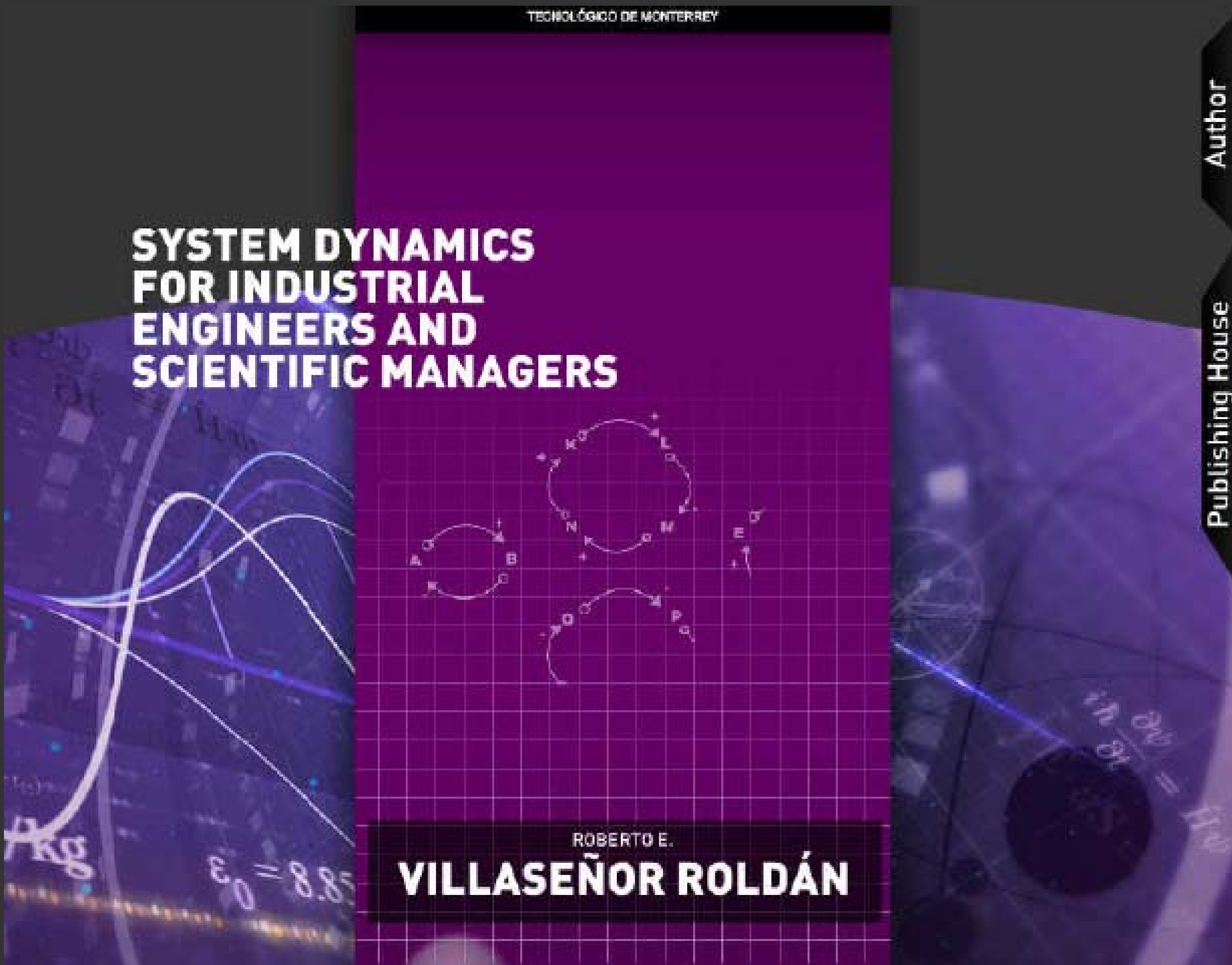
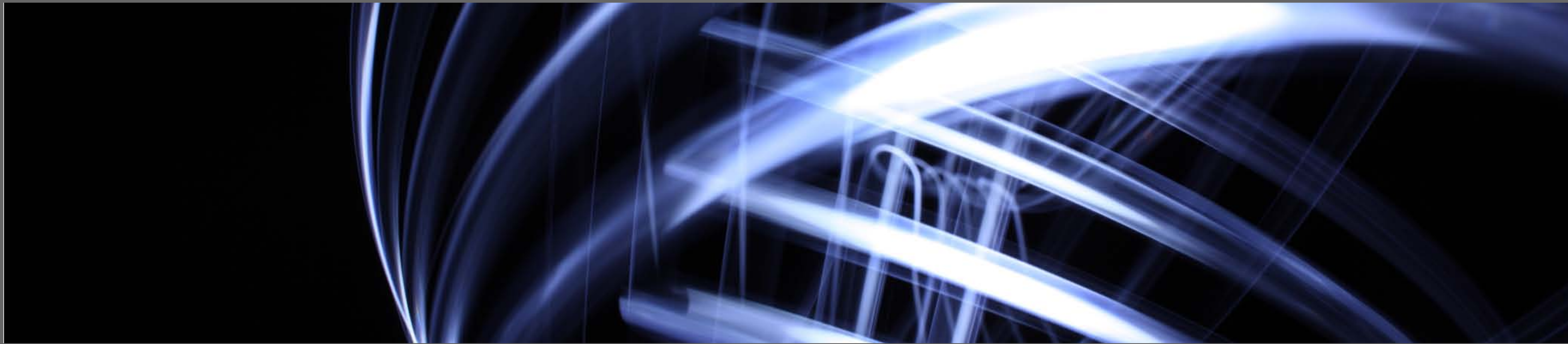

