# Modeling approaches for the design and analysis of complex systems

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**Abstract.** The design of a complex system traditionally relies on a systems engineering process that makes use of text documents and engineering data in multiple formats.

The inherent limitations of the document-based manual approach have been targeted by the model-based systems engineering (MBSE) approach, promoted by the International Council on Systems Engineering (INCOSE), which defines MBSE as "the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle" (INCOSE, 2007).

In this respect, SysML (Systems Modeling Language) is the language that provides the modeling capability required in the systems engineering domain. SysML, which has been developed as an UML (Unified Modeling Language) extension, is now considered the standard modeling notation adopted in the MBSE context (OMG 2010).

In addition, the recent adoption of the Business Process Modeling and Notation (BPMN) standard by the OMG (Object Management Group, the same body that defines and promotes UML and SysML), has introduced into the MBSE discipline the formalization of the business layer describing the interactions among the organizations that make use of systems at the context or operational scenario analysis level (OMG 2011).

The advantages obtained by the MBSE approach, in terms of enhanced communications, reduced development risks, improved quality, increased productivity and enhanced knowledge transfer, can be further scaled up by innovative approaches that treat models as the primary artifacts of development, by increasing the level of automation throughout the system lifecycle.

Such approaches have been introduced in the model-driven engineering (MDE) field and represent a radical shift from a merely contemplative use of models to a productive and more effective use (D. C. Schmidt, 2006). The application of MDE to systems engineering has been denoted as model-driven systems engineering (MDSE) (D. Gianni, A. D'Ambrogio and A. Tolk, 2014).

MDSE applies metamodeling techniques and automated model transformations, introduced in the more general model-driven engineering context, to

the systems engineering domain, thus boosting the aforementioned advantages of the MBSE approach.

The talk first describes the principles and standards of MBSE and then focuses on MDSE approaches by illustrating their application to the simulation-based analysis of modern complex systems, i.e., large-scale heterogeneous systems, which are usually composed of several subsystems (P. Bocciarelli, A. D'Ambrogio and G. Fabiani 2012; P. Bocciarelli, A. D'Ambrogio, A. Giglio and D. Gianni, 2013).

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# Biographies

**Andrea D'Ambrogio** is associate professor of computer science at the Dept. of Enterprise Engineering of the University of Roma "Tor Vergata" (Italy). He has formerly been assistant professor at University of Roma "Tor Vergata" and research associate at the Concurrent Engineering Research Center of the West Virginia University (USA). He is Director of the post-graduate Master degree in "Systems Engineering", established at the University of Roma "Tor Vergata". Andrea D'Ambrogio's research interests are in the software engineering field, specifically in the areas of engineering and validation of system performance and dependability, model-driven systems and software engineering, and distributed and web-based simulation. In such areas he has participated to several projects at both European and overseas level and has authored more than 90 journal/conference papers. He has served as member of the program committee of various international conferences, among which IEEE WETICE, ACM WOSP, ACM ICPE, SCS/ACM/IEEE TMS/DEVS, ACM PADS and SIMUTools. He has been general chair of SCS/ACM/IEEE TMS/DEVS 2014 and of IEEE WETICE 2008. In 2010 he started the IEEE International Workshop on Collaborative Modeling and Simulation (CoMetS) and in 2011 the SCS/ACM/IEEE International Workshop on Model-driven Approaches for Simulation Engineering (Mod4Sim). He is member of the management committee of the ICT COST Action on "Multi-Paradigm Modelling for Cyber-Physical Systems" (MPM4CPS). Andrea D'Ambrogio is member of the editorial board of the IAENG International Journal of Computer Science (IJCS) and the International Journal of Software Architecture (IJSA). He makes scientific advisory work for various industries and national/international organizations, and is member of IEEE, IEEE Computer Society, ACM, SCS and INCOSE.

**Lucio Tirone** is Technical Director at Aster S.p.A., he has over 15 years of field experience, the first half of which spent consolidating his Electromagnetic background, in the development of object oriented software for the computation of e.m. propagation in complex urban/non-urban environments. Since then he has been involved in Systems Engineering activities for the analysis, design, implementation and validation of large technological projects in the Defense, Aerospace and Transport sectors. Certified CSEP, he is currently vice-president of the INCOSE Italia Chapter.