case Studies	**[R-2.3]** Information & Knowledge Management (IV) - Construction	**[F-2.1]** Construction/Risk Management; Regulatory & Legal Aspects	**[F-2.2]** Description Logics and Ontology Application in AEC
12:30-14:00	Lunch Break			Lunch Break			Lunch Break	
14:00-15:00	**[W-3.1]** Information & Knowledge Management (II) - Building and Urban Scale	**[W-3.2]** Standardization of Data Structures and Interoperability	**[W-3.3]** 5D/nD Modelling, Simulation and Augmented Reality	**[R-3.1] Special Session:** Energy Efficient Neighborhoods (ee-Neighborhoods, II)	**[R-3.2]** Building Performance Simulation	**[R-3.3]** BIM Implementation and Deployment (II) - Human Resources & Economics	**Closing Session & Awards Ceremony**	
15:00-15:30								
15:30-16:00	Coffee Break			Coffee Break				
16:00-17:30	**[W-4.1]** Information & Knowledge Management (III) - Life Cycle Operations and Energy Efficiency	**[W-4.2]** Smart Cities		**[R-4.1]** Sustainable Buildings and Urban Environments	**[R-4.2]** Information & Knowledge Management (V) - Infrastructure			
17:30-18:30	**EAPPM Assembly Meeting**			**Meeting of the "Best PhD Paper Award" Committee**				
19:00-20:00	**Welcome Reception**			**Conference Dinner** **Departure Time:** 18:45 (meet at the Lobby of St. Raphael Resort – Venue)				
20:00-22:00								

Wednesday, 7th of September

Registration/ Support Desk hours (08:00 - 13:00 & 14:00 - 17:00)		
09:00-09:15	**Opening/"Kalos Orisate"** (Phoenix) Dr. Symeon Christodoulou, University of Cyprus *Chair: Dr. Symeon Christodoulou, University of Cyprus*	
09:15-09:30	**Quo Vadimus** (Phoenix) Dr. Raimar Scherer, TU Dresden *Chair: Dr. Symeon Christodoulou, University of Cyprus*	
09:30-10:30	**Plenary Session** (Phoenix) Dr. Lucio Soibelman, University of Southern California "Data Rich Design, Construction, and Operations of Sustainable Buildings and Infrastructure Systems" *Chair: Dr. Symeon Christodoulou, University of Cyprus*	
10:30-11:00	Coffee Break	

	Phoenix	Megaron B	Megaron G
11:00-12:30	**[W-2.1] Information & Knowledge Management (I) - Technologies** *Chair: Dr. Matthias Schuss, Vienna University of Technology, Austria*	**[W-2.2] Collaboration and Teamwork** *Chair: Dr. David DA SILVA, CSTB, France*	**[W-2.3] Special Session: Use Case Data Requirements for Product Models to enable Building Energy Simulation** *Chair: Dr. Kris McGlinn, ADAPT Centre, Trinity College Dublin, Ireland*
11:00	Querying Linked Building Data Using SPARQL with Functional Extensions *Chi Zhang, Jakob Beetz*	Integrated buildings and systems design: approaches, tools, and actors *Ardeshir Mahdavi, Birgit Rader*	SWIMing Project - Guidelines for Publishing Building Data as Linked Data *Kris McGlinn*
11:15	Context aware information spaces through adaptive Multimodel Templates *Frank Hilbert, Raimar Scherer*	Ecosystem and platform review for construction information sharing *Irina Peltomaa, Markku Kiviniemi, Janne Väre*	Semantic Data Integration for Smart Cities using Linked Data *Kiril Tonev*
11:30	Access Control for Web of Building Data: Challenges and Directions *Jyrki Oraskari, Seppo Törmä*	Building Information Modeling (BIM) for LEED® IEQ category prerequisites and credits calculations *Giacomo Bergonzoni, Marco Capelli, Simone Viani, Francesco Conserva*	Energy & environmental benefits assessment via modeling & simulation for different building typologies & climates - The RESILIENT project Nikolaos Kaklanis
11:45	Identifying and addressing multi-source database inconsistences: Evidences from global road safety information *Loukas Dimitriou, Paraskevas Nikolaou*	Emotional Intelligence - Improving the performance of Big Room *Otto Alhava, Enni Laine, Arto Kiviniemi*	Capturing Building Data Requirements in the NewTREND Project *Matthias Weise*
12:00	-	A Comparative Review of Systemic Innovation in the Construction and Film Industries *Sujesh Sujan, Gulnaz Aksenova, Arto Kiviniemi, Steve Jones*	A comprehensive ontologies-based framework to support retrofitting design of energy-efficient districts *Gonçal Costa, Álvaro Sicilia, Georgios Lilis, Dimitrios Rovas, José Luis Izkara*
12:15	-	-	ifcOWL for Managing Product Data *Pieter Pauwels*
12:30-14:00	Lunch Break		

	Phoenix	Megaron B	Megaron G
14:00-15:30	**[W-3.1] Information & Knowledge Management (II) - Building and Urban Scale** *Chair: Dr. Pedro Mêda Magalhães, Porto University - Faculty of Engineering, Portugal*	**[W-3.2] Standardization of Data Structures and Interoperability** *Chair: Dr. Loukas Dimitriou, University of Cyprus*	**[W-3.3] 5D/nD Modelling, Simulation and Augmented Reality** *Chair: Dr. Eilif Hjelseth, Oslo and Akershus University College of Applied Sciences, Norway*
14:00	Implications of a BIM-based facility management and operation practice for design-intent models *Pouriya Parsanezhad, Väino Tarandi, Örjan Falk*	Facilitating the BIM coordinator and empowering the suppliers with automated data compliance checking *Leon van Berlo, Eleni Papadonikolaki*	Software library for spatial-temporal modeling and reasoning *Vitaly Semenov, Vladislav Zolotov, Konstantin Kazakov, Konstantin Petrishchev*

Time			
14:15	Pragmatic Use of LOD - a Modular Approach *Niels Treldal, Flemming Vestergaard, Jan Karlshøj*	DRUMBEAT Platform – A Web of Building Data Implementation with Backlinking *Nam Vu Hoang, Seppo Törmä*	BIM Registration Methods for Mobile Augmented Reality-Based Inspection *Marianna Kopsida, Ioannis Brilakis*
14:30	Seamless Integration of Common Data Environment Access into BIM Authoring Applications: the BIM Integration Framework *Cornelius Preidel, André Borrmann, Carl-Heinz Oberender, Markus Tretheway*	A versatile and extensible solution to the integration of BIM and energy simulation *Davide Mazza, Emira El Asmi, Sylvain Robert, Khaldoun Zreik, Bruno Hilaire*	Generation of Serious Games Environments from BIM for a Virtual Reality Crisis-Management System *Anna Wagner, Uwe Rüppel*
14:45	SimpleBIM: From full ifcOWL graphs to simplified building graphs *Pieter Pauwels, Ana Roxin*	IfcTunnel - A proposal for a multi-scale extension of the IFC data model for shield tunnels under consideration of downward compatibility aspects *Simon Vilgertshofer, Javier Ramos Jubierre, André Borrmann*	Simulation model generation combining IFC and CityGML data *Georgios Nektarios Lilis, Georgios Giannakis, Kyriakos Katsigarakis, Dimitrios Rovas, Gonçal Costa, Álvaro Sicilia, Miguel Garcia*
15:00	IFC model checking based on mvdXML 1.1 *Matthias Weise, Thomas Liebich, Nicholas Nisbet, Claudio Benghi*	Delivering COBie data - Focus on curtain walls and building envelopes *Michele Carradori, Michele Scotton, Paolo Borin, Carlo Zanchetta, Jan Karlshøj*	-
15:30-16:00	Coffee Break		
	Phoenix	Megaron B	Megaron G
16:00-17:30	**[W-4.1] Information & Knowledge Management (III) - Life Cycle Operations and Energy Efficiency** *Chair: Dr. Francesco Livio Rossini, Sapienza - Università di Roma, Italy*	**[W-4.2] Smart Cities** *Chair: Dr. Johannes Dimyadi, University of Auckland, New Zealand*	-
16:00	Information Requirement Definition for BIM: A Life Cycle Perspective *Georg Ferdinand Schneider, Aude Bougain, Peter Stephan Noisten, Matthias Mitterhofer*	Energy matching and trading within green building neighborhoods based on stochastic approach considering uncertainty *Seyedeh Samaneh Ghazimirsaeid, Terrence Fernando, Mousa Marzband*	-
16:15	A flexible and scalable approach to building monitoring and diagnostics *Matthias Schuss, Ardeshir Mahdavi, Stefan Glawischnig*	Using a mobile application to assess building accessibility in smart cities *Núria Forcada, Marcel Macarulla, Rafaela Bortolini*	-
16:30	Acquisition and processing of input data for building certification: An approach to increase the reproducibility of energy certificates *Ulrich Pont, Olga Proskurnina, Mahnameh Taheri, Ardeshir Mahdavi, Bernhard Sommer, Goga S. Nawara, Gabriela Adam*	Prediction of traffic characteristics in Smart Cities based on Deep Learning Mechanisms *Vana Gkania, Loukas Dimitriou*	-
16:45	Utilization of GIS Data for Urban-Scale Energy Inquiries: A Sampling Approach *Neda Ghiassi, Ardeshir Mahdavi*	Monitoring Drivers' Perception of Risk within a Smart City Environment *Loukas Dimitriou, Katerina Stylianou*	-
17:00	Semantic Interoperability for Holonic Energy Optimization of Connected Smart Homes and Distributed Energy Resources *Shaun Howell, Yacine Rezgui, Jean-Laurent Hippolyte, Monjur Mourshed*	-	-
17:30-18:30	**EAPPM Assembly Meeting** (Phoenix) *Chair: Dr. Raimar Scherer*		
19:00-20:00	**Welcome Reception**		

Thursday, 8th of September

Registration/ Support Desk hours (08:30 - 13:00 & 14:00 - 17:00)			
09:00 - 10:30	**Plenary Session** (Phoenix) Dr. Rafael Sacks, Technion Israel Institute of Technology "What's in a Model? Intelligent Semantic Enrichment of BIM Models" *Chair: Dr. Symeon Christodoulou, University of Cyprus*		
10:30-11:00	Coffee Break		
	Phoenix	Megaron B	Megaron G
11:00-12:30	**[R-2.1] Special Session: Energy Efficient Neighborhoods (ee-Neighborhoods, I)** *Chairs: Dr. Raimar J. Scherer, Technische Universität Dresden, Germany & Dr. May Bassanino, University of Salford, United Kingdom*	**[R-2.2] BIM Implementation and Deployment (I) - Principles and Case Studies** *Chair: Dr. Leon van Berlo, Netherlands Organisation for Applied Scientific Research TNO, Netherlands*	**[R-2.3] Information & Knowledge Management (IV) - Construction** *Chair: Dr. Uwe Rüppel, TU Darmstadt, Germany*
11:00	A collaborative environment for energy-efficient buildings within the context of a neighbourhood *May Bassanino, Terrence Fernando, Kuo-Cheng Wu, Samaneh Ghazimirsaeid, Krzysztof Klobut, Tarja Mäkeläinen, Mari Hukkalainen*	Is BIM-based product documentation based on applicable principles? – Practical use in Norway and Portugal *Eilif Hjelseth, Pedro Mêda Magalhães*	Construction Information Framework – the role of classification systems *Pedro Mêda Magalhães, Eilif Hjelseth, Hipólito Sousa*
11:15	KPI framework for energy efficient buildings and neighbourhoods *Krzysztof Klobut, Tarja Mäkeläinen, Aapo Huovila, Juha Hyvärinen, Jari Shemeikka*	Necessary conditions for the accountable inclusion of dynamic representations of inhabitants in building information models *Ardeshir Mahdavi, Farhang Tahmasebi*	A Semantic Web Approach to Efficient Building Product Data Procurement *neda ghiassi, Mahnameh Taheri, Ulrich Pont, Ardeshir Mahdavi*
11:30	Multiscale building modelling and energy simulation support tools *Ander Romero, José Luis Izkara, Asier Mediavilla, Iñaki Prieto, Juan Pérez*	Methodology for tracking BIM benefits on project level *Tarja Mäkeläinen, Juha Hyvärinen, Mirkka Rekola*	BIM adoption for on-site reinforcement works – A work system view *Alejandro Figueres-Munoz, Christoph Merschbrock*
11:45	From District Information Model (DIM) to Energy Analysis Model (EAM) via Interoperability *Niccolò Rapetti, Matteo Del Giudice, Anna Osello*	BIM for the integration of Building Maintenance Management: A case study of a university campus *Rafaela Bortolini, Núria Forcada, Marcel Macarulla*	Classification of detection states in construction progress monitoring *Alex Braun, Sebastian Tuttas, André Borrmann, Uwe Stilla*
12:00	Energy modelling of existing facilities *Nicholas Nisbet, John Cartwright, Martin Aizlewood*	A comparative case study of coordination mechanisms in Design and Build BIM-based projects in the Netherlands *Ajibade Aibinu, Eleni Papadonikolaki*	Introducing process mining for AECFM: three experimental case studies *Stijn van Schaijk, Leon van Berlo*
12:15	A collaborative platform integrating multi-physical and neighbourhood aware building performance analysis driven by the optimized HOLISTEEC building design methodology *Hervé Pruvost, Raimar Scherer, Klaus Linhard, Georg Dangl, Sylvain Robert, Davide Mazza, Asier Mediavilla, Dirk Van Maercke, Eberhard Michaelis, Gamal Kira, Tarja Häkkinen, Elisabetta Delponte, Carolina Ferrando*	-	-
12:30-14:00	Lunch Break		

