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Editorial of INSIGHT Special Issue

AFIS Doctoral Symposium: Advancing Systems Analysis and Modeling in French Universities

This special issue of INSIGHT section includes the main contributions presented in workshops that have held during the Systems Engineering Academia-Industry Forum. The aim of this issue is to provide an overview of the French research in the domain of Systems Engineering.

This Systems Engineering Academia-Industry Forum is organized by AFIS (Association Française d'Ingénierie Système), the French chapter of INCOSE, and supported by French universities as a regular series, usually every two years.

This forum provides the opportunity for both academics and industrials to debate on:

- Educate systems engineering and develop competences in systems engineering for professional situations,
- Develop and promote the research in systems engineering.

Thus, workshops and plenary lectures are held during the forum in order to cover the theme of education, research and practices of systems engineering.

In December 2014, the fifth edition of the forum was held in Cergy-Pontoise with the support of the university of Cergy-Pontoise. This edition was dedicated to the important subject of "Interdisciplinary and Collaborative Engineering Based on Models" that has been broken down in 11 topics:

- Model based Systems Engineering,
- Research activities in Systems Engineering,
- From the Systems Engineering deployed by the Gen X to the Systems Thinking needed by the Gen Y,
- Model based Systems Engineering and PLM: which challenge,
- Innovation and Systems Engineering: discrepancy or complementarity,
- Systems Engineering and SysML for education in secondary schools,
- Architecture and allocation of requirements,
- From Design To the Operations,
- Pedagogies and Systems Engineering: challenges and issues,
- ROBAFIS challenge that is organized by AFIS and that promotes project-based collaborative learning in SE,
- Doctoral program in Systems Engineering as a challenge for Research in French universities.

This last topic has given rise to a specific workshop, the doctoral seminar, offering the opportunity for doctoral students to present and to discuss their doctoral works concerned by Systems Engineering, with academics and industrials.

For this issue of INSIGHT, doctoral students and their supervisors have been invited to submit an extended version of their presentations in order to emphasize the research aspects of Systems Engineering. Seven papers have been selected to be included in this edition in order to promote research contributions for an Interdisciplinary and Collaborative Engineering Based on Models.

This emerging paradigm is a challenge for the discipline of systems engineering in order to establish the relation of interoperability for coupling the representation of a system-situation (Lawson 2010), that designates and defines a problem or an opportunity, and the interdisciplinary representations co-specified by the respondent engineering orchestrated by systems engineering as a coherent collaborative whole (Bouffaron et al. 2014). The interest for this systemic vision in both engineering, education and research, has been underlined by the international community of systems engineering (BKCASE Editorial Board 2015) in order to avoid systemic failures (Boardman et Sauser 2008) too often seen a posteriori.

The first paper, *improving human-machine interaction requirements for maintenance enabling systems specification*, authored by Romain Lieber and Gérard Morel is a relevant example of such systemic vision which is expected to be provided by systems engineering to engineer maintenance enabling system as a coherent socio-technical whole. As the performances of such a system are depended on the synergies of the different interactions that take place between technical and human systems when operating a common object, its engineering requires that traditional Systems Engineering framework evolve in order to take into account those critical interactions since the specification phase. The paradigm explores by the authors is based on the hypothesis of possible inter-operations between physiological and technical processes for human-machine modeling. More precisely, within a Model-Based Systems Engineering (MBSE) approach, the authors focus on the specification of a physical-physiological perception interaction for a human to perceive right the meaning of symbolic properties that technical objects afford.

The concept of Systems of Systems addressed by Siqi Qiu, Mohamed Sallak, Walter Schön and Zohra Cherfi-Boulanger in their paper *Graphical models for RAMS assessment and risk analysis of Systems of Systems* under uncertainty is another example of making systemic systems under uncertainty as European Rail Traffic Management System. By considering the hardware aspect, the network aspect and the human factors that characterize these systems, there is a crucial need of a collaborative works between specialized engineering in order to reinforce the assessment of their requirement of Reliability, Availability, Maintainability, Safety (RAMS) and the analysis of the risk to which they may be subjected. Thus, the main contributions of this work consist in the proposition of a methodology to model and evaluate an European Rail Traffic Management System as a System of Systems, from which the RAMS can be evaluated by considering the unavailability of the whole SoS as an emergent property and from which some uncertainties that can be seen can be quantitatively modeled.

Beyond the paradigm of *Interdisciplinary and Collaborative Engineering Based on Models, Systems Engineering* needs also to address the notion of complexity of any system to be engineered. Thus, the works of Chen Zheng, Julien Le Duigou, Matthieu Bricogne and Benoît Eynard is related to the Design Process for Complex Systems Engineering Based on Interface Modelling. As shown by authors, the rise of technologies leads to the multiplicity of disciplines when designing a technical system. And the need to integrate all these disciplines leads to the sense of a technical system as a complex whole. In their works, the authors propose Systems Engineering in order to clarify and elicit customers' needs and required functionality of such complex systems in the early stage of a development cycle. Thus, the authors propose a new method for modelling interface of complex systems. The goal is to support the design process of complex systems based on V-model by making use of the proposed interface modeling.

In the same vein, Nadège Benkamoun, Khalid Kouiss Carrey Dilliot, Philippe Ducreuzot, Jean-Philippe Marcon, Anne-Lise Huyet and Michel Dhome argue that changeability is a characteristic that shall refer to system engineering artefacts in order to suggest a new formalism for representing the architecture of a complex system in a rationale way. In the paper *A design methodology and representation formalism for changeable systems – Application to manufacturing systems*, the authors show how Systems Engineering elements (i.e. requirements and structural components) can be traced to each other in order to give a comprehensive view of a complex system and how changeability requirements – deriving from a stereotype profile of requirement – can be allocated to any of those elements. They demonstrate that the advantages of tracing the design rationale in changeability design are multiple: Identify the relating elements to a changing need ; Analysis change propagation and impacts between system engineering elements ; Move toward a semi-automated design process with the development of a knowledge-based system about changeability possibilities.