TECNOLÓGICO DE MONTERREY
SYSTEM DYNAMICS FOR INDUSTRIAL ENGINEERS AND SCIENTIFIC MANAGERS
ROBERTO E.
VILLASEÑOR ROLDÁN
Author
Publishing House

Concept Map

Systems Thinking and System Dynamics

Basis of System Dynamics

Application of System Dynamics



eBook Introduction

Industries and organizations face problems which are apparently isolated, events that disturb their status quo. These events may take the form of excess or lack of a certain raw material; unexpected new waves of orders or the sudden cancelation of many orders; a valuable collaborator leaving the company and joining the competition; lack of raw materials at a critical phase of the production. When these events happen, engineers and managers are tempted to assign randomness as the main cause for these events together with the chaotic nature of organizational life and its environment. In practice, engineers and managers tend to think that unexpected events are unavoidable and organizations must react and adapt when they appear.

However, under a different time horizon those events may look different because some of them appear with certain regularity. In such situations, engineers and managers know that periodical events are better called patterns. Since some of these patterns are relentless, randomness and chaos cannot be the cause for their emergence. Randomness hardly (if at all) explains the oscillatory behavior of some inventories; it cannot clarify why turnover of human resources increase over time; it hardly explains continuous batch rejections, rework, and their associated costs. Randomness cannot be the cause of events at a more strategic level: It does not explain organizational success or failure to innovate products and services; it is an unfortunate excuse for lack of planning and the preservation of an organizational culture. Since patterns that change the status quo still require explanation, external causes to the organizations, rather than randomness, are often quoted as the responsible for the emergence of such patterns, for example: Economic cycles; recession; emergence of new standards; changes in the market needs and wants; and tougher competition.

Due to the configuration of patterns, some engineers and managers are often capable of predicting their emergence and behavior because patterns are frequently very well structured. A structure can be understood as an established set of relationships between variables that produce a standard behavior. Jay W. Forrester, the founder of the field of study known as system dynamics, maintained that responsible analysis of structures and their associated patterns and behaviors normally would point out that causes of unexpected change are internal to organizations rather than external (Forrester, 1980).

In summary, although different organizational stakeholders observe the same situation, their approach to understanding and engaging that situation may be fundamentally different. If they choose to engage situations as isolated events, their time horizon would be short, and their solutions would focus on the immediate present. If they choose to engage situations as patterns, their solutions would include medium and short term actions; but they are likely to react to influences outside the organization, and blame the environment as the source of organizational disorder. Finally, stakeholders may choose structures as the focal point of their analysis. Such stakeholders would prefer long term analysis in order to understand how events evolved into patterns. They would also prefer to examine actions and interactions within organizations in order to place responsibility inside the organization rather than in the environment. The latter is the type of analysis this book considers to be a systems thinking view about organizations.