	Phoenix	Megaron B	Megaron G
14:00-15:30	**[R-3.1] Special Session: Energy Efficient Neighborhoods (ee-Neighborhoods, II)** *Chairs: Dr. May Bassanino, University of Salford, United Kingdom and Dr. Raimar J. Scherer, Technische Universität Dresden, Germany*	**[R-3.2] Building Performance Simulation** *Chair: Dr. Seppo Törmä, Aalto University, School of Science, Finland*	**[R-3.3] BIM Implementation and Deployment (II) - Human Resources & Economics** *Chair: Dr. Ana Roxin, University of Burgundy, France*
14:00	Collaboration requirements and interoperability fundamentals in BIM based multi-disciplinary building design processes *Rasso Steinmann, Klaus Linhard, Georg Dangl, Gloria Calleja-Rodriguez, Marie-Christine Geissler, Romy Guruz*	A novel approach to building performance optimisation via iterative operations on attribute clusters of designs options *Ardeshir Mahdavi, Hamidreza Shirdel, Farhang Tahmasebi*	Human-Resources Optimization & Re-Adaptation Modelling in Enterprises *Stylianos Zikos, Savvas Rogotis, Stelios Krinidis, Dimosthenis Ioannidis, Dimitrios Tzovaras*
14:15	Technical challenges and approaches to transfer building information models to building energy *Frank Noack, Vanda Dimitriou, Stephen K. Firth, Tarek M. Hassan, Peter Katranuschkov, Raimar Scherer, Nuno Ramos, Pedro Pereira, Pedro M. N. Maló, Terrence Fernando*	BIM-based building design platform - Local environmental effects on building energy performances *David Da Silva, Patrick Corrales, Philippe Tournier, Margarita Cherepanova*	Building Information Modeling in use: How to evaluate the Return on Investment? *Annie Guerriero, Sylvain Kubicki, Sandrine Reiter*
14:30	Task-Specific Linking for Generating an eeBIM Model based on an Ontology Framework *Mathias Kadolsky, Raimar Scherer*	Using BIM to Support Simulation of Compliant Building Evacuation *Johannes Dimyadi, Michael Spearpoint, Robert Amor*	A new training concept for implementation of 5D planning with regard to construction of large-scale projects *Leonid Herter, Katja Silbe, Joaquín Díaz*
14:45	Visual support for multi-criteria decision making *Tuomas Laine, Francisco Forns-Samso, Ville Kukkonen*	Intelligent Emergency Exit System Framework for Real-time Emergency Evacuation Guidance *Raja R. A. Issa, Jun Zhang*	Combining BIM models and data with game technology to improve the decision making process: 'Playconstruct'. *Howard Jeffrey*
15:00	An IT-based holistic methodology for analysing and managing building lifecycle risk *Hervé Pruvost, Tom Grille, Raimar Scherer*	-	-
15:15	Open eeBIM Platform for Energy-Efficient Building Design *Raimar Scherer, Peter Katranuschkov, Ken Baumgärtel*	-	-
15:30-16:00	Coffee Break		
	Phoenix	Megaron B	Megaron G
16:00-17:30	**[R-4.1] Sustainable Buildings and Urban Environments** *Chair: Dr. Ardeshir Mahdavi, TU Wien, Austria*	**[R-4.2] Information & Knowledge Management (V) - Infrastructure** *Chair: Dr. Jan Karlshøj, Technical University of Denmark, Denmark*	-
16:00	Energy savings and maintenance optimization through the implementation of GESTENSIS energy management system *Marcel Macarulla, Miquel Casals, Marta Gangolells, Blanca Tejedor*	Detecting, classifying and rating roadway pavement anomalies using smartphones *Charalambos Kyriakou, Symeon Christodoulou, Loukas Dimitriou*	-
16:15	Responsiveness based material – [a] Passive shading control system *Maria João De Oliveira, Vasco Rato, Carla Leitão*	Patch Defects Detection for Pavement Assessment, using Smartphones and Support Vector Machines *Georgios Hadjidemetriou, Symeon Christodoulou*	-

16:30	Promoting energy users' behavioural change in social housing through a serious game *Miquel Casals, Marta Gangolells, Marcel Macarulla, Alba Fuertes, Rory Jones, Sabine Pahl*	Comparing Diurnal Patterns of Domestic Water Consumption: An International Study *Julia Terlet, Gaelle Bulteau, Thomas H. Beach, Yacine Rezgui*	-
16:45	Total life cycle and near real time environmental assessment approach: an application in a district and urban environment? *Corentin Kuster, Yacine Rezgui*	Waterloss Detection in Streaming Water Meter Data Using Wavelet Change-Point Anomaly Detection *Symeon Christodoulou, Elena Kourti, Agathoklis Agathokleous, Christina Christodoulou*	-
17:00	An Agile Process Modelling Approach for BIM Projects *Udo Kannengiesser, Ana-Maria Roxin*	-	-
17:30-18:30	**Meeting of the "Student Paper Competition (SPC)" Award Committee** (Phoenix) *Chair: Dr. Symeon Christodoulou, University of Cyprus*		
19:00-22:00	**Conference Dinner** **Departure Time:** 18:45 (meet at the Lobby of St. Raphael Resort – Venue)		

Registration/ Support Desk hours (08:30 - 13:00 & 14:00 - 15:00)		
09:30-10:30	**Plenary Session** (Phoenix) Dr. Ioannis Brilakis, Cambridge University "Virtualizing Infrastructure" *Chair: Dr. Symeon Christodoulou, University of Cyprus*	
10:30-11:00	Coffee Break	
11:00-12:30	Phoenix	Megaron B
	[F-2.1] Construction/Risk Management; Regulatory & Legal Aspects *Chair: Dr. Symeon Christodoulou, University of Cyprus*	**[F-2.2] Description Logics and Ontology Application in AEC** *Chair: Dr. Ulrich Pont, TU Wien, Austria*
11:00	Managing constructability on a construction stage: BIM methods *Matti Tauriainen, Joni Helminen, Jari Puttonen*	Structured building monitoring: ontologies and platform *Ardeshir Mahdavi, Stefan Glawischnig, Farhang Tahmasebi, Matthias Schuss, Alexandra Heiderer*
11:15	Integrating BIM and Agent-Based Modelling for construction operational optimization *Francesco Livio Rossini, Gabriele Novembri, Antonio Fioravanti, Cristiano Insola*	SemCat: Publishing and Accessing Building Product Information as Linked Data *Gudni Gudnason, Pieter Pauwels*
11:30	Topological Robustness and Vulnerability Assessment of Water Distribution Networks *Agathoklis Agathokleous, Christalleni Christodoulou, Symeon Christodoulou*	Automatic ontology-based Green Building Design Parameter Variation and Evaluation in Thermal Energy Building Performance Analyses *Ken Baumgärtel, Raimar J. Scherer*
12:30-14:00	Lunch Break	
14:00-15:00	**Closing Session & Awards Ceremony** (Phoenix) *Chairs: Dr. Symeon Christodoulou & Dr. Raimar Scherer*	

Social Events

Welcome Reception

Wednesday, 7th of September

Time: 19:00
Location: St. Raphael Resort – Venue

Welcome Reception is the first social gathering between all conference delegates and it will take place at the Venue Hotel. It will be a relaxing evening during which delegates will have the opportunity to talk to colleagues and peers, while enjoying local drinks and ample canapés.

Price per accompanying person: € 30

*Welcome Reception is included in **all** registration fees. For accompanying persons you may buy tickets at the registration/support desk.*

Excursion & Conference Dinner

Thursday, 8th of September

Departure Time: 18:45 (meet at the Lobby of St. Raphael Resort – Venue)
Location: Local Restaurant

We will get together at 18:45 at the lobby of St Raphael Resort – Venue, from where we will promptly depart in air-conditioned coaches for a fascinating tour. Experienced professional guides will tell us about the history of Cyprus in general and Limassol town in particular. We will visit and walk through the streets of the old city, walk around the Limassol Castle and visit the newly built Marina.

Our tour will finish with a dinner which will consist of an array of traditional dishes complimented with local drinks and desserts. During the dinner we will enjoy an entertaining programme. The event can definitely be considered as an opportunity to meet and get to know better fellow delegates in a different yet relaxed environment.

Ticket: € 60

*Conference Dinner is included in ECPPM2016 Full Registration **only**. You may buy tickets at the registration/support desk.*

Travel Information

About Limassol

Limassol is one of the fastest growing modern metropoles in Europe. The city's infrastructure is constantly upgraded from all aspects (way of living, public construction projects, education, etc) with the most distinct project of this sort being the Limassol Marina and the revamped coastline, which covers a 15 kilometre distance. The Limassol Marina is an exciting new destination for living, yachting, dining and shopping. It combines elegant residences and a full service marina with an enticing mix of restaurants and shops, to create a lifestyle uniquely shaped by 'living on the sea'.

Limassol, a city counting centuries of history, is located between two of the most renowned ancient kingdoms of the island, Amathous at the east and Kourion at the west. "Lemessos" as it is called by locals, is the second largest urban area in Cyprus (after the capital, Nicosia) and its municipality is the most populous in the country with 235,000 inhabitants (2011 Census).

In recent years Limassol has progressed as one of the largest commercial ports in the Mediterranean and it is now considered as one of the most important centres of tourism, trade and offshore companies. The city is also the business and financial centre of Cyprus as hundreds of international shipping and financial companies have their headquarters here.

It is undisputable that Limassol's prosperity is not an achievement of nowadays. Since antiquity, Cyprus' source of income has been wine, which according to testimonials was a "must" during religious events, festivals or even moments of sorrow. Wine production in Limassol started thousands of years ago along with the vineyard plantation and, especially after the 20th century, contributed in the city's welfare, as it has become the centre of wineries.

Top Limassol Landmarks

Limassol Castle

There is no doubt that the Limassol Castle occupies a dominant position in the landmark and tourist attractions in the city. Richard the Lionheart is supposed to have married his fiancée Princess Berengaria of Navarre in this castle. The Castle was used as a prison between 1790 and 1940 and it now serves as a medieval museum. A visitor can see numerous exhibits: Cannons, wood carvings of the 17th and 18th

century, paintings and tombstones, statues, suits of armour, coins, terracotta, metalware and pottery, glass and marble articrafts.

Archaeological Museum

The Archaeological Museum in Limassol is a particularly interesting sight for art and history lovers. The museum houses artefacts related to societal development of Cyprus, which include ceramics, pottery and antiquities from the Roman period. Also, on display are finds from the Neolithic until the Late Bronze Age.

Municipal Garden

The Municipal Garden, along the coastal road, has a rich bounty of green and shady space where visitors relax or take a stroll down the pathways. The nearby area plays host to several family attractions like the Lemesos Zoo Garden and Dinosaur Park.

Twin Cities Park

The Twin Cities Park (or the Sculpture Park), situated on the waterfront and spanning more than 1,5 km long, is home to a series of sculptures commissioned by the Limassol Municipality and created by Cypriot and foreign sculptors.

Amathus Ruins

The ancient city of Amathus is one of the oldest imperial cities on the island. A greek myth would have Amathus built by one of the sons of Heracles who was worshipped there. The city had a very special place for Phoenix, the goddess of beauty and love. Visitors at the ruins can perceive an era that existed 3000 years ago through the mythical excavations and artefacts.

Kolossi Medieval Castle

A renowned archaeological site, the castle was built in the 15th century by the Knights of Saint John of Jerusalem on a land gifted by King Hugh I. Earlier, it used to be home to a 13th century fortress whose ruins are still visible in the castle. Later the castle was occupied by Richard I of England and the Knights Templar.

Kourion Archaeological Site

One of the most famous attractions in Cyprus and a stunning archaeological excavation, thanks to its impressive Greco-Roman theatre, stately villas, spectacular floor mosaics, an early Christian Basilica and other kingly treasures.

Travelling Around Limassol

For all tourist information concerning sites of interest, visit the official webpage of Cyprus Tourism Organization www.visitcyprus.com.

A list of all buses around Cyprus including night buses, rural buses and intercity buses can be found on 'Cyprus by Bus' website at www.cyprusbybus.com. The buses are separated by city while route details, timetables and maps are available for each route.