In their paper Anderson Luis Szejka, Alexis Aubry, Hervé Panetto, Osiris Canciglieri Júnior, Eduardo Rocha Loures propose *a method for formalizing requirements interoperation in complex systems engineering*, and address the problem of definition, modelling and formalisation of the system requirements and their relationships. They are formally defined in terms of transformation (translation, conversion and sharing) and traceability, based on an ontological approach. The authors demonstrate that there are significant lacks of interoperability between requirements in SE due to heterogeneity of information from multiple domains and different phases of systems life cycle. Then they proposed a method dealing with requirements interoperability across different phase of the life cycle and domains to formally model requirements interoperation in terms of transformation, traceability and conflicts analysis.

Blazo Nastov, Vincent Chapurlat, Christophe Dony, François Pfister propose *a framework for the V&V (Verification & Validation) in Model Based Systems Engineering: towards executable and verifiable DSMLs* (Domain Specific Modeling Languages) They are developing a formal approach for modeling dynamic semantics of DSMLs making then appear the concept of Executable, verifiable and interoperable DSMLs (eviDSML). It is based on the idea that among DSML's concepts, some of them take part in the dynamics of the DSML, called “evolving” concepts where the expected behaviors is designed by using software engineering languages

Finally, Melissa Issad, Leila Kloul, Antoine Rauzy, Karim Berkani developed *a scenario oriented modelling language for railway systems* that is allowing a textual and graphical representation of a railway system. The language can be extended to any other complex system easily since it relies on generic system architectures.

To add value to this INSIGHT issue, the editors chose to include a paper related to the important issues that the ROBAFIS challenge procure to the education of Systems Engineering. In the paper *RobAFIS student competition actuality: A continuously evolving pedagogy for Systems Engineering*, Jean-Claude Tucoulou and David Gouyon describe the different methods of this particular educational challenge that encourages students to place themselves in an engineering role so that they practice Systems Engineering processes by designing, realizing and validating a technical system in an operational situation.

All these contributions are valuable material for the Systems Engineering research and education as tracks for future works.

We are grateful to the authors for their impressive contribution and to the reviewers for their valuable assistance to the scientific relevance of this issue of INSIGHT.

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The Editors

Dr. Hervé Panetto is a full Professor of Enterprise Information Systems at the University of Lorraine, TELECOM Nancy. He conducts research at the Research Centre for Automatic Control (CRAN), Joint Research Unit with CNRS, where he is managing a project on the use of ontology for formalising models related to the interoperability of production information systems. He has been involved in European projects including IMS FP5-IST Smart-fm project (awarded by IMS) and the FP6 INTEROP NoE. He is member of the Editorial Board of the Annual Reviews in Control, Computers In Industry, the Journal of Applied Mathematics, Hindawi, the International Journal on Universal Computer Science, the scientific journal Facta Universitatis, series Mechanical Engineering, and an Associate Editor of the international Journal of Intelligent Manufacturing (JIM), Springer and the Enterprise Information Systems (EIS) journal, Taylor & Francis. After being Chair of the IFAC TC5.3 “Enterprise Integration and Networking”, he is currently, Chair of the IFAC Coordinating Committee 5 on Manufacturing and Logistics. He received the IFAC France Award in 2013 and the INCOSE 2015 Outstanding Service Award.

Dr. Frédérique Mayer is Associate Professor at University of Lorraine, France. Her research project is a contribution to the definition and the designation of the systemic interoperability between the interdisciplinary representations of a situation, a system and their engineerings to realize a system as a whole.. In particular, her research works focus on the systemic thinking based process for modelling a complex system in the field of systems engineering and enterprise modelling. She was the chairwoman of the Technical Committee 9.2 on "Social

Impact of Automation" of IFAC and she is member of the International Council on Systems Engineering (INCOSE). The main courses she gives are related to Systems Integration and Engineering, Enterprise Modelling and Systems Thinking based approaches. She received the IFAC France Award in 2014 and the INCOSE Outstanding Service Award in 2015.

Dr. Eric Bonjour is a full professor specialized in systems engineering, at the Université de Lorraine / Graduate School of Innovation and Systems Engineering (ENSGSI). In summary, his main research interests touch upon the fields of innovation, systems engineering, product architecture, product family, knowledge management, competency management and project organization. He has supervised 9 PhD thesis related to these topics. He is the Vice-chair of the French chapter of INCOSE (AFIS), responsible for "Research – Training" topics (since 2012) and a co-head of the "Knowledge management and competence management in industrial companies" working group, affiliated to the National Research Council GDR MACS/CNRS (since 2007). He was the academic co-chair of the Program Committee of an international conference dedicated to systems engineering: CSD&M (Paris, 2015). He has published more than 70 papers for conferences, journals and books. In 2015, he received the INCOSE Outstanding Service Award 2015.

List of Papers

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Romain Lieber, Gérard Morel
Improving human-machine interaction requirements for maintenance enabling systems specification

Siqi Qiu, Mohamed Sallak, Walter Schön and Zohra Cherfi-Boulanger
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Chen Zheng, Julien Le Duigou, Matthieu Bricogne and Benoît Eynard
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A design methodology and representation formalism for changeable systems – Application to manufacturing systems

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V&V in Model Based Systems Engineering: towards executable and verifiable DSMLs

ScOLA, a Scenario Oriented Modeling Language for railway systems
Melissa Issad, Leila Kloul, Antoine Rauzy, Karim Berkani □ □