

The 'systems community' embraces the whole of this broad constituency. Only a few sectors of the systems community will need deep insight into systems and sophisticated systems skills, but each member would benefit from a fair degree of insight. Understanding systems is truly for all.

## 1.6 This book

This book sets itself the task to present a systems paradigm in a language that is precise and readily understandable, accurate enough to describe the problem and represent the solution to the various stakeholders in as much detail as they demand and are willing to absorb.

The book has a dual aim:

1. to inform the interested lay reader or members of a specialist profession, and
2. to contribute towards the formation of a 'systems profession'.

It presents a systems outlook, defines key concepts, and outlines the principles of characterizing systems. It introduces a language of expressing requirements and solutions, together with related collection of models, measures, methods and tools.

The key methods are Product/process (P/p) modelling and model-based measurement. P/p modelling affords the clear representation of any kind of entity as a system, be it simple or complex, man-made or natural, active or passive, hard or soft. It may be used for representing the problem, the solution, the organizations involved, or the *processes* of obtaining, managing and operating the solution. It can describe the system as a complete whole or as a structure of parts, and allows each part of a complex system to be characterized in any degree of detail, while keeping complexity under control.

At an *introductory level*, the language of P/p modelling is simple enough to be learned quite rapidly. Thereafter, anyone can use a P/p modelling to create a representation of a system, and anyone can read and interpret the representation created by others. Thus, the language of P/p modelling can be used throughout the constituency of a project, facilitating the expression of ideas and serving as the means of communication between all concerned.

The skills of P/p modelling can be refined into a *professional skill*. The systems professional can use P/p modelling and model based measurement in eliciting from the client the specification of the problem and the required solution, devising solution strategies, creating, analyzing and verifying over-all designs, guiding and managing system development, and interfacing between systems models and other, specialized methods and professional formalisms. P/p modelling also serves in assuring, controlling and enhancing quality throughout the project and in course of the utilization of the solution.

## *Structure of the book*

The book is divided into three parts.

*Part 1* is at an introductory level, requiring no preliminary preparation. It presents all the basic ideas and defines all key concepts of a systems approach [6].

Chapter 2 discusses the nature of *problems* and the processes of *communication*.

Chapter 3 explains the notion of ‘definition’, the importance and use of definitions from the viewpoint of problem solving, and the characteristics of definitions of good quality. It also defines other key *general concepts*, among them ‘measurement’, ‘time’, ‘attribute’, ‘representation’ and ‘language’.

Chapter 4 offers a historical perspective of the systems approach, and goes on to define key *systems concepts*, among them ‘system’, ‘referent’, ‘black box’, ‘structure’, ‘product’, ‘process’ and ‘systems methodology’. It also distinguishes various types of graphs, since graphs form the basis of the language of Product/process modelling.

Using these foundations, Chapter 5 introduces *Product/process modelling*: a generic, widely applicable method for representing problems, solutions and the processes leading from one to the other. Product/process models are simple in presentation, easy to use and understand, and their syntactical correctness is verifiable.

Chapter 6, the closing chapter of Part 1, uses Product/process modelling to review in detail the *problem solving process*, and discusses alternative problem solving strategies. It acts as a route map to problem solving: a process that is often confusing and ill delineated. This chapter defines ‘specification’, introduces a novel distinction between problem specification and requirement specification, and follows the evolution of the solution from the initial idea to the final validation of the implementation.

*Part 2* is for the more advanced reader who has become acquainted with the contents of Part 1, perhaps with the view of becoming a systems professional. It offers deeper understanding of the concepts introduced in Part 1, expressing them formally, developing them further, and using the methods rigorously. In this part of the book, the presentation of ideas in natural language and in diagrams is complemented with mathematical symbolism. Mathematics can offer powerful assistance to the problem solver in expressing ideas precisely, and reasoning about them securely. The mathematics used is of a basic nature: sets, functions and relations are used, and should not prove an obstacle to the specialist professional or the intelligent layman.