Limassol boasts a reliable and efficient public bus service which runs every day and covers the whole Limassol District. The bus fare for a single journey is €1.50 (day fare) and €2.50 (night fare, after 21:00). The daily ticket with unlimited journeys costs €5.00 and the weekly ticket costs €20.00. Tickets can be purchased on the bus. For more information about the bus routes and schedules can be found on the Limassol's Transport Organization (EMEL Buses) website, www.limassolbuses.com.

For ease of reference, **Route 30 (MY MALL - LE MERIDIEN HOTEL - MY MALL)** passes close by all the conference hotels.

Taxi Service

Taxis in Cyprus are relatively cheap and reliable. It is best to use a registered taxi company; therefore we recommend that you ask as a member of staff at the on-site Conference Help Desk who will be pleased to reserve a taxi for you.

Getting Back to the Airport

Private Transportation

Whether you require a transfer to Larnaca or Paphos Airports, you can contact a member of staff at the on-site Conference Help Desk who will be pleased to reserve a taxi for you.

Public Transportation

In case that you would like to use the public bus service, you may take the direct service to Larnaca or Paphos International Airports handled by 'Limassol Airport Express' coaches. Please visit www.limassolairportexpress.eu for the latest information and time schedule.

Useful Contact Numbers

Country code prefix	+357
Directory Enquiry Service	11892
Private Doctors on Call	90 901432
Ambulance & Police	112
Pharmacies (after hours)	90 901412
Limassol General Hospital	25 801100
Limassol Transport Organization	77 778121
Larnaca and Paphos International Airports	77 778833

Hotel Contact Details

St. Raphael Resort (Venue)

Address: 502 Amathus Avenue, 4520 Pyrgos, Limassol, Cyprus
Phone: +357 25 834200
Fax: +357 25 636394
Email: reservations@raphael.com.cy

Kapetanios Odyssia Hotel

Address: Panayioti Symeou str. 4-6, Limassol, Cyprus
Phone: +357 25 586266
Fax: +357 25 591032
Email: limassolhotel@kapetaniosgroup.com

Curium Palace Hotel

Address: 11 Byron Street, 3105 Limassol, Cyprus
Phone: +357 25 891100
Fax: +357 25891350
Email: info@curiumpalacehotel.com.cy

Park Beach Hotel

Address: 12, Georgiou A' Avenue, Limassol, Cyprus
Phone: +357 25 321301
Fax: +357 25 323755
Email: info@parkbeach.cy.net

Vegas Hotel Apartments

Address: 20, Amathus Avenue, Limassol, 4532, Cyprus
Phone: +357 25 320222
Fax: +357 25 320754
Email: info@vegashotelapts.com

Venue & Hotels Map

V	St. Raphael Resort (Venue)
1	Vegas Hotel Apartments
2	Park Beach Hotel
3	Kapetanios Odyssia Hotel
4	Curium Palace Hotel

Conference Coordinators

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Querying linked building data using SPARQL with functional extensions

C. Zhang & J. Beetz
Eindhoven University of Technology, Eindhoven, The Netherlands

ABSTRACT: In this paper, we propose to extend SPARQL functions for querying building models. Building models captured by the IFC data model are the target data sources to develop extended functions. By extending these functions, we aim to 1) simplify writing queries and 2) retrieve useful information implied in building models. These functions are classified into four categories according to required data inputs. A prototype implementation is provided with indicate performance testing. Since this system is compatible with SPARQL and Linked Data environment, building models can be queried with data from other fields. A case study is conducted to query building and regulatory data for code compliance checking purpose. It demonstrates an approach which can be applied and extended for many other use cases.

Context aware information spaces through adaptive multimodel templates

F. Hilbert
Institute of Applied Computer Science, Dresden University of Technology, Germany

R. J. Scherer
Institute for Construction Informatics, Dresden University of Technology, Germany

ABSTRACT: This paper addresses context aware information supply for information processes in the construction industry. The planning and creating of structures and buildings is based on collaborative construction information processes whose information supply is characterized by a decentralized exchange of heterogeneous application models. Throughout a construction project numerous architecture, engineering and management information models are created and used because of the inherent complexity of the building product and processes as well as the corresponding high number of involved domains. The various specialized applications e.g. CAD, FEM, cost or scheduling software and standards used lead to a weak software integration and inconsistent data handling. Therefore a central challenge in construction projects is still the management of the inhomogeneous distributed information environment where domain models data need to be adequately transformed, exchanged and managed horizontally (between client and contractor and among various discipline specific representations), longitudinally (in their temporal development along the project phases), and vertically (on different levels of abstraction).

To bundle various application models and indicate their dependencies the Multimodel as a kind of an information space was developed. Increased requirements for specialized work processes as well as the growing complexity of construction projects lead to an increase in the amount, scope and complexity of the exchanged information spaces. The corresponding Multimodels quickly become very large and unwieldy. This leads to an inhibitory effect on the construction information processes. The transfer of Multimodels and the orientation in the information spaces will be more complicated. In addition, this effect prevents a mobile use of Multimodel based information spaces. However various construction information processes for

planning and creating of structures and buildings usually doesn't need the entire information available in construction projects. When considering the situational information requirements of construction information processes, a context dependence is revealed that determines the quantity and quality as well as the cutouts and linking depth of the required information spaces depending on various aspects of the processing context. The information needs depends on the context. For an efficient information supply of construction information processes by matching information spaces therefore the consideration of the processing situation is necessary. That is why the design of the required Multimodels is determined by various aspects of the process situation. With knowledge of these aspects, context dependent information needs can be anticipated and targeted information supply of construction information processes can be realized.

A prerequisite for such a context aware information logistics is a methodology that enables formal depict dependencies between contextual information and information space elements and evaluate them automatically. For this purpose, in this work an approach is presented to formalize the context dependencies of the information needs of construction information processes. The influence of information logistically relevant context aspects to the design of information needs, the context relations, can be described directly in Multimodel templates. For this a special rule language, called ContextScript was developed that can be annotated instead of static attribute values into the template. In this way, based on Multimodel information spaces, context adaptive Multimodel templates can be defined, which can persisted along with an associated reference process. By evaluating these templates at time of use, situative information needs can be anticipated as Multimodel template (MMT) and an adequate context oriented Multimodel can be generated. Thus the presented approach allows the realization of a context oriented information supply that allows to anticipate context based information needs and to generate a corresponding situationally information space.

Access control for web of building data: Challenges and directions

J. Oraskari & S. Törmä

School of Science, Aalto University, Espoo, Finland

ABSTRACT: Web of Building Data enables open publication of building-related data on the Web. However, a large part of building data requires access control for reasons of facility security, resident privacy, competition, and IPR protection. The linking across multiple models at different hosts creates challenges to implement an access control scheme that could avoid repeated and tedious registrations and authentications by users, and enable simple definition of the access control rules at different hosts. In this study the access control challenges of practical use cases are analyzed, objectives for access control are summarized, and possible decentralized access control solutions are explored. The focus is on WebId+TLS and OpenId Connect. The importance of common ontologies for role or property based access control is discussed.

Identifying and addressing multi-source database inconsistencies: Evidences from global road safety information

L. Dimitriou & P. Nikolaou

Dept. Of Civil and Environmental Engineering, University of Cyprus, 75 Kallipoleos Str., P.O. Box 20537, 1678 Nicosia, Cyprus

ABSTRACT: The data collection and the creation of extensive databases for the investigation of different global phenomenon, such as road traffic fatalities, inherent risks of information inconsistencies. The current paper is presenting a novel approach on the efficiently detection of potential data anomalies (inconsistencies), using wide in range socio-economic factors from different 'instances' years (2010 and 2013), for the investigation of the phenomenon of road traffic fatalities concerning 121 UN countries (restricted to UN countries with significant population). Unfortunately, collecting information from different, even reliable, sources (global organizations) raises speculations of uncertain, implausible, inconsistent and unstable information, which can be transparent with different data-model analysis likewise Principal Component Analysis, Negative Binomial regression analysis and Structural Equation Modeling.

Integrated buildings and systems design: approaches, tools, and actors

A. Mahdavi and B. Rader
Department of Building Physics and Building Ecology, TU Wien, Vienna, Austria

ABSTRACT: Buildings involve both predominantly static features such as building construction, fabric, and envelope, as well as dynamically operating environmental control systems. The optimal life-time performance of buildings depends arguably on a well-coordinated design and configuration of these two aspects. However, the communication and collaboration between primary building designers and building service engineers in the design process is frequently sub-optimal. In the present contribution, we address these issues in two ways. First, we report on the results of an inquiry into the mind-set of both primary building designers and building systems specialists regarding building systems integration issues and their mutual roles in the corresponding process. Second, we briefly describe a possible comprehensive workflow process for the systemic generation and assessment of building systems configurations that are tightly integrated with primary (spatial) building designs.

Ecosystem and platform review for construction information sharing

I. Peltomaa, M. Kiviniemi & J. Väre
VTT Technical Research Centre of Finland, Oulu/Tampere/Espoo, Finland

ABSTRACT: Emerging digitalization is radically changing industrial world. Disruptive technologies give companies great challenges, but also huge opportunities to develop their businesses. One perspective for gaining business benefit from digitalization wave is to utilize ecosystem-based thinking. This paper presents a development of an ecosystem and platform analysis for AEC/FM industry information sharing. The objective of this paper is to identify and classify existing information sharing ecosystems and platforms applicable to AEC/FM industry. Web of Building Data initiative is introduced as one of the construction industry approaches for information sharing. Presented work is a part of a project where the objective is to provide information sharing method and technology for AEC/FM industry. As a part of the project an information sharing platform on the basis of the Web of Building Data is developed. Ecosystem analysis is used as a base for conceptualize an open ecosystem to be formed around platform.

Building Information Modeling (BIM) for LEED[®] IEQ category prerequisites and credits calculations

G. Bergonzoni, M. Capelli, G. Drudi, S. Viani & F. Conserva
Open Project S.r.l., Bologna, Italy

ABSTRACT: A good Indoor Environmental Quality is required for any building applying for Leadership in Energy and Environmental Design (LEED®) certification. The room-by-room calculations required to demonstrate compliance with the Indoor Enviromental Quality (IEQ) prerequisites and credits, starting from the building geometry and use and the HVAC technical data, may be time consuming and error-prone. With Building Information Modeling (BIM) all the required data can be incorporated into the design model, thus speeding up the process, automate the design validation and minimize the errors. The research explored the use of BIM for the Mechanical design following the LEED IEQ P1 and IEQ C2 qualification, and the automation of calculus for the verification process with the use of Dynamo visual scripting tool for the data exchange between Autodesk Revit and electronic spreadsheets.

Emotional intelligence - Improving the performance of big room

O. Alhava
Fira Oy, Vantaa, Finland

E. Laine
European Investment Bank, Luxemburg

A. Kiviniemi
University of Liverpool, Liverpool, UK

ABSTRACT: Given the importance of collaboration in the construction industry, the perspective of emotional intelligence is almost completely absent from construction project management articles and literature. In many other industries collaboration, co-working and co-creation are recognized as common practices to create customer value.

As a crucial soft skill required for efficient collaboration, the role and benefits of emotional intelligence should be investigated and clarified especially when Big Room methods are applied increasingly in construction projects. The purpose of this paper is to test and verify a framework for the assessment of Big Room facilitator's emotional intelligence to improve the performance of Intensive Big Room (IBR) process during the design phase of construction projects.

This study aims to take the performance of the IBR into new level by studying the effects of the emotional intelligence in the co-creation process. The findings indicate that the application of emotional intelligence methods in facilitation immediately improved the performance of the social processes in inter-disciplinary collaboration. Furthermore, the participant motivation and stakeholder satisfaction were increased when emotional intelligence methods were included to the facilitation process of IBR process.

A comparative review of systemic innovation in the construction and film industries

S. F. Sujan, G. Aksenova, A. Kiviniemi & S. W. Jones
University of Liverpool, Liverpool, United Kingdom

ABSTRACT: Generalising the construction and film industries as a Project Based Inter-Organisational Network (PBION) and Building Information Modelling (BIM) adoption as a systemic change allows phenomena to be compared. The film industry was chosen because of the number of disruptive systemic innovations that have occurred since the late 19th century. Acknowledging that the nature of end products in both industries differ widely, this paper draws fragmentation as common phenomena and is associated with increased transaction costs and lower fixed costs. Due to this research area's highly abstract interdisciplinary nature, two perspectives are investigated for their explanatory and guiding potential. Structuration theory in a macro-perspective associated with the accumulated changes that occur when implementing a form of systemic innovation whereas CHAT is associated with the use of tools in historically developing interacting activity systems and systemic changes.

[W-2.3] Special Session: Use Case Data Requirements for Product Models to enable Building Energy Simulation

SWIMing Project - Guidelines for publishing building data as linked data

K. McGlinn

ADAPT Centre, Trinity College Dublin, Ireland

ABSTRACT: This talk will present the guidelines developed within the SWIMing project for supporting projects in the process of capturing use cases, identifying data requirements, aligning these with existing standards and ontologies and publishing data as Linked Data to support semantic querying over open, interlinked data.