Organizational analysis informed by a systems thinking about organizations avoids short-term thinking because its solutions are likely to deliver immediate rewards but undesirable consequences in the long term. For example, single-event solutions such as “hire more people, “buy a more powerful machine, “offer more subventions, or “change the contract conditions, may be well intentioned and may bring immediate rewards to organizations. They may even lead to salary increases and promotions to those who suggested and implemented them. However, a systemic view may warn that:

- **Hiring more employees may increase production capacity, but after certain delay because new employees make mistakes and require training. If engineers and managers increase the production rate due to an isolated increase of demand, a higher level of workforce will mean more future costs and idle capacity.**
- **Introducing new technologies, such as more powerful machines, may increase throughput in the short term; however, unexpected consequences relating workforce level of training and costs may emerge. Engineers and managers are likely to know that new technologies often mask disorganization and sub-optimization.**
- **Increasing the amount of subventions may increase sales in the short term, but it also has an impact on intangible resources such as image and prestige of a brand. It may sacrifice future performance for present performance (Warren, 2008).**

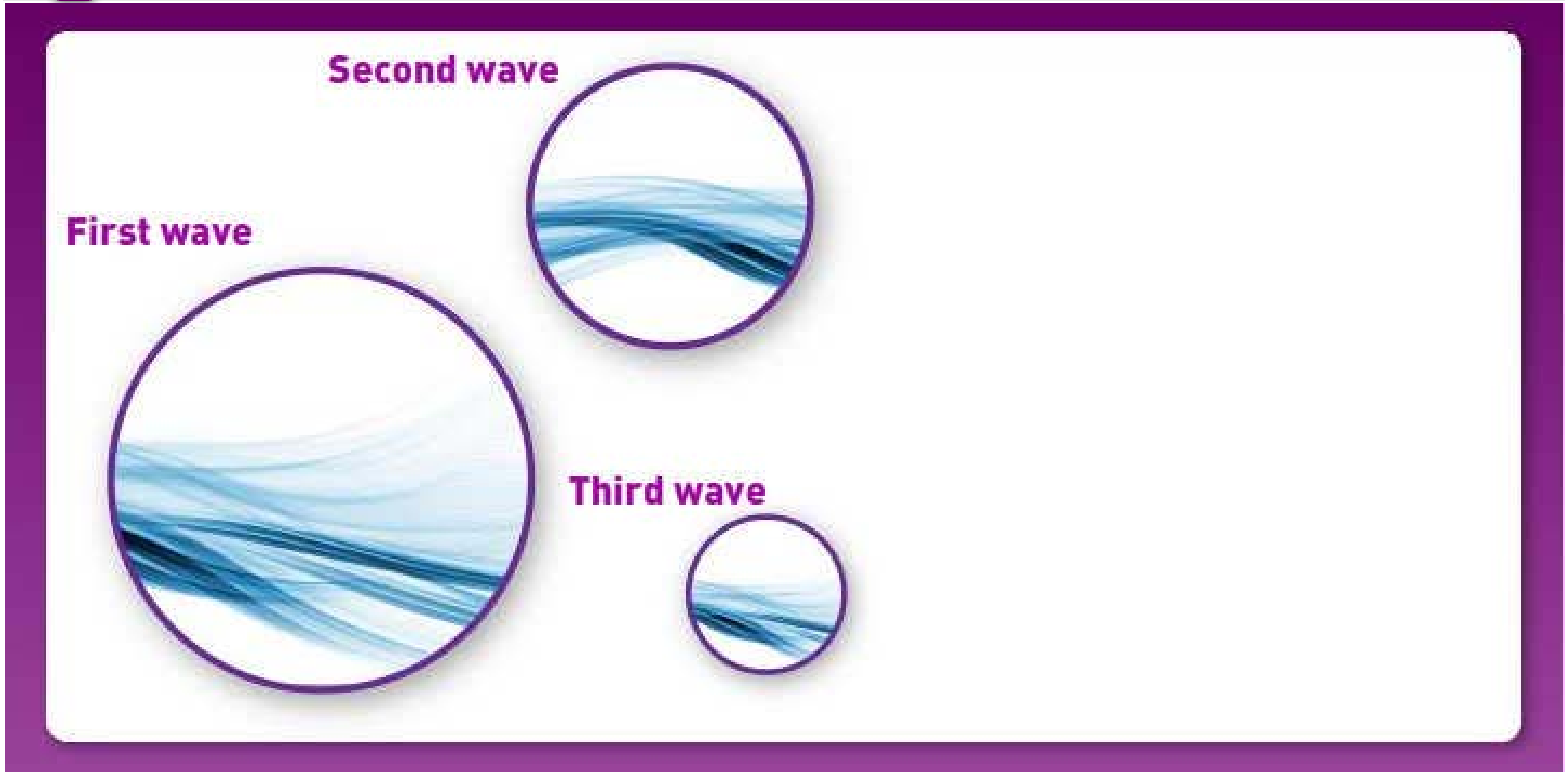
These arguments may not discourage engineers and managers to propose and implement courses of action. On the contrary, they should encourage actions informed by a systemic view, in particular informed by a system dynamics approach.