Chapter 7 defines ‘*system*’ as a mathematical entity, reinforcing the idea that ‘system’ is a universal notion, a representation of any entity in the real world. This definition gives the same format for representing a system as black box and as structure, and offers criteria for classifying systems. The chapter examines the role of the environment of the system and of the observer.

Chapter 8 is concerned with the fundamentals of *measurement*. It explains that a good measure need not be a number, and that, without a model defining their context, measures are meaningless. It reviews basic measurement scales, analyses the hierarchy of valid measurements, and shows the constraints which must be applied to 'utility' measures as the basis for forming and expressing value judgements and making informed decisions.

Chapter 9 explores the nature of the *black box representations*. It shows how to represent both individual items and classes of entities in the unambiguous framework of the generic system model detailed in chapter 7, and using the measures of chapter 8.

Chapter 10 applies the same argument to *structures* as chapter 9 did to black box representations. It explains the importance of structural representations, demonstrating that structures rely for their meaning on the black box representation of their basic components. This chapter also investigates the principle of constructivity: the need to define structures formally, such that one could derive the overall characteristics of the whole system from the characteristics of the components and the structural interrelationships between components.

One may regard the preceding chapters as an introduction to Chapter 11. Here we explain that any entity of the real world may be regarded as a *product* or a *process*, the two being distinguished by the attribute, of time duration. We then go on to define both products and processes as black boxes and as structures. The chapter also discusses all types of Product/process graphs, and introduces *gates*: essential modelling aids for structural representation.

*Part 3* is entirely devoted to practical issues of general interest, giving comprehensive illustrations of P/p modelling and model based measurement at work.

Chapter 12 deals in depth with the topic of *process management*, adopting a generic approach that applies both to hard and to soft systems. Numerous examples allow the reader to examine applications in individual fields. Analytical rigour demands that, where possible, natural language statements are mirrored in mathematical language, but these latter are in no way essential to understanding the contents.

Chapter 13 introduces the topic of the *maturity* of organizations. This is of vital importance to managers, and provides a unique measurement tool to guide improvements in managerial practice, which can easily be mapped, into current quality assessment standards. The chapter goes on to discuss the development of quality management and the use of quality certification standards the context of organizational maturity.

Chapter 14 is an account of *contract management*, offering an overview, encouraging detailed examination of the subprocesses involved, and illustrating the allocation of responsibility and the factors which must be taken into account to achieve an outcome satisfactory to all parties.

Each chapter contains many examples, and Parts 1 and 2 include a collection of exercises.

The text is complemented by a *Glossary* which collects the definition of key terms, showing how they are based on everyday notions, and how they relate to each other.

## 1.7 Footnotes and References

- 1 Independent on Sunday, 3.12.95.
- 2 Kuhn, T S: "The structure of scientific revolutions". University of Chicago Press, 1970.

3

paradigm

a set of scientific and metaphysical beliefs that make up a framework within which scientific theories can be tested, evaluated, and if necessary revised

Cambridge Dictionary of Philosophy, Ed. R Audi, Camb Univ Press, 1999

- 4 See e.g. the draft standard ISO/FDIS 9001:2000.
- 5 Interdisciplinary – involving two or more academic disciplines.  
Multidisciplinary – of, or relating to, the study of one study involving several subject disciplines. Source: Collins English Dictionary, 1992
- 6 We quote from the SE Handbook, version 1, INCOSE 1998. The handbook refers specifically to systems engineers, but the ideas apply to all members of the systems constituency.

"It is essential to advancement of the field of systems engineering that common definitions and understandings be established regarding general methods and terminology. As more systems engineers accept and use a common terminology, we will experience improvements in communications, understanding, and ultimately, productivity."

"In many well-established industries there is historical precedent and good reason not to change terminology. This is certainly acceptable. What is not acceptable is an undefined or inconsistent system terminology. The good systems engineer will ensure that an acceptable terminology is established very early in the program and communicated to all."