Semantic data integration for smart cities using linked data

K. Tonev

Institute for Information Management in Engineering, Karlsruhe Institute of Technology, Germany

ABSTRACT: The smart city initiatives aim to contribute to more sustainable cities characterized by integrated technologies and services related to energy efficiency. The energy efficiency technologies and services require active and synergical roles from multiple stakeholders, for instance citizens, energy providers, and policy makers. Those technologies and services generate and consume data from multiple, originally unrelated domains. The presentation will introduce linked data approach to interlink the generated and existing open data to facilitate the data integration. The linked data is developed by following the guideline of SWIMing project. The presentation will also demonstrate the mechanism to query the linked data.

Energy & environmental benefits assessment via modeling & simulation for different building typologies & climates - The RESILIENT project

N. Kaklanis

Information Technologies Institute, Centre of Research & Technology Hellas, Thessaloniki, Greece

ABSTRACT: Inter-connectivity between Buildings, DERs, Grids and other Networks constitutes one of the present major issues regarding energy and environmental aspects, even more at a district level. RESILIENT meets this challenge by Designing, Developing and Providing Assess to energy and environmental benefits through a wide variety of building models (with diverse size, materials, use and occupancy patterns, etc.) and libraries of various component units of different capacities that enable district energy accurate simulations. This presentation will present the most indicative use cases and data requirements that originated by the evaluation and selection of different kinds of energy supply systems taking into account the relationship

among performance of energy supply systems, available technologies and conditions of the considered district, and their mapping with well known external sources (e.g. ifcOWL), following the guidelines of the SWIMing project.

Capturing building data requirements in the NewTREND project

M. Weise
AEC3, Munich, Germany

ABSTRACT: The NewTREND project is developing an integrated design methodology for energy retrofit of buildings addressing all phases of the refurbishment process. This requires consideration of a large set of different data sources, ranging from architectural drawings, structural data, energy models, operational data and district data. This presentation will cover the first steps of the SWIMing guidelines as applied to the modelling of project use cases which require product data along with the initial mappings of these to existing standards.

A comprehensive ontologies-based framework to support the retrofitting design of energy-efficient districts

G. Costa & Á. Sicilia
ARC, La Salle Engineering and Architecture, Ramon Llull University, Barcelona, Spain

G.N. Lilis
Department of Production Engineering and Management, Technical University of Crete, Chania, Greece

D.V. Rovas
Institute for Environmental Design and Engineering, The Bartlett School of Environment, Energy and Resources, University College London, UK

J. Izkara
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ABSTRACT: As part of the Europe 2020 strategy, one of the challenges for the European construction sector is to reduce the energy footprint and CO_2 emissions from new and renovated buildings. This interest is also fostered at a district scale with new technological solutions being developed to achieve more efficient designs. In response to this challenge, a web-based platform for district energy-efficient retrofitting design projects has been proposed in the context of OptEEmAL research project. In order to provide data integration and interoperability between BIM/GIS models and energy simulation tools through this platform, a District Data Model (DDM) has been devised. In this model, fields for urban sustainable regeneration (energy, social, environment, comfort, urban morphology and economic) are related to existing ontological models based on the CityGML and IFC schemas. This paper discusses how the semantic representation from

IFC and CityGML files with different levels of detail can be integrated to obtain consistent description of the district in the proposed district data model.

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ifcOWL for Managing Product Data

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ABSTRACT: Managing product data across the Building Life Cycle remains a challenge due to the heterogeneous and fragmented nature of the data. IfcOWL povides a standard approach for describing building data, like product data, in RDF. This supports the publication of Product data on the web, making it accessible over HTTP. In this presentation some of the different properties of Building Products in IFC will be explored and how these may be applicable to the requirements of a diverse set of use cases, in domains such as energy modelling, retrofitting and intelligent control.

Implications of a BIM-based facility management and operation practice for design-intent models

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ABSTRACT: The aim of this paper is to investigate how beneficial contemporary design-intent BIM deliverables could be to FM&O activities and what should be changed with regard to their structure and content for further development of FM&O-intent BIM hand-over. Deliverables of the detailed design phase of a middle-sized educational building were evaluated against requirements derived from a diverse set of resources and directives. The most crucial qualities for the detailed design BIM hand-over documents to be used in FM&O are general concerns about the overall structure of the models as well as classification, attributes and relations of objects. Flexibility and extensibility of the models is also decisive for suitability of the models for FM&O. A number of deficiencies and insufficiencies with the structure and content of the BIM deliverables of the case project have been disclosed. Findings could provide valuable insights for improving the quality of future BIM hand-over documents.

Pragmatic use of LOD – A modular approach

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ABSTRACT: The concept of Level of Development (LOD) is a simple approach to specifying the requirements for the content of object-oriented models in a Building Information Modelling process. The concept has been implemented in many national and organization-specific variations and, in recent years, several solutions have been proposed to address the challenge of the LOD concept being either too simple to fully describe the requirements for BIM deliverables or too complex to be operational in practice. This study reviews several existing LOD concepts and concludes that addressing the completeness and reliability of deliveries along with use-case-specific information requirements provides a pragmatic approach for a LOD concept. The proposed solution combines LOD requirement definitions with Information Delivery Manual-based use case requirements to match the specific needs identified for a LOD framework. This framework can act as a basis for future LOD solutions to harmonize the conceptual understanding of LOD definitions.

Seamless integration of common data environment access into BIM authoring applications: The BIM integration framework

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ABSTRACT: In today's construction industry collaborative processes have received increasing attention due to new digital methods such as Building Information Modeling (BIM). This method bases on the application of digital 3D building models enriched by semantic information. Since a construction project is a composition of several collaborating processes executed by many project participants, a federated model approach has emerged as the most practical solution. It is widely recognized, that for the implementation of this approach and the related collaborative processes digital platforms are required. The Common Data Environment (CDE) is defined as a common digital project space, which provides well-defined access areas for the project stakeholders combined with clear status definitions and a robust workflow description for sharing and approval processes. Since most of today's software solutions lack direct accessibility and integration, we introduce a framework that allows for seamless integration of CDE access and management functionality into standard BIM authoring and analysis applications.

SimpleBIM: From full ifcOWL graphs to simplified building graphs

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ABSTRACT: Recent research in semantic web technologies for the built environment has resulted in several proposals to further improve information exchange among stakeholders from the domain. Most notable is the production of several OWL ontologies that allow to capture building data in RDF graphs. For example, an ifcOWL ontology allows to capture IFC data in an RDF graph. As the building data is now available in a semantic graph with an explicit formal basis, it can be restructured and simplified so that it more easily matches the different requirements associated with practical use case scenarios. In this paper, we investigate several proposals and technological approaches to simplify ifcOWL building data, thus addressing the needs of specific industrial use cases.

IFC model checking based on mvdXML 1.1

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ABSTRACT: A significant barrier for successful use of BIM is the ability to efficiently and transparently agree on what data should be delivered by the many stakeholders of the supply chain and when. This requires additional agreements and specification work on top of existing standards like IFC. Ideally, these specifications are ready for automatic model checking to ensure the exchange of required BIM data. Based on the IDM/MVD methodology and the mvdXML 1.1 format developed by buildingSMART a web-based requirements management solution called BIM-Q and the mvdXML extension of the XBIM toolkit is discussed that demonstrates how BIM exchange requirements can be configured, managed and used for automatic model checking. All necessary steps are shown using an example from the STREAMER project, namely the Program of Requirements (PoR) and the early design of the room layout for hospitals. Besides presenting preliminary process implementation findings, grounded on data collected from various projects, persisting limitations for managing requirements and in particular for model checking based on mvdXML are discussed. An outlook of potential extensions and improvements of the different tools, mvdXML specification and the whole checking process is presented at the end.

[W-3.2] Standardization of Data Structures and Interoperability

Facilitating the BIM coordinator and empowering the suppliers with automated data compliance checking

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ABSTRACT: In projects with Building Information Modelling (BIM), the collaboration among the various actors is a very intricate and intensive process. The various suppliers and engineers provide their input in Industry Foundation Classes (IFC), which in turn is used for design coordination. However, the IFCs have to undergo an intermediate checking process to ensure compliance with various client-set and technical requirements. The paper focuses on the potential of (semi-)automatic IFC compliance checks and discusses a relevant recent initiative in the Netherlands, according to which several IFC compliance criteria were agreed among 14 contractors. This study aims to unravel the changes induced by this development not only as to the IFC compliance checks, but also as to potentially balancing the roles between the BIM coordinator and the suppliers.

DRUMBEAT platform – A web of building data implementation with backlinking

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ABSTRACT: The purpose of Web of Building Data (WoBD) is to support the sharing of building data among the diverse stakeholders over a construction lifecycle. DRUMBEAT platform is an open-source, proof-of-concept implementation of WoBD. Many practical issues have been addressed during its development, concerning the organization and description of published data, URI design for objects, publication and management of links, and the users' access to links. The paper describes in detail the architecture used to publish multiple manifestations of the same model: versions, views, and partial exports. Different ways to publish links are supported but the object access interface, and a special backlinking protocol ensure that links can always be included in object descriptions without complicating the interface with explicit link access methods.

A versatile and extensible solution to the integration of BIM and energy simulation

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ABSTRACT: Energy simulation represents now a critical step of the building design process, but the integration between BIM authoring tools and simulation tools is still a source of issues and problems. Most simulation engines still require the definition of a specific input model, thus making impossible to directly use the BIM model information to configure and run simulations. The lack of agreements on standards for simulation input files makes software integration between BIM and simulation tools insufficient. With this aim, this paper presents a software framework for BIM-Simulation integration aiming at both effectiveness and extensibility. An intermediary conversion step for the generation of simulation-specific yet tool-agnostic building design model (here called Building Simulation Model) allows to tackle the problem through a two-step generation scheme (BIM-to-BSM and BSM-to-simulation tool) leveraging the principles of the Model-Driven Engineering methodology. Targeted engines have been EnergyPlus and COMETH (the French regulatory thermal engine) in the scope of an on-going European project (FP7 HOLISTEEC).

IfcTunnel - A proposal for a multi-scale extension of the IFC data model for shield tunnels under consideration of downward compatibility aspects

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ABSTRACT: The Industry Foundation Classes (IFC) provide a comprehensive, standardized and neutral data format to enable the exchange of digital building models. However, the current version of IFC lacks the ability to comprehensively describe infrastructure facilities such as roads, bridges, railways or tunnels in detail. This paper shows the general concept for a space oriented approach to describe shield tunnel models by extending the IFC and the integration of multiple levels of detail into the IFC standard in the scope of considering downward compatibility aspects. The proposal therefore introduces three consecutive levels of extension. Thus, we enable any IFC-viewer supporting IFC4 to visualize the exemplary instance files created in the first level by using proxy objects. The higher levels extend the standard IFC4 schema by tunnel-specific semantic elements. They also integrate an approach aiming at the representation of multi-scale models by integrating multiple levels-of-detail.

Delivering of COBie data - focus on curtain walls and building envelopes

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ABSTRACT: COBie is a standard data framework whose main purpose is to transmit useful, reliable and usable information collected throughout the whole building process and to be consumed in order to properly maintain the facility. Focusing on Facility Management information exchanges and considering the UK BIM policies and requirements, this paper shows the results obtained applying COBie to complex products such as curtain walls. Two Information Delivery Manuals (IDMs) were also developed, in order to provide a commonly known and standardized framework, which can regulate the COBie-based information exchanges. Future developments of this study could concern the application of the developed IDMs to different case studies in order to overtake that specificity characterizing each single project and verify the validity of the proposal.

[W-3.3] 5D/nD Modelling, Simulation and Augmented Reality

Software library for spatial-temporal modeling and reasoning

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ABSTRACT: Visual 4D modeling and planning technologies have recently begun to play a crucial role in the realization of complex construction projects and programs. They enable to improve communication and coordination among stakeholders and, thereby, to reduce risks and waste during the project implementation by means of simulation and visualization of project activities in space dimensions and across time. Modern project modeling systems possess some underlying functions for such purposes, but are still limited in reasoning capabilities necessary for automated validation of the project schedules in terms of their feasibility and absence of spatial-temporal conflicts. Basically, these are collisions and interferences of construction objects, missing collision-free paths to deliver the objects to destination positions in planned time, and invalid schedules leading to the objects hanging without any reliance. A software library providing advanced capabilities for spatial-temporal modeling and reasoning is presented in the paper. The library called Constructivity4D supports a representation of all of the core concepts in the scene modeling and possesses a wide range of operators and validation functions. The modeled dynamic scenes are suggested to be hierarchically organized with the objects obeying particular behavioral patterns. Being compliant with popular qualitative reasoning formalisms and relation algebras, the supported operators and functions can be combined to identify non-trivial spatial-temporal conflicts originated from the construction project validation problems. The paper discusses the design considerations of the library, its functionality, interfaces. Particular attention is also paid to applied computational methods and implementation details.

