

## **Thesis subject: Semantic-based Federation of SoS Models**

### **PhD Advisor:**

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### **Context of the thesis:**

The thesis is part of the project activities of the Laboratory of Excellence (LABEX) at the Université de Technologie de Compiègne (UTC) in France on the Control of Technological Systems of Systems (MS2T) ([www.utc.fr/labexms2t](http://www.utc.fr/labexms2t)).

**Industrial partner:** Airbus Defence and Space (formerly Cassidian), Elancourt, France  
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The thesis would be co-financed by Airbus Defence and Space.

### **PhD thesis description:**

The modelling of systems of systems (SoS) becomes more and more frequent because it is important for mastering coherence, management of changes and analysis of specifications. However, models often remain specific to a domain of study (hardware architecture, software, electrical engineering, fluids, ...) and the global coherence is always managed by humans, which is source of unavoidable errors leading to additional engineering costs.

Furthermore, projects of SoS are rarely unique in a company. Several projects evolve in parallel, often with important intersection parts. Because of their own life cycle, each project recreates parts of models that were created in other projects. This can be due to various good reasons:

- The domain knowledge has been deepened,
- The use of the model has changed and some information is too much detailed,
- Existing models were not designed to be reusable,
- Models have to be autonomous because of constraints on the projects,
- ...

Finally, because of their complexity, evolutions of systems are taken into account on periods of time that can last on several weeks or even months. During first implementations, the user is unavoidably confronted to unexpected behaviours that challenge parts of the previous specifications. In this context, one must identify demands having an immediate impact on the current delivery and those that have to be delayed to a subsequent delivery.

The PhD thesis will be centred on the federation of SoS models. It will address the three previous related problems in order to: (1) allow unconstrained alignment of multi-domain models; (2) consider multi-projects data; (3) take into account change over time of each system.

The thesis subject is therefore centred on effective means of organisation and management that could allow an engineering company to:

- Facilitate the use of existing models;
- Allow comparison of models to study alternative options;
- Inform the stakeholders of an engineering project of modifications impacting their application domain;
- Allow to analyse the impact of changes on the SoS over time and between projects;
- Take into account methodological constraints such as the use of architecture frameworks (NAF, DoDAF, SysML, ...).

The approach will be based on ontologies and semantic technologies. Ontologies [Gruber, 1995] can be used for example to explicit the tacit knowledge of engineers through annotations of models [Zayas, 2012], to compare models [Oliveira et al., 2009], to discover meaningful associations between design models by using complex ontology mappings [An & Song, 2008] and to check the quality of models by reasoning. The goal is to design a semantic-based framework that will help to solve problems related to the modelling of SoS, such as understanding, sharing, federation, reusability, coherence and consistency. This framework will be applied to the design of SoS in aeronautics.

**Keywords:**

Systems engineering, NAF architecture framework, Ontology, Semantic Analysis, Inference, Knowledge Engineering

**References:**

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Grüber, T. (1995). Toward Principles for the Design of Ontologies Used for Knowledge Sharing. *International Journal of Human-Computer Studies*, Volume 43 , Issue 5-6 Nov./Dec. 1995, Pages: 907-928.

Oliveira, K., Breitman, K., & Oliveira, T. (2009). Ontology Aided Model Comparison. *14th IEEE International Conference on Engineering of Complex Computer Systems*.

Zayas, D. S. (2012). A framework for the management of heterogeneous models in Systems Engineering, thèse de doctorat de l'ENSMA, Poitiers.

**Candidate's profile:**

- Communication, analysis and synthesis skills
- Spoken and written English
- Knowledge of system engineering and semantic technologies appreciated

N.B.: Freddy Kamdem Simo has already applied for this PhD thesis subject. He is an UTC student who recently made his final-year project under the supervision of Dominique Ernadote at Cassidian. I think in accordance with Dominique that he could be a good candidate for this thesis.