

Preface

The problems of understanding complex system behavior and the challenge of developing easy-to-use models are apparent in the field of business management. We are faced with the problem of optimizing economic goals while at the same time managing complicated physical and social systems. In resolving such problems, many parameters must be assessed. This requires tools that enhance the collection and organization of data, interdisciplinary model development, transparency of models, and visualization of the results. Neither purely mathematical nor purely experimental approaches will suffice to help us better understand the world we live in and shape so intensively.

Until recently, we needed significant preparation in mathematics and computer programming to develop, run, and interpret such models. Because of this hurdle, many have failed to give serious consideration to preparing and manipulating computer models of dynamic events in the world around them. Such obstacles produced models whose internal workings generally were known to only one person. Other people were unsure that the experience and insights of the many experts who could contribute to the modeling project were captured accurately. The overall trust in such models was limited and, consequently, so was the utility. The concept of team modeling was not practical when only a few held the high degree of technical skill needed for model construction. And yet everyone agreed that modeling a complex management process should include all those with relevant expertise.

This book, and the methods on which it is built, will empower us to model and analyze the dynamic characteristics of human–production environment interactions. Because the modeling is based on the construction of icon-based diagrams using only four elementary icons, the modeling process can quickly involve all members of an expert group. No special mathematical or programming experience is needed for the participants. All members of the modeling team can contribute, and each of them can tell immediately if the model is capturing his or her special expertise. In this way, the knowledge of all those involved in the question can be captured faithfully and in an agreeable manner. The model produced by such a team is useful, and those who made it will recommend it throughout the organization.

Such a model includes all the appropriate feedback loops, delays, and uncertainties. It provides the organization with a variety of benefits. The modeling effort highlights the gaps in knowledge about the process; it allows the modeling of a variety of scenarios; it reveals normal variation in a system; and, of course, it gives quantitative results. One of the more subtle values of team modeling is the emergence of a way of analogously conceiving the process. The model structure provides a common metaphor or analogous frame for the operation of the process. Such a shared mental analogue greatly facilitates effective communication in the organization.

Our book is aimed at several audiences. The first is the business-school student. Clearly, those being directly prepared for life in the business world need to acquire an understanding of how to model as well as the strengths and limitations of models. Students in industrial engineering often perform modeling exercises, but they often miss the tools and techniques that allow them to do group dynamic modeling. We also believe that students involved in labor and industrial relations should be exposed to this form of business modeling. The importance of the dynamics of management and labor involvement in any business process is difficult to overstate. Yet these students typically are not exposed to such modeling. In short, we want this book to become an important tool in the training of future process and business managers.

Our second general audience is the young M.B.A., industrial engineer, and human-resources manager in their first few years in the workplace. We believe that the skills acquired through dynamic modeling will make them more valued employees, giving them a unique edge on their more conventionally trained colleagues. This book is an introductory text because we want to teach people the basics before they try to apply the techniques to real-world situations. Many times, the first model a person will build is a complex model of an organization. Problems can result if the user is not grounded in the fundamental principles. It is like being asked to do calculus without first doing basic algebra.

Computer modeling has been with us for nearly 40 years. Why then are we so enthusiastic about its use now? The answer comes from innovations in software and powerful, affordable hardware available to every individual. Almost anyone can now begin to simulate real-world phenomena on his or her own, in terms that are easily explainable to others. Computer models are no longer confined to the computer laboratory. They have moved into every classroom, and we believe they can and should move into the personal repertoire of every educated citizen.

The ecologist Garrett Hardin and the physicist Heinz Pagels have noted that an understanding of system function, as a specific skill, must and can become an integral part of general education. It requires recognition that the human mind is not capable of handling very complex dynamic models by itself. Just as we need help in seeing bacteria and distant stars, we need help modeling dynamic systems. For instance, we solve the crucial dynamic modeling problem of ducking stones thrown at us or safely crossing busy streets. We learned to solve these problems by being shown the logical outcome of mistakes or through survivable accidents of judgment. We experiment with the real world as children and get hit

by hurled stones; or we let adults play out their mental model of the consequences for us, and we believe them. These actions are the result of experimental and predictive models, and they begin to occur at an early age. These models allow us to develop intuition about system behavior. So long as the system remains reasonably stable, this intuition can serve us well. In our complex social, economic, and ecological world, however, systems rarely remain stable for long. Consequently, we cannot rely on the completely mental model for individual or especially for group action, and often, we cannot afford to experiment with the system in which we live. We must learn to simulate, to experiment, and to predict with complex models.

Many fine books are available on this subject, but they differ from ours in important ways. The early book edited by Edward Roberts, *Managing Applications of System Dynamics* (Productivity Press, 1978), is comprehensive and yet based on Dynamo, a language that requires substantial effort to learn. *Factory Physics*, by Wallace Hopp and Mark Spearman (Irwin/McGraw-Hill, 1996), focuses on the behavior of manufacturing systems. They review the past production paradigms and show how dynamic modeling processes can improve the flow of manufacturing lines. *Business Dynamics*, by John Sterman (Irwin/McGraw-Hill, 2000), is a clear and thorough exposition of the modeling process and the inherent behavior of various if somewhat generic modeling forms.

In a real sense, our book is a blend of all three of these books. We focus on the use of ithink[®], with its facility for group modeling, and show how it can be used for very practical problems. We show how these common forms of models apply to a variety of dynamic situations in industry and commerce. The approach we use is to start from the simplest situation and then build up complexity by expanding the scope of the process. After first giving the reader some insight into how to develop ithink models, we begin by presenting our view of why dynamic modeling is important and where it fits. Then we stress the need for system performance measures that must be part of any useful modeling activity. Next we look at single- and multistep workflow processes, followed by models of risk management, of the producer/customer interface, and then supply chains. Next we examine the tradeoffs between quality, production speed, and cost. We close with chapters on the management of strategy and what we call *business learning systems*. By covering a wide variety of topics, we hope to impress on the reader just how easy it is to apply modeling techniques in one situation to another that initially might look different. We want to stress commonality, not difference!

In this book, we have selected the modeling software ithink with its iconographic programming style. Programs such as ithink are changing the way in which we think. They enable each of us to focus and clarify the mental model we have of a particular phenomenon, to augment it, to elaborate it, and then to do something we cannot otherwise do: find the inevitable dynamic consequences hidden in our assumptions and the structure of the model. ithink and the Macintosh, as well as the new, easy-to-use, Windows[®]-based personal computers, are not the ultimate tools in this process of mind extension. However, the relative ease of use of these tools makes the path to freer and more powerful intellectual

inquiry accessible to every student. Whether you are a whiz at math or somewhat of a novice is irrelevant. This is a book on systems thinking and on learning how to translate that thinking into specific, testable models.

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