BIM registration methods for mobile augmented reality-based inspection

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ABSTRACT: On-site construction inspection for progress monitoring is a manual, time consuming and labour intensive process consumed by exhaustive manual extraction of data from drawings and databases. Efforts have been made to facilitate the inspection process by using emerging technologies such as Augmented Reality (AR). AR based systems can simplify and reduce the time of inspection by providing the inspector with instantaneous access to the information stored in the Building Information Modelling (BIM). However, precise alignment between the BIM model and the real world scene is still a challenge. For estimating the position and orientation of the user, methods have been proposed that either use markers or confine the user to a specific location, or use Global Positioning System (GPS) which cannot operate efficiently in an indoor environment. This paper presents an evaluation of different methods that could potentially be used for a marker-less BIM registration in AR. We implemented and tested line, edge, and contour detection algorithms using images, data from LSD and ORB Simultaneous Localisation and Mapping (SLAM) methods and 3D and positioning data from Kinect sensor and Google Project Tango. The results indicate that sparse 3D data is the input dataset that leads to the most robust results when combined with XYZ method.

Generation of serious games environments from BIM for a virtual reality crisis-management system

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ABSTRACT: The presentation of building information as game content enjoys an increasing interest from various fields throughout the civil-engineering sector. The application of serious games or virtual reality visualisations for clients are just two examples.

With this work, we present a concept for a translation from building models to a game environment. For this purpose, city and building models are merged and the resulting geometries retrieved. The geometry then is used to define a map in the game environment. To achieve realistic results, an ontology maps defined building materials to textures existing in the game content.

The demonstrator can be modified to work with other game engines and offers an easy and forward way of automatically generating a gaming map from building information models.

Simulation model generation combining IFC and CityGML data

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ABSTRACT: The energy efficiency requirements at district scale revealed the need for detailed building energy simulations, with which the overall district energy demand can be estimated with an acceptable degree of accuracy. In order to meet this need, an automated simulation model generation process is introduced at the context of the European project OptEEmAL, which includes: a query stage where data are gathered from IFC, CityGML files, and a transformation stage where a single IDF file is generated for a building in a district environment, suitable for EnergyPlus simulations. The queried data are assumed to conform to certain correctness, completeness and consistency conditions across district and building scales. As a demonstration example, a simulation model is generated for a specific building. Future improvements of this work are discussed related to the integration of all the data requirements of the proposed process, in a District Data Model under an ontological framework.

Information requirement definition for BIM: A life cycle perspective

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ABSTRACT: Adopting the Building Information Modeling (BIM) methodology assists in fulfilling stringent cost and time objectives in architecture, engineering, construction and facility management industry. To enable further adoption of the technology a life cycle oriented approach needs to be pursued. In this work, information requirements for the whole life cycle of a building are defined and the capabilities of existing BIM models to assist the identified information areas are evaluated. The results indicate missing support on information about equipment efficiency curves, description of decentralized energy conversion devices, occupant behavior, thermal and visual indoor comfort and information on the preservation status. Furthermore, to support future BIM model development, the novel information management method GASCEeIiL is presented which allows tracing the use of a piece of information by each stakeholder along the information life cycle.

A flexible and scalable approach to building monitoring and diagnostics

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ABSTRACT: This paper presents a flexible and easily adaptable building monitoring and diagnostics approach that combines an IoT-influenced hardware setup with a web based application design. Small data concentrators and logger modules implemented on Arduino YUN development boards are used to collect data in a distributed way over the Internet. This data could be synced with a data repository and analyzed in a modular web application. The typically used hardware and a general system setup is presented in detailed, followed by a description of developed modules used in the web based diagnostics application. Finally, we demonstrate the flexibility of the approach in use cases of real project related implementations.

Acquisition and processing of input data for building certification: An approach to increase the reproducibility of energy certificates

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ABSTRACT: One of the key aspects of the European Building Performance Directives (EPBD) of 2002 and 2010 was the definition of the obligation to issue building energy certificates for the majority of existing and all to-be-constructed buildings. EU-member states were required to reflect this obligation into their national legal frameworks and derivative guidelines. Thereby, the primary intentions were to: i. define calculation rules for certain key energy and thermal performance indicators (KPI) for buildings (in Austria a normative monthly method was formulated to derive buildings' heating demand (HWB) and related indicators); ii. facilitate an easy-to-understand comparison between different buildings for tenants and owners via ranking of such KPIs (illustrated as energy-performance-class figures); iii. provide clear and well-defined evaluation schemes for minimum requirements of the thermal quality of buildings and for public subsidy schemes (for instance grants for realizing efficient retrofit strategies). However, since the legal implementation of energy certificates in Austria several problems have emerged: First, the calculation guidelines and corresponding standards changed several times, including a change in the heating-demand threshold values underlying different KPI classes. This renders comparison between energy certificates issued in different years difficult. Furthermore, guidelines entail a number of vague formulations and miss some relevant definitions. Thus, Issuers of energy certificates "enjoy" a high degree of interpretative freedom, as the resulting energy certificates do not necessarily reveal the underlying assumptions. This obviously renders the targeted comparability of buildings rather difficult. Moreover, the expected quality assurance regarding thermal building performance levels cannot be satisfactorily achieved given such uncertainties. This contribution reports on recent efforts and progress of an ongoing research project (EDEN), which addresses the above issues. The project aims to define rigorous procedures for comprehensive documentation of input data used in energy certificates. The primary objective is to achieve, thus, more transparent and reproducible energy certificates. The paper documents the major steps involved in the implementation of the project as follows: i. Identification of uncertainties concerning the data derived from buildings' geometry and topological circumstances (e.g., neighboring buildings, surrounding obstructions); ii. Identification of uncertainties concerning physical attributes of the buildings' envelope as well as other input assumptions concerning building usage and operation; iii. Extensive test series (and comparative outcome analyses) with professional and semi-professional participants, who were requested to independently perform energy certificate calculations for the same set of buildings; iv. Sensitivity analysis based on comprehensive test series to identify and document input assumptions with high and low impact on the values of the final KPIs.

Utilization of GIS data for urban-scale energy inquiries: A sampling approach

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ABSTRACT: Over the past years, new energy supply and management paradigms, such as distributed power and heat generation, have highlighted the significance of urban-scale energy assessments. The present contribution briefly presents an ongoing research effort towards development of a bottom-up simulation supported urban energy model for the hourly estimation of heating demand in the city of Vienna, Austria. The presented research project adopts a sampling approach towards high-resolution urban energy modeling and employs a well-known data mining method, Multivariate Cluster Analysis, to select representative buildings based on energy-related building characteristics. The selected sample is subjected to detailed performance assessments, the results of which are up-scaled to obtain the overall energy profile of the neighborhood. Focusing on the data-related challenges of urban energy modeling, the paper describes the informational requirements for the adopted approach, and elaborates on the underlying data structure and the data processing methods developed to overcome the encountered challenges.

Semantic interoperability for holonic energy optimization of connected smart homes and distributed energy resources

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ABSTRACT: Recent work has attempted to deliver optimized distributed energy resource management, including the use of demand side management through smart homes. This aims to reduce power transmission losses, increase the generation share of renewable energy sources and create new markets through peak shaving and flexibility markets. Further, this leverages the development of product models at the device, building, and network level within the operational lifecycle stage, beyond the conventional role of BIM between design and construction stages. However, the management of heterogeneous software entities, incompatible data models and domain perspectives, across systems of systems of significant complexity, represent critical barriers to sustainable urban energy solutions and leads to a highly challenging problem space. The presented work describes a systemic approach based on the concept of holonic systems, which exemplify the role of autonomy, belonging, connectivity, diversity and emergence across entities. This reduces the decision complexity of the problem and facilitates the implementation of optimized solutions in real power systems in a scalable and robust manner. Further, the concept of a flexibility market is introduced, whereby smart appliance owners are able to sell load curtailment and deferment to a local aggregator, which interfaces between a small number of homes and a distribution system operator. Artificial intelligence is present at each of the entities in order to express constraints, trade energy and flexibility, and optimize the network management decisions within that entity's scope. Specifically, this paper focuses on enabling interoperability between system entities such as smart homes, local load aggregators, and last mile network operators. This interoperability is achieved through ontological modelling of the domain, based on

the existing standards of CIM, OpenADR, and energy@home. The produced ontology utilizes description logic to formalize the concepts, relationships and properties of the domain. A use case is presented of applying the ontology within a multi-agent system, which enables the optimization of day-ahead markets, load balancing, and stochastic renewable generation, and closely aligns with the holonic approach to deliver a holonic multi-agent system. The use case assumes a scenario in line with the emerging energy landscape of a district of domestic prosumers, with a high penetration of micro-generation, energy storage and electric vehicles. Initial results demonstrate interoperability between heterogeneous agents through ontological modelling based on an integration and extension of existing standards, which acts as a proof of concept for the approach.

Energy matching and trading within green building neighborhoods based on stochastic approach considering uncertainty

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ABSTRACT: Non-dispatchable generation resources can be installed as small scale generation units that environmentally and economically could be competitive with conventional power generation. To reach this aim, a hybrid system including several types of non-dispatchable generation, dispatchable generation resources incorporated with energy storage assets can provide a sustainable necessary electricity/thermal/water pumping power during a green building's daily operation. The objective of this paper is to model a dynamic system for a single green building considering several generation resources for feeding of some electrical and thermal specific load demands needed in a sustainable way. The proposed model based on a dynamic decision process is implemented to manage and monitor a complex hybrid system encompassing several generation resources and load demands by considering various uncertainties. In order to handle the uncertainties, scenario generation approach is utilized. The model is developed in The General Algebraic Modeling System (GAMS) environment in order to determine the optimal solution with scheduling resources by setting up the optimal power set-points for them. The optimization model is applied to a case study where the produced power is also used to supply water pumping for domestic consumption. Furthermore, other capabilities such as extendibility, reliability, and flexibility are examined about the proposed approach.

Using a mobile application to assess building accessibility in smart cities

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ABSTRACT: Mobile applications and well-implemented technology can help governments increase the efficiency and effectiveness of information analysis and exchange. This paper presents a case study on the implementation of a mobile application to record accessibility information in the commercial buildings of Terrassa. To record and analyze the accessibility of the commercial buildings a taxonomy including general information and accessibility data was created. The analysis results confirmed the only 1% of the recorded commercial buildings fulfilled all accessible parameters. The main problems were in the access steps or ramps and also in the interior furniture. This data can then be implemented in other applications to be used by people with disabilities. Results also demonstrate that mobile and well-implemented technology can help governments save money and be more efficient. The use of this application simplified and reduced the time needed to record accessibility information while the standardized information helped them obtaining consistent data.

Prediction of traffic characteristics in smart cities based on deep learning mechanisms

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ABSTRACT: Cities worldwide face rapid growth and huge transportation challenges. By monitoring traffic performance and patterns over time, cities can ensure they operate at full capacity. The prediction of traffic characteristics such as traffic flow and travel time stands for an important feature in Advanced Traveler Information Systems (ATIS). In the era of data availability, the dissemination of accurate traffic information to travelers could have a huge impact on their trip choices and thus in systems' performance. The scope of this paper is traffic modeling and prediction based on artificial neural networks namely deep learning mechanisms. The proposed framework enables the estimation of traffic characteristics between a predefined set of Origin-Destinations (O-D) locations, by taking into account available disaggregate traffic data. The proposed application is tested on a realistic road system, namely that of Cyprus. The aim of the study is to provide reliable travel information to users in order to improve significantly the use of the existing transportation networks.

Monitoring drivers' perception of risk within a smart city environment

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ABSTRACT: An important aspect of a Smart City framework is its transportation system and the existence of an efficient traffic management system. Efficiency in a traffic management system is characterized –among others- by the network's level of road safety. This paper studies a road safety oriented contribution to Smart Cities by quantifying driver's risk perception in relation to vehicle to vehicle interaction. The objective of this study is to propose an automatic driving behavior monitoring mechanism for an urban environment, which identifies near-crash phenomena by capturing rear-end potentials at a microscopic level, while furthermore to induce driving behavioral aspects, valuable for understanding drivers' perception on rear-end collision risk. The disaggregated data utilized in the study were obtained by inductive loop detectors in the urban network of Nicosia, Cyprus. The data gathered from the loop detectors was post-processed and a risk index based on rear-end potential was derived, which was used to classify drivers into four risk levels describing whether given their individual characteristics, drivers would engage in a potential rear-end collision. The proposed risk index results showed that 65% of the car-following events were considered as potentially unsafe. It was also shown that when engaged in car-following situations with Heavy Goods Vehicles-HGVs mean speeds of the following vehicles are lower. The proposed methodology enables the identification of potential near-crash events in an urban environment in real time. The information and knowledge collected by real-time data processing are key aspects of an efficient traffic management system and consequently a Smart City as a whole.

[R-2.1] Special Session: Energy Efficient Neighborhoods (ee-Neighborhoods, I)

A collaborative environment for energy-efficient buildings within the context of a neighborhood

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ABSTRACT: This positioning paper explains our approach to creating a collaborative environment to assist multi-disciplinary teams in designing better energy efficient buildings with consideration of their neighborhoods. A scenario-driven approach was used here to define the energy related activities, the actors involved and the tools required to perform these activities. More specifically, the paper has a focus on energy matching activities throughout the whole product's life cycle. The paper will go on to suggest an appropriate User Interface to allow multi-disciplinary teams to collectively explore various solutions as they visualize BIM models and data models in a 3D interactive workspace to achieve optimum energy efficient buildings at neighborhood level.

