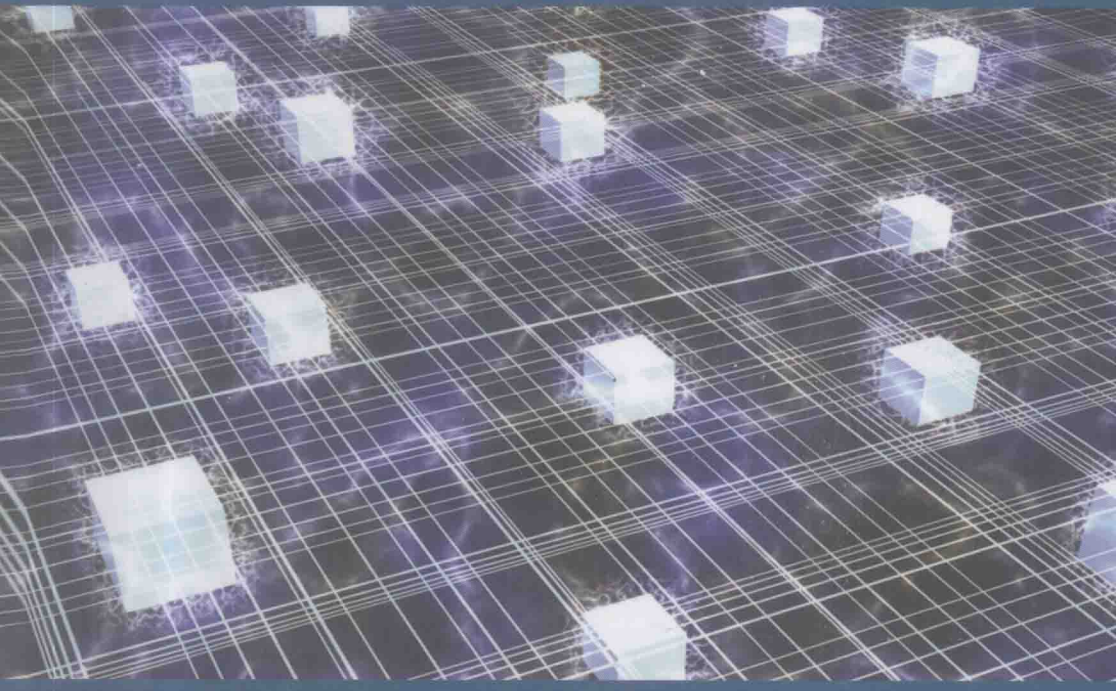
Systems of Systems

Edited by
Dominique Luzeaux
Jean-René Ruault



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Systems of Systems

Author Biographies

Michel CHAVRET

Engineer in automatisms and informatics, Michel Chavret has dedicated most of his career to the design of systems in the field of transport, with a few years spent developing complex systems for industry and the army. Since 2000, when the SETEC ITS society was created, he has directed Lyon's agency. He was a project director in the ACTIF project, keystone of modeling and design of systems of systems in France in the field of intelligent transport systems.

Lui KAM

Lui Kam graduated from the *Ecole nationale supérieure des ingénieurs des études et techniques d'armement* (ENSIETA) in 1996, from Paris XI University with a doctorate in electronics in 2000, and from the London Business School with a Master of Business Administration in 2007. During his 11-year-long career in the *Délégation Générale de l'Armement* (DGA), his fields of expertise covered the signal and image processing, the methods, tools and standards used in modeling and simulation, as well as in systems engineering. Since 2007, he has been working as a Business Strategy and Development Consultant, and is currently based in Shanghai.

Dominique LUZEAUX

Dominique Luzeaux is a graduate from the *Ecole polytechnique* (1987) and the *Ecole nationale supérieure des techniques avancées* (1989). After graduating with a PhD from Paris XI University in 1991, he was a research fellow at Berkeley University till 1992. Hired by the DGA, he has taken on various technical responsibilities in the fields of robotics, optoelectronics and observation systems. From 2002 to 2004, he was the director of Simulation-Based Acquisition at the DGA, where he notably oversaw the R&T (Research & Technology) programs in system engineering. From 2005 to 2007, he was director of the IT production center.

From 2008 to 2009, he was deputy director of the C4ISR programs. Since April 2009, he has held the position of director of Land Systems acquisition. Moreover, accredited to supervise research since 2001, he has overseen a dozen doctoral theses and published more than 60 articles in conferences and international reviews. He teaches robotics at the ENSTA, systems of systems engineering at the ENSIETA and the ISAE, and is also a speaker in mathematics and computer sciences theory at the *University of Montpellier II*. Laureate of the prize of *Ingénieur général Chanson* in 2006 for his works in the field of military terrestrial autonomous robotics, he co-wrote *A la conquête du nanomonde : nanotechnologies et microsystèmes* with Thierry Puig, published by the *Editions du Félin* in March of 2007.