A system dynamics approach takes into account simplicity and complexity; it demands rationalization and imagination; it requires a microscopic and a telescopic view. It does not neglect the influence of external causes that disrupt organizational events; however, the main focus remains on the internal structure of organizations. It leads to ideas that sometimes are difficult to accept: For example, the idea that problems are self-inflicted, i.e. that certain solutions or strategies ultimately intensify those problems they intended to solve. Or to the notion that the overuse of a certain resource could lead to unexpected rather than gradual scarcity (Sterman, 2000; Meadows, 2008). A system dynamics approach may lead to a deeper understanding of organizational processes and capabilities, and to a realistic outlook of what can be changed, under which circumstances, and up to what degree.

System dynamics and systems thinking

System dynamics is part of a rich tradition of knowledge congregated under the umbrella name of systems thinking. According to Midgley (2000), systems thinking have evolved through three different waves of ideas and authors[1].

Click on the waves to show you the descripction of each one



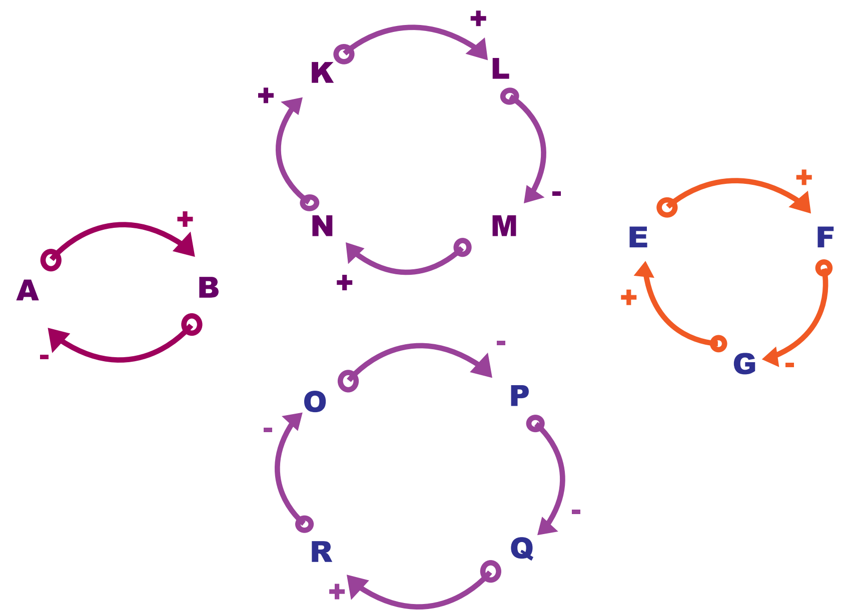
The purpose of this book is to make a contribution by further disseminating some systems thinking ideas; specifically, tenets and principles that have been nourished by the community of system dynamics practitioners. As a result, the book will explain to the reader that system dynamics is one systemic way to approach events, patterns and structures. System dynamics is both a philosophy and a practical approach that embrace short and long-term views (Meadows, 2008). It approaches real-world situations through models that could be individually or collectively constructed and simulated. It involves mental models and computer simulations. In order to accomplish this task, the book is structured in the following way:

The primary audiences of this book are practitioners of engineering and management disciplines interested in the systems dynamics approach. Therefore, it relies on themes and examples that are typical of industrial and organizational settings. However, it is important to emphasize that the scope of applications of system dynamics is far beyond industries and organizations.

The book was written having in mind those who are training for the engineering and management professions, and that have not been in touch with systems dynamics theory and practice. As a result, the book introduces concepts based on simple examples and then proceeds to increase understanding through more complex models. It is a book that introduces system dynamics to beginners. In order to accomplish this task, the following section describes the main four parts of the book.