KPI framework for energy efficient buildings and neighbourhoods

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ABSTRACT: Design4Energy (D4E) project aims at developing a design methodology that is able to create energy-efficient buildings within the context of their neighbourhoods. An indicator framework for managing project strategic objectives has been set up, with Key Performance Indicators (KPIs) to assess buildings' performance in use. Selected performance, economic and environmental indicators, enriched with neighbourhood energy efficiency indicators are defined with assessment criteria and metrics. The D4E usage scenarios are formalised following Information Delivery Manual (IDM) methodology: capturing the KPI target setting and their assessment processes in project definition and early design phases in Business Process Modelling Notation (BPMN) process maps, and specifying the content of each of those exchanges as Exchange Requirements (ER). This paper will demonstrate how D4E design methodology with a set of KPIs can be used to improve building design process, including neighbourhood context.

Multiscale building modelling and energy simulation support tools

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ABSTRACT: Building and district modelling (BIM, CityGML…) are key technologies for the deployment of energy efficiency strategies at building and district level, from the initial stages of planning and design to the

operation and maintenance ones. These technologies allow satisfying the interoperability requirements that facilitate the cooperation among the multiple stakeholders and provide the framework to develop more intelligent tools. This paper introduces five complementary European R&D projects in which TECNALIA is collaborating, very good examples of innovative systems based on these concepts. MOEEBIUS enhances passive and active building elements modelling approaches enabling improved building energy performance simulations. HOLISTEEC focuses on building multi-physical simulations considering the neighborhood context. FASUDIR exploits the high potential of GIS tools for urban sustainability analysis and accurate building energy performance evaluation. EFFESUS integrates district and building scales in historic districts. OPTEEMAL develops a platform at district level, based on an IPD approach.

From District Information Model (DIM) to Energy Analysis Model (EAM) via interoperability

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ABSTRACT: Energy saving for existing buildings is considered one of the most important issues in the last years for the development of a smart city. The DIMMER (District Information Modeling and Measuring for Energy Reduction) project starts from the development of a 3D parametric model, able to collect heterogeneous data at different scale. It aims at improve the energy consumption optimization, monitoring real-time data and simulating all energy flows.

Starting from Building Information Models (BIMs), based on the development of DIM models, it is possible generate an Energy Analysis Models (EAM) able to simulate building energy usage compared with indoor temperature coming from real time temperature sensor.

Finally, the DIMMER project is focused on management, modelling and visualization of different data that describes the district, connecting different data-sources with different level of information. In order to achieve these goals, interoperability is considered a crucial step for sharing data between different environments, across various software

Energy modelling of existing facilities

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ABSTRACT: The emphasis of both building and energy modelling has often been on new-build with existing buildings having minimal attention due to incomplete information or the lack of any immediate prospect of validation. This paper is about discussing a new approach of energy modelling for existing facilities using UK

Rotherham Hospital (TRF, 2013) [1] as an existing facility with no BIM models and few available records to be explored during the EU STREAMER, 2013 [2] project.

This paper will examine in detail the methods used to capture sufficient information relating to the existing building stock, from written text, poorly reproduced drawings and on-site monitoring. The paper will also explain the tools used to capture that information including textual analysis and mark-up, mapping of semi-structured information to IFC, non-interactive simulation and the deployment of gaming strategies to identify optimum strategies. Multiple strategies were tested against two departments of similar size and construction but with differing operational needs.

A collaborative platform integrating multi-physical and neighborhood-aware building performance analysis driven by the optimized HOLISTEEC building design methodology

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ABSTRACT: The paper presents the technical developments made in the course of the HOLISTEEC project. HOLISTEEC is an EU FP7 project whose objective is to first, formalize a new optimized building design methodology, and second, to develop the software platform and modules that implement that design methodology. The paper focuses on the developments made on that software infrastructure that shall at the end of the project provide a BIM-based collaborative platform supporting the optimization of the building design in terms of performances and also enhancing the building design process itself. As an important driver for that optimized methodology the project sets a focus on the consideration of interactions between the building and its neighborhood as well as multi-physical aspects including energy, acoustics, lighting and environmental impact.

[R-2.2] BIM Implementation and Deployment (I) - Principles and Case Studies

Is BIM-based product documentation based on applicable principles? – Practical use in Norway and Portugal

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ABSTRACT: This study explored implementation solutions for BIM-based product documentation in Norway and Portugal, two countries with different BIM maturity. In this respect, significant differences in BIM-based product documentations are expected. The work was based on a selection of small, medium and large companies (type of company: architects, engineers, contractor, owner and facility management (FM), both private and public sector) used as case study of the two countries. Integrated Design and Delivery Solution (IDDS) is the framework for structuring findings and analysis. The study confirmed that BIM-based product documentation is limited compared to traditional document-based solution on paper and/or PDF documents. There were no significant differences between Norway and Portugal, but the expectations were higher in Norway. However, companies with high implementation of digital solutions understood BIM-based product documentation in a different and more integrated way than as just an extension of properties in BIM-based objects. The impact of this contributes to increase understating of product data as extension of BIM or need for development of Asset Information Modelling (AIM) -based solutions.

Necessary conditions for the accountable inclusion of dynamic representations of inhabitants in building information models

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ABSTRACT: To cater for the informational requirements of building assessment applications, building information models need to include representations of inhabitants. Thereby, the representation of people as passive and static entities is unlikely to yield reliable building performance assessment and building operation planning. Rather, adequate representations of building inhabitants should account for user-initiated actions (e.g., interactions with buildings indoor environmental control devices and systems). To address these requirements, many recent model development efforts have explored the potential of sophisticated mathematical formalisms. However, the resulting occupancy-related behavioural models have rarely gone through a rigorous evaluation process. The present contribution is indeed motivated primarily by the lack of general procedures and guidelines for the evaluation of proposed user-related behavioural models. Specifically, we formulate a number of conditions that are necessary for systematic and dependable enrichment of building information models with representations of buildings' inhabitants. Toward this end, we discuss both general model evaluation requirements as well as specific circumstances pertaining to models of building inhabitants. Moreover, we present, as a case in point, a model evaluation study involving

a number of recently proposed window operation models. Thereby, our main objective is to promote a rigorous process toward quality assurance while considering and integrating behavioural representations in building information models that are meant to meet sound scientific requirements as well as professional accountability criteria.

Methodology for tracking BIM benefits on project level

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ABSTRACT: A BIM Benefit Matrix is introduced as a tool to clarify advantages and to identify benefits from BIM. Methodology is based on indicators, related to a BIM functionalities and n characteristics of BIM process. The methodology was developed and tested with four follow-up indicators, one of them for design performance, during the design of a large infrastructure development project in Finland. The client made remarkable investment in implementing BIM and was interested to show the return of the investment. Objective of the study was to measure and make visible the benefits from using BIM in the studied project, and to add understanding about potential benefits and how they can be achieved. The findings suggest that BIM advantages are relatively clear and easy to formulate, but measuring benefits is challenging and time consuming effort. This paper clarifies the discussion of benefits with a framework that separates BIM advantages from measured benefits.

BIM for the integration of building maintenance management: A case study of a university campus

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ABSTRACT: In the Operation and Maintenance (O&M) phase of an existing building, frequently, different systems are available to manage data about building maintenance. However, current practices do not integrate these systems and still manually process dispersed and unformatted data. The purpose of this paper is to investigate the potential benefits of the integration of data of Building Maintenance Management (BMM) in Building Information Modelling (BIM) in existing buildings. To do so, a questionnaire to evaluate the Facility Management practices in buildings is presented. This questionnaire is then used in the case study of Terrassa Campus at Universitat Politècnica de Catalunya (UPC). Conclusion demonstrated that the integration of BMM in BIM can enable support for maintenance decisions and increase the efficiency of the maintenance process.

A comparative case study of coordination mechanisms in design and build BIM-based projects in the Netherlands

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ABSTRACT: BIM implementation can affect the project coordination mechanisms in unexpected ways, even in widely-applied project procurement structures. Apart from the chosen procurement approach, the BIM technology and the distribution of roles in the project team influence and shape the project coordination. This paper aims to explore the emerging coordination structures and processes from BIM implementation in design-build procurement. An exploratory comparative case study has been undertaken. The findings included two main coordination mechanisms: a centralized and decentralized structure and a hierarchical versus participative decision-making processes. These two patterns subsequently open a debate about the relationship between BIM implementation and business models in AEC and particularly the emergence of specialized all-around BIM firms versus BIM-knowledgeable engineering firms.

Construction Information Framework – The role of classification systems

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ABSTRACT: This paper focuses on understanding the role of Construction Information Classification Systems (CICS). Information Classification Systems (ICS) that range several economic activities including construction are also explored in order to find touch points and define future trends. This starts with an overview of classification systems, framed with ISO 12006-2:2015. Two different realities, Norway and Portugal, were studied following ISO framework, providing a vision of the developments and applicability of both types of classification systems. Needs for further development have been discussed in a relation to the new possibilities of BIM. The outcome of this study is a list of proposals for further developments. Classification systems represent information. Information coherency is fundamental towards the objectives of efficiency on the industry. The use of BIM can enforce the development of a new generation of CICS.

A semantic web approach to efficient building product data procurement

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ABSTRACT: Multiplicity of views and lack of a common ontological understanding of a building and its components among stakeholders involved in the building delivery and operation processes, result in an information gap between the requirements of various tasks and applications and the available building product representations. On the other hand, due to the extent and the dispersion of the available data, extraction of useful information in the right format has become a cumbersome and error-prone process. BAU_Web is an ongoing research effort aimed at exploring the potential of Semantic Web Technologies towards facilitating the utilization of web-based building product data. The present contribution describes the data-related challenges of the AEC (Architecture-Engineering-Construction) domain using the example of a loadbearing wall component, introduces the framework suggested by the BAU-Web project to address these challenges, and reports on the current state of the project.

BIM adoption for on-site reinforcement works – A work system view

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ABSTRACT: Building Information Modeling (BIM) technology can support the Architecture, Engineering and Construction (AEC) industry throughout all stages of project delivery. Nowadays, the quality and maturity of BIM models allow for their use beyond design. However, many firms struggle adopting BIM for supporting the construction phase of a project. The organizational challenges that BIM adoption entails are reported as one of the main obstacles for BIM aiding construction. In this article, we explore a successful case of BIM adoption by a Norwegian contractor. The industrial setting of the study consists of a major construction project where sophisticated models of the reinforcement were used to support on-site works. The theoretical approach used to structure the findings is the Work System Theory. The wide scope of this theory enables to complement prior knowledge about the adoption process. Our work shows that using BIM can further simplify the reinforced concrete supply chain.

Classification of detection states in construction progress monitoring

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ABSTRACT: The research conducted in this publication focusses on automated progress monitoring. The recording of the current as-built state of a construction site is achieved by photogrammetric methods (e.g. UAVs) and compared to an as-planned (4D) BIM model. To visualize the detected elements and evaluate their respective detection rate, a schema for the classification of each individual element is presented. It compares the as-built ground truth with the actually detected elements and thus facilitates a quick and easy interpretation of the current construction state. Temporal data from construction schedules is added to further complete the provided information through visualization. Additionally, the classification helps to identify possible lacks of detection algorithms. New parameters for detection algorithms can be applied and the results are immediately visible with an easily understandable color scheme.

Introducing process mining for AECFM: Three experimental case studies

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ABSTRACT: The research field of process mining is relatively new and not been applied often in the Architecture, Engineering, Construction and Facility Management industry (AECFM). Process mining uses databases of existing IT systems to gain major insights in processes. Currently the AECFM industry increasingly adapts IT systems within all phases of the process. This creates the possibility to use process mining techniques to gain insight in the processes of construction projects. This paper introduces process mining by presenting three experimental case studies which are conducted in order to study the applicability of process mining in the AECFM. Studies are done in the design-, build- and operational phase. The study has proven to provide useful insight and potential applications. The research method that was used does not allow generalisation of the conclusions for the whole industry. Additional research is needed to study the potential of integrating different data sources from several phases.

[R-3.1] Special Session: Energy Efficient Neighborhoods (ee-Neighborhoods, II)

Collaboration requirements and interoperability fundamentals in BIM based multi-disciplinary building design processes

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ABSTRACT: This paper is reflecting the concepts of the buildingSMART standards IDM (Information Delivery Manual) and MVD (Model View Definition) based on specific energy efficient BIM-information levels within design processes. Taking into account the needs of different LOD (Level of Development) stages, the impact of LoD (Level of Detail), and LoA (Level of Approximation) an extended definition of LoI (Level of Information) is being proposed. The paper also reflects the potential to derive well defined purposes for BIM-information exchange on the basis of so called BIM-Functions. The research that this paper is based on was conducted within the eeEmbedded project. eeEmbedded is funded by the European Commission within the Seventh Framework Programme.