Jean-Pierre MEINADIER

Jean-Pierre Meinadier is an engineer of l'*Ecole centrale*, an honorary teacher at the *Conservatoire national des arts et métiers*, and a scientific consultant at the AFIS. He first developed his career in the field of IT systems engineering and integration at the CEA from 1963 to 1974, where he created real-time systems activity. He then created and directed, from 1975 to 1986, the head office of GIXI, a systems engineering company of the CEA-CISI group. Consultant from 1987 and later professor, he founded the chair of systems integration at the CNAM in 1990. He has penned several works in the field of systems architecture and engineering. He has taught computer architecture, and later systems engineering, in several engineering schools.

Patrice MICOUIN

Senior consultant in the field of systems engineering, Patrice Micouin works with enterprises such as DCNS, Airbus, Eurocopter and the CNES. In 2006, he held a doctorate dissertation at the *Ecole nationale supérieure des arts et métiers* (ENSAM) on the definition and implementation of system engineering processes in the automotive sector. He teaches a class on system engineering at the ENSAM, gives speeches at *l'Ecole centrale Paris*, and supervises, in the LSIS laboratory (UMR CNRS 6168), research centered on requirements engineering, system design and knowledge engineering.

Frédéric PRADEILLES

Graduate of l'*Ecole Polytechnique*, and holder of a PhD in mathematics, Frédéric Pradeilles first taught mathematics at *SUPAERO* (now ISAE), before joining the DGA to take on various technical responsibilities in the fields of observation and intelligence, and the use of space in the gathering of intelligence. He has also been director of the research and technological programs in the field of complex system engineering, and has acted as a representative for the DGA at the System@tic Paris-Région Cluster. Today, he is Chief Technical Officer within *CS Systèmes d'Information*.

Jean-René RUAULT

After a DEA in experimental social psychology, Jean-René Ruault followed additional training in industrial informatics. He worked in various service firms for more than ten years, contributing to projects at various stages of the systems' life cycles. He joined the DGA in 2004, where he now works in systems engineering within the SdS pole. He co-chairs the working group on systems of systems within the AFIS. Moreover, he has published several articles in the field of systems of systems engineering and human-machine interactions. He was co-president of the Ergo'IA conference in 2006.

Danièle VÉRET

Danièle Véret a barrister at Paris Bar has a Master's degree in public and private law, and a DEA in comparative law, "*droit anglais et nord-américain des affaires*" (British and North-American business law). She rapidly turned to IT laws, and later to the laws regulating new technologies. A lawyer within the legal department of an SSI, and later at ALAIN BENSOUSSAN AVOCATS, she takes care of counseling and litigation cases, out of court, in court (commercial, civil and administrative) and in arbitration (arbitrator at the *Centre de médiation d'arbitrage de Paris-CMAP*). Lecturer in IT law at the *Université Paris XII-Créteil*, and in regulations of industrial maintenance contracts and legal risk management at the *Ecole des ingénieurs du Val de Loire* (Blois) and the *Ecole nationale des arts et métiers* (Paris), she has also contributed to legal workgroups within Syntec Informatique, IFESI, AFSM, and AFNOR. She has contributed to a dozen books on legal risk management, IT maintenance and regulations, IT contracts, as well as articles on new technologies and industrial maintenance, notably on public markets, in numerous reviews.

Jean-Luc ZOLESIO

Jean-Luc Zolesio is the chief of research and innovation within THALES's "*Solutions de Sécurité et de Services*" division. After a thesis in mathematics, he successively worked for IBM, ITT and THALES, all the while teaching, first at the University of Nice, then at the *Ecole Centrale* in Paris. He has been director of a department on exploratory research, technical director of ground and surface radar activity, and director of the THALES *Think Tank*, before taking on his current role. Moreover, he has been laureate of the "*Grand Prix de L'Electronique Général Férrié*" (1993). He is the author of more than 30 patents and has had many of his works published internationally.

Introduction

Today's society is permeated with the notion of systems: electoral system, ticket booking system, air traffic control system, etc. Is this a simple linguistic convention? Or a revival of systemics, perceived by some as the revival of a structuralism which, while formerly praised to the skies, had been brutally disparaged? Or, perhaps, the need to clarify a certain number of concepts and their dispersal within our society, a process accelerated by the rapid spread of technologies?