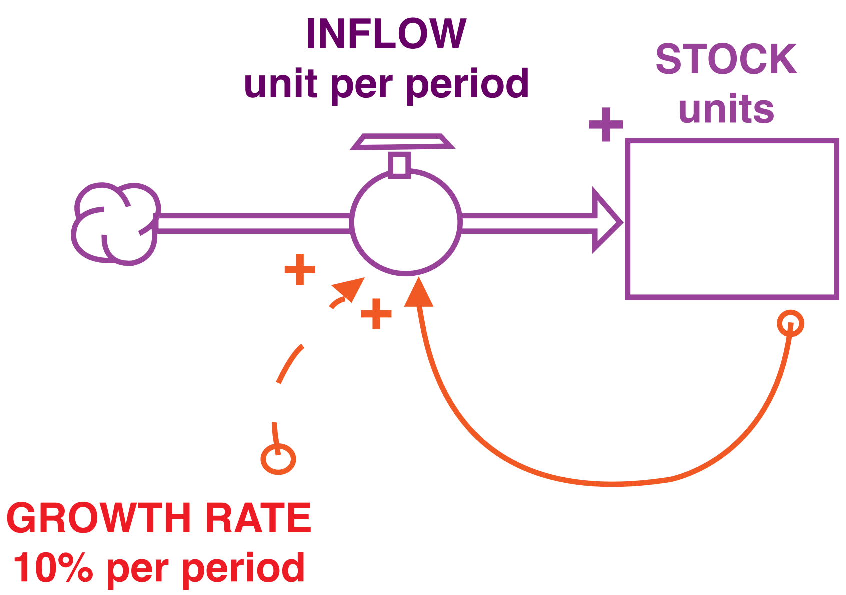
Description of the contents

Part 1. Systems thinking evolution



The main objective of the first part is to introduce readers to the main ideas of systems thinking and, in particular, of system dynamics as a field of study. In order to achieve this objective chapter 1 introduces the book and describes systems dynamics as one field of study within the systems thinking tradition. It presents the origins of the systems thinking tradition. It explains how systems thinking have split into two main schools of ideas and methods: the “hard” and “soft” approaches to systems thinking. This chapter also presents the basic concepts of system dynamics and their relation with the hard and soft systems thinking approaches. Finally it describes the basic principles of systems thinking as a field of study and practice.