Technical challenges and approaches to transfer building information models to building energy

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ABSTRACT: The complex data exchange between architectural design and building energy simulation constitutes the main challenge in the use of energy performance analyses in the early design stage. The enhancement of BIM model data with additional specific energy-related information and the subsequent mapping to the input of an energy analysis or simulation tool is yet an open issue. This paper examines three approaches for the data transfer from 3D CAD applications to building performance simulations using BIM as central data repository and points out their current and envisaged use in practice. The first approach addresses design scenarios. It focuses on the supporting tools needed to achieve interoperability given a

wide-spread commercial BIM model (Autodesk Revit) and a dedicated pre-processing tool (DesignBuilder) for EnergyPlus. The second approach is similar but addresses retrofitting scenarios. In both workflows gbXML is used as the transformation format. In the third approach a standard BIM model, IFC is used as basis for the transfer process for any relevant lifecycle phase.

Task-specific linking for generating an eeBIM model based on an ontology framework

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ABSTRACT: In the last decades scarcity of resources and global warming have led to a more and more efficient building design and usage aimed to reduce energy consumption and CO_2 emission. For increasing energy efficiency of buildings over the whole life cycle analyzing and simulation tools became an important technology. For such engineering analyses the use of one domain model is mostly not enough. Often, additional information coming from other domains are required and have to be combined creating an overall information basis and providing the input information for the envisaged external simulation tools and their related simulation models. These link models are task specific and in the most cases the link models differ only slightly regarding the usage of different simulation software. So, embedding link models and relating quality checks in a context and making them available for a restricted group or even for unrestricted use could lead to more reliability.

In this paper an approach will be presented describing a generic framework for efficiently using of link models and quality checks based on a certain context definition. As description method for this framework an ontology approach is considered linking and consolidating the different input sources and creating the base for the quality checks.

Visual support for multi-criteria decision making

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ABSTRACT: Successful building project needs sufficient feedback for the decision making. Currently only a few alternative solutions are analyzed and decision making is not able to support multi-discipline collaboration or multi-criteria view. By introducing the new Key Point methodology and visual KPA tool for decision making the different sustainability aspects can be effectively analyzed and optimized in a totally new way.

An IT-based holistic methodology for analyzing and managing building life cycle risk

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ABSTRACT: By nature every building project is affected by uncertainties that can result at some point in the future in building performance deviations. In order to avoid or at least minimize that unwanted effect, uncertainty should be taken into consideration as early as possible, and in particular since the design phase of a building. With the aim of analyzing and keeping a certain control over uncertainty several techniques and standards have emerged in the field of risk management. Unfortunately the AEC industry still makes poor use of such techniques and risk analysis is still often done manually and sporadically. Moreover, often only one specific category of uncertainty is analyzed, namely cost risk. Nevertheless, even if cost is one of the most important decision criterions, risk can have effect on all building performance aspects. In order to close those gaps this research proposes an approach that relies on IT-methods for systematizing as well as automating as much as possible the analysis and management of risk in the building life cycle. The overall aim is then to provide building project stakeholders with a holistic view of risk as basis for decision making.

Open eeBIM platform for energy-efficient building design

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ABSTRACT: The application of BIM as new working methodology in AEC has many facets ranging from team collaboration tasks to the support of individual engineering work and enhanced tool interoperability. Great progress has been made in the last decade with regard to the BIM-based support for design communication, data exchange and data sharing but the use of BIM for creative design work performed with the help of specialized engineering applications is still limited to partial solutions with considerable interoperability constraints. The idea of an open, configurable and vendor-independent BIM-based design platform acting as a virtual lab for design practitioners is thus yet to be realized. In this paper we describe the concept and a first reference implementation of such a platform, which was initially developed by the TU Dresden for the domain of energy-efficient building design, and discuss options for possible further development and use of the platform in research and practice. Drawing upon results from the EU projects HESMOS and ISES the paper presents the current achievements accomplished in the frames of the on-going open eeBIM initiative supported by the EU projects eeEmbedded, Streamer, HOLISTEEC and Design4Energy.

A novel approach to building performance optimization via iterative operations on attribute clusters of designs options

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ABSTRACT: The present paper explores the potential of a novel approach toward iterative global optimization of locally optimized attribute clusters of building design solutions. Thereby, clusters of design space attributes that are comprehensible to typical building designers as a compound yet coherent aspects of a design are made subject to multiple passes of local simulation-assisted optimizations. Hence, instead of allocating an individual dimension to each and every variable of a complex design within the context of a single-pass global optimization campaign, multiple iterative optimization steps target coherent clusters of such attributes and pursue those until the overall design meets the expected performance (or until further performance improvement is not forthcoming). The implementation of the proposed approach employs a number of existing – and freely accessible – computational applications, including an optimization software coupled to an energy simulation tool. We illustrate and document the performance of the current implementation of the proposed approach via an optimization case study. Thereby, different system operation options (i.e., sequential versus random cycling between attribute clusters) are demonstrated.

BIM-based building design platform - Local environmental effects on building energy performances

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ABSTRACT: For complex building projects, energy engineers, economists and other domain experts are usually integrated in the design team, to take part in the decision-making process starting from the beginning of the project. Within the current design practices, the iterative design process is difficult to implement, mainly because of the data exchange between the designers and the evaluators is far from optimized thus causing unacceptable delays. We present a BIM-based, on-the-cloud, collaborative building design software platform. This platform will account for all physical phenomena at the building level, while also taking into account external, neighborhood level influences. Within this platform, the paper presents the physical models developed to take into account local environmental effects on building energy performances. Several models are presented and applied to two building types (residential and office building). The results allow drawing some impact quantification of these new parameters in building energy consumption. The paper exposes the application of this platform as a tool to derive optimal building design under different constraints and   gives perspectives for further works and developments.

Using BIM to support simulation of compliant building evacuation

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ABSTRACT: Buildings must have a means of evacuating their occupants at times of emergency such as in the event of a fire. Such a provision typically needs to conform to applicable regulatory requirements. For simple buildings, this is achieved by incorporating a set of prescriptive requirements into the design. For more complex buildings, engineering analysis and simulation using advanced computational tools are often necessary to demonstrate conformance. This analysis and simulation process can be laborious if the required geometric and occupant data must be manually gathered from paper-based design information and relevant regulatory publications. BIM can provide an effective sharing of building information for the simulation stage and the output from the simulation can be used for compliance audit. In this paper, we develop a process of sharing BIM data with a probabilistic network evacuation simulation tool and use the output from the tool to inform a computer-aided compliance audit framework.

Intelligent emergency exit signage system framework for real-time emergency evacuation guidance

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ABSTRACT: Light-based single-function emergency exit signs may lead occupants to a fire-blocked route or a crowded exit resulting in a delayed evacuation and even more serious situation during an emergency evacuation. This paper will propose a real-time emergency evacuation sign guidance system which guides occupants to safe and fast evacuation routes considering fire source location and development trends, and human traffic flow trends in real time. The proposed system includes a fire detection sensor network system monitoring fire source and propagation, an occupant sensor network system evaluating the existing occupant traffic flow, and intelligent exit sign systems showing fire-free and crowd-free route directions. All fire detection sensor units communicate with each other to broadcast the danger location information. The occupant sensor network system detects the traffic flow coming in and going out for each direction, and detects and predicts crowd areas based on the traffic flow trends. The intelligent exit sign systems generate an evacuation strategy in response to the signals from the fire detection sensor network and occupant sensor network, and show the recommended directions to evacuate and the directions not suitable to evacuate. If crowded situation occurs, the exit sign systems also will show the directions to the fastest evacuation routes. The proposed system will generate first-hand evacuation sign guidance based on real-time emergency situations to achieve safe and fast evacuation. The installation of the proposed system will improve building evacuation performance and reduce injuries and fatalities.

[R-3.3] BIM Implementation and Deployment (II) - Human Resources & Economics

Human-resources optimization & re-adaptation modelling in enterprises

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ABSTRACT: Optimization of Human Resources (HR) and re-adaptation are of vital importance to enterprises in order to keep the workload balanced and maintain high performance levels when unexpected events or exceptions occur, such as an arrival of a new unscheduled task. In this paper, a novel HR optimization & re-adaptation model for enterprises is introduced. The model integrates different entities such as employees, processes, work schedules, resources, and location information. The heterogeneous information is translated to a common vocabulary in order to be utilized for assigning tasks to human resources automatically without the need of supervision. Conditional Random Fields (CRFs) probabilistic models are trained, so as to learn the already applied task assignment patterns, and their output is taken into account in the decision process. The HR optimization toolkit, which comprises the models and the HR optimization tool, has been tested with real data acquired from an industrial environment achieving favourable results towards HR assignment.

Building information modeling in use: How to evaluate the return on investment?

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ABSTRACT: BIM (Building Information Modeling) is a new paradigm, which changes the way facilities are designed, built and managed. It is now recognized that implementing BIM in AEC (Architecture, Engineering and Construction) projects implies both organizational and technological challenges. The benefits of BIM are also well described in scientific and professional literature, in public and private BIM guidelines published by governments and owners, as well as in the marketing campaigns of software editors. However, implementing BIM internally in organizations or in AEC projects' teams remains a strategic investment. The value of BIM investments (i.e. Return on Investment) is not well defined nowadays, especially when it comes to projects' organizations, i.e. sharing of costs vs. sharing of benefits among the design/construction/facility management chain. The article proposes a project-level and structured method, enabling to assess the BIM ROI among project partners and projects' workflows implementing BIM (BIM uses). This method is then deployed on real construction projects and results are discussed.

A new training concept for implementation of 5D planning with regard to construction of large-scale projects

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ABSTRACT: This paper describes the possible incorporation of a training concept in support of the nationwide introduction of Building Information Modelling (BIM) as from 2016. After analysing the requirements, standards and general conditions set by the *Bundesministerium für Verkehr und digitale Infrastruktur (BMVI)* [Federal Ministry of Transport and Digital Infrastructure] and their cooperation partners, including *Deutsche Bahn AG* [German Railway Corporation] (Germany's largest property owner and operator of the country's national railway infrastructure), the *Technische Hochschule Mittelhessen (THM)* [Mittelhessen University of Applied Sciences] in Giessen developed a concept for training BIM experts and specialists. The concept is intended for the coworkers of both the principal and the contractor, whose job it is to promote the implementation and development of the new work method BIM in the construction sector.

Combining BIM models and data with game technology to improve the decision making process: 'PlayConstruct'

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ABSTRACT: Using BIM models and associated data, to enable visualisations of how the built environment will be constructed, appear and be used is increasingly well established. The potential to combine these visualisations and the associated data with game technology to illustrate, by 'gamification', the consequence of a decision is being explored in this research project. For example, the components and products that could all potentially meet the brief but might have variable impact on the environment, programme and procurement, durability as well as cost could be selected but not necessarily in the optimum combinations, depending on the drivers. By creating a game 'template' which is called 'Playconstruct', these varying parameters can be installed then selected in game play and compared to achieve the optimum solution for the project and the reasoning captured and illustrated. The benefits should be the engagement of parties interested in the design and construction process as well as the owners and end users. There is also potential for the principle to be beneficial in the broader education and training sectors. For example, illustrating to students the consequences of decisions in a fun and interactive way. Also where training methods can be enhanced by the game experience and scenarios created that are only limited by the imagination of the game designers. This has the potential to be able to create simulations to illustrate circumstances and consequences to be avoided, such as damaging underground services during excavations, or reinforcing good practice. There are many such instances where unnecessary cost and injury occur, despite no doubt rigorous training and toolbox talks etc. that the complementary use of Playconstruct simulations might reduce. The game template can be adapted to suit almost any process in any sector. The illustration of the consequences of decisions, both good and bad, in real time which previously may not have become apparent for some time is likely to find many applications. The technology will bring some of the time served traditional training methods right up to date and have the power to elicit during the currency of the game play a response from what could be far in the future.

[R-4.1] Sustainable Buildings and Urban Environments

Energy savings and maintenance optimization through the implementation of GESTENSIS energy management system

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ABSTRACT: Buildings in Europe are responsible of 40% of the final energy consumption. With the aim to accomplish the European 20/20/20 targets, buildings play an important role. Moreover, public buildings should exemplify the best practices in terms of energy efficiency. In this context this paper describes an energy management system for buildings developed in the GESTENSIS project. The system is composed by 5 modules that give tools to building managers to optimize the energy consumption. The building managers have a set of metrics to understand how their building is working and to know if the building performance is decreasing. The system also supports building managers in their daily building operation, optimizing the different types of spaces (corridors, lecture rooms and PC rooms). The system also helps building managers to carry out maintenance activities. It is expected to reduce 15.26 % of the gas consumption and 37.59 % of the electricity consumption.