This book follows this logic, and aims to be a multidisciplinary reflection on "systems of systems", which are currently found in many fields: banks, army, transportation, etc. What should we see in this, beyond the simple repetitive use of the concept of "system"? What makes this new field worthy of theoretical and practical attention? Do we need new tools to manage those systems?

To try and offer an extensive review of the field, this book is separated into two parts:

– "Systems of Systems, Concepts and Practical Illustrations" (Part 1);

– "Systems of Systems Engineering, Methods, Standards and Tools" (Part 2).

Introduction to Part 1

After laying down the definition of a system (it should be noted that this definition includes the system's components and their interfaces, as well as the processes of their respective life cycles, from design to disposal and dismantling, and therefore includes the products and services necessary for these processes) and defining what a system of systems *is*. Chapter 1 ("Systems of Systems: From Concept to Actual Development", Dominique Luzeaux) will set out the ways of

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Introduction written by Dominique LUZEAUX and Jean-René RUAULT.

monitoring a system of systems design and, more generally, its life cycle, with particular emphasis on the need for an integrated approach on the level of the engineering process and the use of simulation during the entire life cycle. It will also address the need to adjust the usual balance between general contracting and project management and their contractual relationships, in a context where the purchase of systems must be done in an incremental manner, in time, and in constant co-evolution. Examples will be taken from experiences in the field of armament concerning the management of complex defense systems and program management.

Chapter 2 ("Emergence and Complexity of Systems of Systems", Patrice Micouin) will shed further light on that issue, first establishing a dichotomy between natural systems and artificial or technological systems, then including systems of systems within the family of technological systems. However, systems of systems distinguish themselves from individual technological systems by their specific formation mode, essentially linked to an initiative of voluntary association for the achievement of multiplied capability. The notions of interface, interoperability and engineering thus take on, if not a new meaning, an increased importance in this effort to control the increasing complication, or even complexity, of artificial systems.

The following two chapters will look at two complementary aspects which are essential for systems of systems. Chapter 3 ("Contractual Aspects of the Acquisition and Use of Systems of Systems", Danièle Véret) deals with the legal aspects of the contracting stage, paying special attention to the transfer of ownership and intellectual property rights. It helps place the initial issue back within a context larger than the simple technical context, the one addressing economical aspects, and therefore requiring a legal framework. Chapter 4 ("The Human Factor within the Context of Systems of Systems", Jean-René Ruault) will look at the decision making process in a system of systems from a more sociological standpoint, taking the organizational and cultural aspects into account.

The four following chapters will offer concrete illustrations of systems of systems. Chapter 5 ("The Space Communication and Observation System of Systems", Frédéric Pradeilles and Dominique Luzeaux) addresses the spatial field; Chapter 6 ("Intelligent Transport Systems", Michel Chavret) addresses the transportation field; Chapter 7 ("Systems of Systems in the Healthcare Field", Jean-René Ruault) addresses the healthcare field; and Chapter 8 ("Critical Infrastructure Protection", Jean-Luc Zolesio) addresses the field of crisis management with large human involvement (firefighters, ER, NGO, police, etc.) including the case of international mobilization (tsunami).

Chapter 9 ("Globalization and Systemic Impacts", Dominique Luzeaux, Jean-René Ruault and Lui Kam) follows this reflection and addresses two topics: on the

one hand it shows how globalization can be modeled as a system of systems and how some phenomena benefit from such a model, in terms of interpretation. On the other hand, it broaches the possibility of entering new markets in emerging countries, in which we must control the risks linked to a misconception of the market, the potential users, the regulations and the culture, as well as new competition which requires us to keep the upper hand, to offer more complete and integrated products and services or to get those products and services on the market faster and with cheaper prices.

Introduction to part 2

Three chapters will provide the key to understanding all the technical aspects of systems of systems. Chapter 10 ("Methods and Tools for Systems of Systems Engineering", Dominique Luzeaux) lays down the issue of collaborative working environments and specific engineering tools. It underlines the importance of models in every aspect of engineering work, in particular in the first stages of concept analysis and during the definition of architectures. Chapter 11 ("Model-driven Design and Simulation", Lui Kam) follows on that work and studies software engineering techniques such as MDE (model-driven engineering, with its model transformation) and complex systems simulation. It shows how these techniques can help find tangible answers to the problems of interoperability, reuse and capitalization, three major aspects which need to be managed when working with a system of systems. Chapter 12 ("Standardization in the Field of Systems and Systems of Systems Engineering", Jean-René Ruault and Jean-Pierre Meinadier) lists the key standards not only for systems engineering but also for the various data and models exchanged in the course of this engineering (15288, AP233, SysML).

Building on this triptych "theory-illustration-method", this book, written by ten professionals with various specializations, offers multiple visions on a thriving subject.

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