Part 2. Building blocks to model dynamic systems

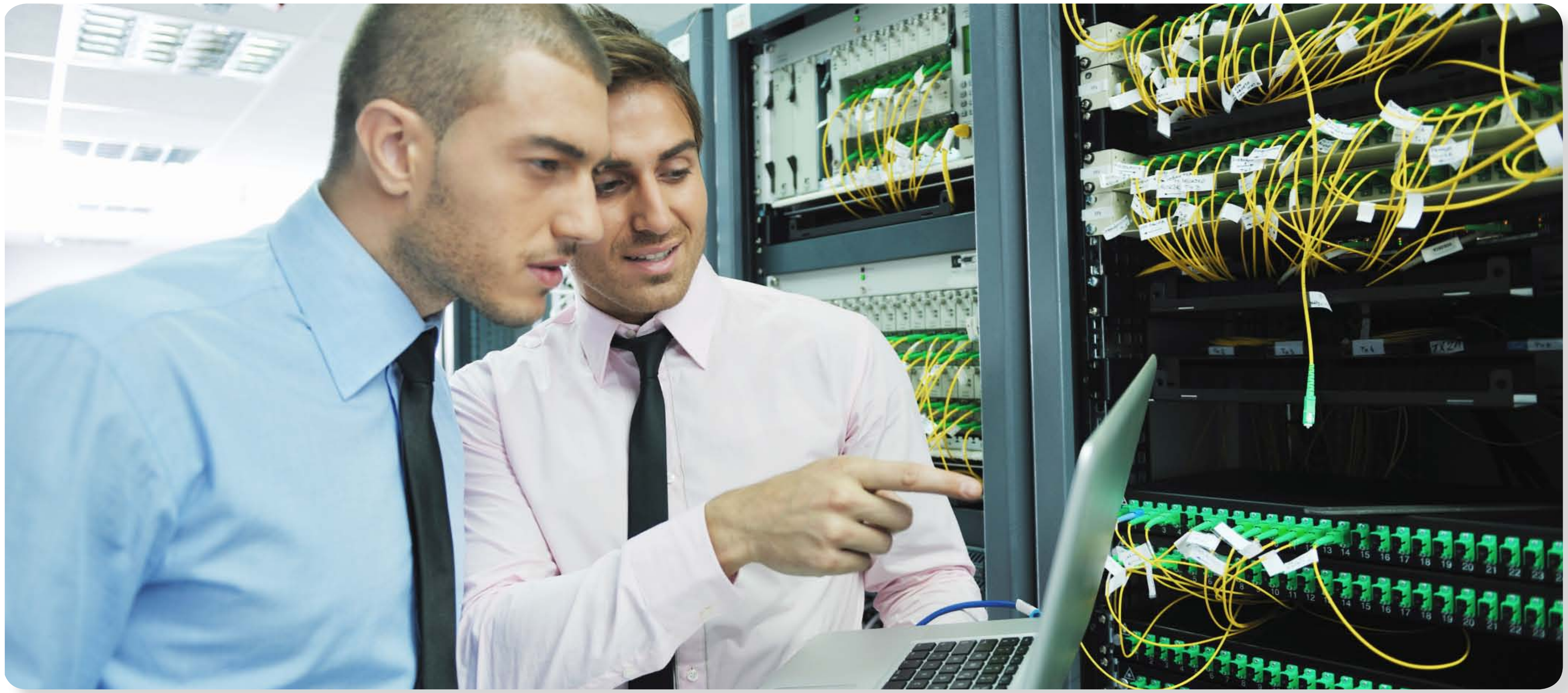


The objective of this part is to explain the three building blocks necessary to represent dynamic systems. First, chapter 2 explains how variables affect other variables through the concept of “polarity”. Then it explains how variables create patterns of behavior through the concepts of reinforcing and balancing feedback. Chapter 4 points out that while analyzing events, patterns and structures, systems thinkers may notice that some factors of a problematic situation seem to accumulate tangible or intangible entities while other factors facilitate or block such accumulations. Therefore, chapter 3 explores such accumulations and circulations called “stocks” and “flows”. Chapter 4 closes the second part of the book by linking the concepts reviewed in chapters 2 and 3. The result of such link is what this book calls the three basic archetypes for organizational understanding: Organizational systems based on growth; organizational systems based on adjustment; and organizational systems based on fluctuations. Chapters 2, 3 and 4 emphasize examples on industrial and organizational settings; however, due to the interdisciplinary approach of system dynamics they also refer to examples of other disciplines.

Part 3. Industrial engineering: A system dynamics explanation

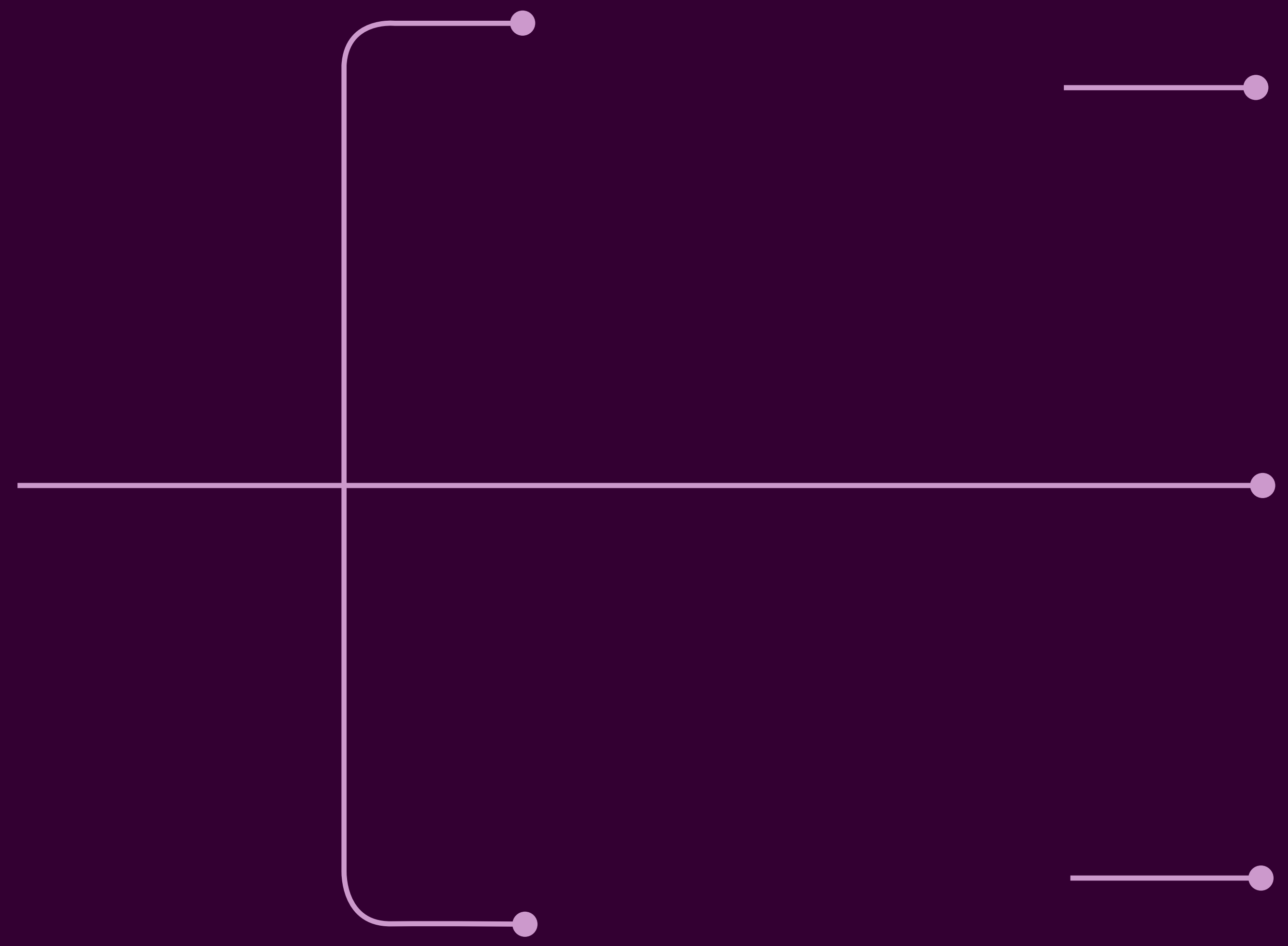
The final part of this book explains a wide variety of situations encountered in industrial engineering analyzed through the system dynamics theory. Chapter 5 explains the structures and behavior involved in modeling inventories and supply chains. Its focus is to help engineers and managers to understand and model supply and demand problems. Chapter 6 presents an account on how system dynamics may help practitioners to manage reverse logistics processes.