Responsiveness based material – [a] Passive shading control system

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ABSTRACT: During the last decades Architecture has been looking to its basic principles, finding in nature a natural and obvious inspiration. Materials and environment have been playing an important and essential role in this process. Recovering the ideals of the 1950's intellectually movement *Performative Turn,* performance-oriented design finds its fundaments on the understanding that architecture unfold their performative capacity by absorbing the complexity conditions and processes. Following this premise, architecture and environment are simultaneously set at a spatial, material and temporal level.

The following article has the goal to describe a methodology to find the material and environmental driven parameters to be considered in the design and construction of a passive shading system. This research aims to develop a universal parametric definition, based on cork material and environmental essential and determinant driven parameters that could enable us to design a totally personalized passive shading system to any location and time.

Promoting energy users' behavioural change in social housing through a serious game

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ABSTRACT: Housing represents about 29% of the total energy consumption in Europe and contributes with around 20% of emissions (European Commission 2013). Social housing represents about 12% of the total European housing stock and therefore is a significant target for energy efficiency measures by governments of EU member states. This paper is aimed at exploring how an innovative serious game could contribute to energy consumption and carbon emissions reduction in social housing by increasing the social tenants' understanding and engagement in energy efficiency. The proposed solution is being developed under the auspices of the EnerGAware project (Energy Game for Awareness of energy efficiency in social housing communities), funded by the European Commission under the Horizon 2020 programme.

Total life cycle and near real time environmental assessment approach: an application to district and urban environment?

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ABSTRACT: This paper presents the ongoing research on the development of a total life cycle and near real time environmental assessment. Over 30 widely used sustainability assessment tools have been reviewed. This is done through investigating different characteristics of each tools namely: locality, scale, life cycle stage implementation, chosen criteria, chosen weighting system; and the definition of common patterns and issues. Additionally, forecasting models applied for power and energy consumption have been reviewed with around 120 applications spread into 46 papers. Forecasting applications are compared in order to define particular pattern. The methodology of the future application is presented in this paper as well. The methodology and technical approach used in the new neighbourhood environmental assessment framework is described. Cardiff Urban Sustainability Platform (CUSP), base for the development of this project, is presented with a brief overview of its main features and its ongoing application on the city of Ebbw Vale.

An agile process modelling approach for BIM projects

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ABSTRACT: In the domain of Building Information Modelling (BIM), the open standardisation of methods for product and process modelling is undertaken by the buildingSMART association. Currently, buildingSMART recommends the use of Business Process Model and Notation (BPMN) for creating process models in Information Delivery Manuals (IDMs). This paper argues that BPMN is closely linked to the waterfall nature of today's BIM projects, leading to a number of issues including long project durations, lack of stakeholder involvement, and disconnect of processes and data. Subject-oriented Business Process Management (S-BPM) is introduced as an alternative modelling approach for IDMs, based on its support for agile development that has the potential to address the above issues. Specifically, it is shown that S-BPM supports key concepts of agility, including stakeholder involvement, individual creativity, collaboration, rapid prototyping, and iterative design. The increased agility of S-BPM based IDM development can help make BIM projects faster, more flexible and better adapted to the needs of BIM users.

[R-4.2] Information & Knowledge Management (V) - Infrastructure

Detecting, classifying and rating roadway pavement anomalies using smartphones

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ABSTRACT: Pavements are major roadway infrastructure assets, and pavement maintenance to the preferred level of serviceability comprises one of the most challenging problems faced by civil and transportation engineers. Presented herein is a study on the utilization of low-cost technology for the data collection and classification of roadway pavement anomalies, by using sensors from smartphones and from automobiles' on-board diagnostic (OBD-II) devices while vehicles are in movement. The smartphone-based data collection is com-plimented with artificial neural network techniques, various algorithms and classification models for the clas-sification of detected roadway anomalies. The proposed system architecture and methodology utilize nine metrics in the analysis, are checked against three types of roadway anomalies, and are validated against hun-dreds of roadway runs (relating to several thousands of data points) with an accuracy rate of about 90%. The study's results confirm the value of smartphone sensors in the low-cost (and eventually crowd-sourced) detec-tion of roadway anomalies.

Patch defects detection for pavement assessment, using smartphones and support vector machines

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ABSTRACT: The condition evaluation of roadway transport networks is conducted to provide decision support for appropriate maintenance activities, preventing the possibility of detrimental effects. The costly, time-consuming and subjective current pavement assessment methods lead to the requirement for automation of the underlying process. Presented herein is an automated methodology for pavement patches detection; a process which is crucial for pavement surface evaluation and rating. Support Vector Machine (SVM) Classification is utilized, whilst the possibility of collecting pavement frames from smartphones, positioned insides of cars is examined. The SVM is trained and tested by feature vectors generated from the histogram and two texture descriptors of non-overlapped square blocks, which constitute an image. The outcome is the indication of the frames that include patches and the image blocks which are characterized as parts of patches.

Comparing diurnal patterns of domestic water consumption: An international study

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ABSTRACT: The increasing variability of water supply and demand makes the creation of improved sustainable water management systems crucial. Optimized decision making tools are required to better manage urban water resources. This paper presents the implementation of the WISDOM project aiming at (a) increasing user awareness and modifying behaviours, (b) encouraging water conservation and (c) reducing peak-period of water distribution loads. By collecting near real-time data, smart metering encourages behaviour changes and informs water companies about their customers' consumption while feedback provided through in-home displays educates people about their usage. Collecting disaggregated data about domestic water use also allows the profiling of behaviours that need to be targeted to promote conservation. In the context of the WISDOM project, these two devices were implemented within households in Cardiff (UK) allowing the collection of disaggregated data. These new technologies will optimize the peak-period management of water while encouraging water conservation and behavioural change.

Waterloss detection in streaming water meter data using wavelet change-point anomaly detection

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ABSTRACT: Described herein is a method for the detection of pipe breaks and water losses in urban water distribution networks, by use of a wavelet change-point anomaly detection algorithm and streaming water consumption data from an urban locale. The wavelet change-point method utilizes the continuous wavelet transform (CWT) of signals to analyze how the frequency content of a signal changes over time, and wavelet coherence to reveal time-varying frequency content common in multiple signals. The method also utilizes streaming water consumption data from consumers ('automatic meter reading' devices, AMR) and from district meter areas (DMA), to acquire inherent knowledge of water consumption at normal conditions at house and area-wide levels, and to make inferences about water consumption under abnormal conditions. This temporal anomaly detection is then georeferenced and used for spatial anomaly detection, producing 'heatmap' representations of the areas in the city with high probability of waterloss incidents.

[F-2.1] Construction/Risk Management; Regulatory & Legal Aspects

Managing constructability on a construction stage: BIM methods

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ABSTRACT: Constructability has emerged as an important tool for improving construction performance, productivity and quality. Recently, it has been suggested that constructability can be promoted through the use of building information modeling (BIM). This research focused on BIM based methods used on the building site in order to improve constructability at the construction stage. An empirical study was carried out by using three different research methods; interviews, action and literature research. The research group helped personnel in charge of construction works solving daily issues and to search optimum solutions for constructability with BIM-based methods. Solutions were tested with the personnel. Constructability development was winded around 4D schedule including visualization, 3D site layout and modeling of temporary support and structures. With BIM-based 4D schedule the constructability of structures could be analyzed, and it was easier to control and instruct workers, plan tasks beforehand, make procurements and plan an assembly sequence than using conventional construction planning methods.

Integrating BIM and agent-based modelling for construction operational optimization – A LBS approach

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ABSTRACT: The need to manage complexity, and the current necessity of interventions on existing buildings to provide project and construction methodologies and tools capable to support them in a proficient way. With the scope to define in advance the places occupied by workers to accomplish a task, is defined a methodology and a related tool to integrate Building Information Modeling (BIM) with an Agent-Based simulation of workers. The goal is to know as early as possible: where it is possible to work in a productive and safe way; how it is possible to be more efficient placing in the same working space different working phases; when it is possible to allow the continuity of building operations.

Topological robustness and vulnerability assessment of water distribution networks

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ABSTRACT: Being able to assess the reliability of the network against different hazards helps water distribution agencies prioritize their interventions and ensure a minimum reliability level of the network. Research to-date has helped identify a number of potential time-invariant and time-dependent risk factors contributing to pipe fragility and network reliability. Among them are factors such as a pipe's age, diameter, material and number of previous breaks, as well as the network's topology, operating pressure and water flow. In terms of introducing a network's topology to its risk level, recent work has highlighted the importance of a network's connectivity to its reliability and the need for robust appraisal methods of network connectivity metrics. The work described herein discusses such a method based on a network's 'betweenness centrality' index and demonstrates its importance using a case-study water distribution network (WDN) under both normal and abnormal operating conditions. The proposed method is also coupled with spatial mapping to indicate areas of concern in the network, and with a decision support system to assist in prioritizing actions to improve on the network's robustness and resilience.

[F-2.2] Description Logics and Ontology Application in AEC

Structured building monitoring: ontologies and platform

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ABSTRACT: Building data monitoring can provide performance feedback for operational optimisation of existing facilities and improve future designs. It can support energy and performance contracting, smart load balancing, model-predictive building systems control, and preventive building maintenance. However, a closer look at the current practice suggest that the commonly deployed technical infrastructures are not mature enough and their hardware resilience and software interoperability are in need of improvement. To address these issues, we first introduce in this paper an ontology for the representation and incorporation of multiple layers of data in pertinent computational applications such as building performance simulation tools and building automation systems. We then address common data processing requirements and exemplify a number of typical queries that building monitoring data repositories must support. Finally, we describe a specific technical platform for the structured collection, storage, processing, and multi-user exchange of monitored data.

SemCat: Publishing and Accessing Building Product Information as Linked Data

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ABSTRACT: Building product information is still mostly distributed, heterogeneous, unstructured, with inconsistent semantics and communicated using low technology means. Over the last decade, there has been little progress towards change. Architecture, Engineering and Construction (AEC) practitioners still face challenges when searching and acquiring necessary information and re-using it in their ICT tools. Whilst manufacturer information is more focused on trade and business processes, the demand for precision technical data by designers and engineers is continually growing with more mature and complex standards and ICT tools used in energy performance analysis, life-cycle cost (LCC), life-cycle assessment (LCA) and BIM processes. The majority of product manufacturers are small, regional companies, many with limited ICT capabilities and resources to keep up with this growing demand. In this paper we report on an enhanced approach to provide standard structured building product information with consistent semantics across multidisciplinary processes. The approach is based on Linked Data technologies.

Automatic ontology-based green building design parameter variation and evaluation in thermal energy building performance analyses

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ABSTRACT: Thermal energy analyses based on Building Information Models (BIMs) are becoming more and more practicable in architecture, engineering and construction. This enables detailed studies about the building energy behaviour with predefined energy-relevant parameters. Although this is an absolute advantage there are also some problems regarding the daily work of energy experts. The simulation configurations and executions cost much time and the pre-processing can be very erroneous due to design modelling problems, wrong material assignments etc. To allow assignments from external data like product catalogues or climate information to BIM data, the energy-extended BIM (eeBIM) framework was developed as multimodel concept for energy simulations. This multimodel was extended by ontologies to allow semantic enrichments and constraints for checking the model quality of inter-linked models. It can be used as an input data set for thermal energy performance analyses. An energy performance platform, called Virtual Energy Laboratory (VEL), integrates different energy tools and data management functions to allow complex thermal energy simulations based on a BIM and additional energy-relevant data. This paper shows how an optimized Green Building Design (GBD) can automatically be derived from a building information model using semantic technologies and highly-scalable processing methods based on an ontology-controlled workflow in the VEL.

In the last two decades, the biennial ECPPM (European Conference on Product and Process Modelling) conference series, as the oldest BIM conference, has provided a unique platform for the presentation and discussion of the most recent advances with regard to the ICT (Information and Communication Technology) applications in the AEC/FM (Architecture, Engineering, Construction and Facilities Management) domains.

ECPPM 2016, the 11th European Conference on Product & Process Modelling, was hosted by the Department of Civil and Environmental Engineering of the University of Cyprus (7-9 Sep. 2016), and covered complementary thematic areas that hold great promise for the advancement of research and technological development in the modelling of complex engineering systems. This book encompasses a substantial number of high quality contributions that cover a large spectrum of topics pertaining to ICT deployment instances in AEC/FM, including:

- Information and Knowledge Management
- Construction Management
- Description Logics and Ontology Application in AEC
- Risk Management
- 5D/nD Modelling, Simulation and Augmented Reality
- Infrastructure Condition Assessment
- Standardization of Data Structures
- Regulatory and Legal Aspects
- Multi-Model and distributed Data Management
- System Identification
- Industrialized Production, Smart Products and Services
- Interoperability
- Smart Cities
- Sustainable Buildings and Urban Environments
- Collaboration and Teamwork
- BIM Implementation and Deployment
- Building Performance Simulation
- Intelligent Catalogues and Services

As such, *eWork and eBusiness in Architecture, Engineering and Construction 2016*, represents a rich and comprehensive resource for academics, researchers and professionals working in the interdisciplinary areas of information technology applications in architecture, engineering and construction.

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