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

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.