It is the hope of the author of this eBook that the models and explanations presented throughout the following chapters may help industrial engineers and managers to improve their understanding about organizational concerns through the discipline of system dynamics.



Chapter 1. Systems Thinking and System Dynamics

Graphic Organizer



Introduction

A system consists of a number of elements and the relationships between them (von Bertalanffy, 1969).

System does not refer to things in the world but to particular way of organizing out thoughts about the world (Flood and Jackson, 1991).

A system is a set of things interconnected in such a way that they produce their own pattern of behavior over time (Meadows, 2008).

The main objective of the first part of this eBook is to introduce the main ideas about systems thinking and, in particular, the relationship between system dynamics and systemic thinking. In order to fulfill this objective, section 1.1 describes the emergence of systems thinking as a field of knowledge and research. It argues that two interpretations or approaches have lead research and practice in systems thinking. Section 1.2 explores the main tents of the "hard" systems approach and one of its iconic interpretations: The Viable Systems Model. Section 1.3 explores the main concepts of the soft systems approach and its most influential set of ideas: Soft Systems Methodology. Section 1.4 introduces the main concepts underneath the theory of system dynamics and justifies why it fulfills the main objectives of the general systems theory. Finally, Section 1.5 presents the common tenets of systemic thinking as a field of study.

1.1 Origins of Systems Thinking

According to von Bertalanffy (1969), modern science is characterized by an increasing level of specialization. Such specialization splits science into several disciplines and sub-disciplines of knowledge. As a result, communities of scientists might become isolated within the models and ideas acknowledged as "appropriate" in their disciplines. According to Midgley (2000), it could be argued that the increased level of scientific specialization is the result of **reductionism**, which represents the idea that physical and social phenomena could be better understood by separating such phenomena into several simpler components. Experience has proved that decomposing physical and social phenomena into several components may eliminate "unnecessary complexity", allowing a clearer view of such phenomena. However, studying separated components of phenomena only allows partial knowledge about the phenomena because it discards the interactions between components; consequently, the resulting knowledge is likely to be limited (Midgley, 2000).

In order to avoid the limitations of a reductionist view of science, von Bertalanffy proposed the creation of a **general systems theory** that aimed to develop unifying principles and theoretical frameworks applicable to different disciplines.

Glossary

Reductionism

Represents the idea that physical and social phenomena could be better understood by separating such phenomena into several simpler components.

General systems theory

Set of principles aimed to develop unifying principles and theoretical frameworks applicable to different disciplines. At its maximum manifestation, the general systems theory attempted to create "a general science" concerned with discovering laws that applied to all systems regardless of their scientific background, and to discover the principles of organization at its various levels.

The general systems theory, as conceived by von Bertalanffy, was grounded in beliefs such as:

- **Similar frameworks of ideas have evolved out of different disciplines.**
- **It is possible and desirable to offer to the scientific community a common background (language and models) for the advancement and dissemination of their field of study.**
- **Limitations of fragmented disciplines could be overcome through such common background.**

In order to develop a general systems theory, von Bertalanffy together with the economist Kenneth Boulding, the biomathematician Anatol Rapoport, and the physiologist Ralph Gerard founded in 1954 the Society for the Advancement of General Systems Theory, later renamed Society for General Systems Research. The goals of the society were:

"… to (1) Investigate the isomorphy of concepts, laws and models in various fields, and to help in useful transfers from one field to another; (2) encourage the development of adequate theoretical models in fields which lack them; (3) minimize the duplication of theoretical effort in different fields; (4) promote the unity of science through improving communication among specialists." (von Bertalanffy, 1969; p. 15).

Although von Bertalanffy and his colleagues in the Society for General Systems Research are widely credited with the idea of searching the general principles of organization, other authors such as Alexander Bogdanov reflected and published this idea previously (Dudley, 1996).

At its maximum manifestation, the general systems theory attempted to create "a general science" concerned with discovering laws that applied to all systems regardless of their scientific background, and to discover the principles of organization at its various levels (from the atomic level to the planet as a whole; from the individual to the society). According to Jackson (2000), these hopes were never fulfilled. In fact, part of the scientific community rejected the general systems theory and dismissed it as trivial, vague, fantastic, presumptuous and hard to prove (von Bertalanffy, 1969).

Although the general systems theory failed to create "a general science", it triggered a plethora of frameworks and ideas around the "system" concept. In other words, the general systems theory did not evolve as a united field of study, but several interpretations about the purpose of systems emerged in the form of system's approaches. Such systems' approaches embrace different assumptions about the nature of systems (ontology), knowledge about systems (epistemology) and the ways in which systems should be studied and managed (methodology). Despite its pluralist development, frameworks of ideas based on systems have widely influenced the physical and the social sciences. As a result, it could be argued that the debate that the general systems theory triggered was its most important and lasting contribution.

The following sections describe some systems thinking approaches that, in the view of the author, have been the most influential in the systems literature, research and practice.

1.2 The Cybernetic Approach to Systems Thinking

One interpretation of the general systems theory is represented by the **Viable Systems Model (VSM)**. The author par excellence of the VSM was **Stafford Beer**, a British engineer who developed a model based on subsystems and their interactions, which all viable systems contain.

In an attempt to prove that the viable systems model could be deduced from natural systems, and that designed systems should resemble natural systems, Stafford Beer dedicated three parts (fifteen chapters) of his book “Brain of the Firm” to explain that the principles that govern the neurophysiology of humans should also govern the management systems of a firm.

The result of applying the viable systems model in organizational settings is a prototype of organization different from the classic organizational chart because it concentrates on the functions that every firm should perform in order to remain viable, not on positions that reflect organizational status (Beer, 1967).

1.2.1 The concept of System in Cybernetics

Cybernetics as defined by Weiner (1962) and Beer (1985) is the science of communication and control; and it focuses on the automatic responses of any entity (living body or machine). It seems that the term “cybernetics” was grounded by a group of people interested in issues such as communication and control:

Thus, as far back as four years ago, a group of scientists ... and myself had already become aware of the essential unity of the set of problems centering about communication, control and statistical mechanics, whether in the machine or in living tissue. On the other hand, we were seriously hampered by the lack of unity of the literature concerning these problems, and by the absence of any common terminology, or even a single name for the field ... We have decided to call the entire field of control and communications theory, whether in the machine or in the animal by the name of cybernetics, which we form from the Greek |J ®Σ⟩{| || *(Weiner 1962, p.11)*

According to Weiner (1962), cybernetics needs to focus on a specific entity. Aggregated entities become systems when there is a functional connection between them: A radio, a dog, a company, a society. Systems are composed by subsystems and are part of macro systems.

The system we choose to define is a system because it contains interrelated parts, and in some sense a complete whole in itself. But the entity we are considering will certainly be part of a number of such systems, each of which is a subsystem of a series of larger systems. (Beer 1967, p.10)

In general, the cybernetic approach to defining and managing systems has been labeled the “hard systems approach” to systems thinking. This may be because from

Glossary

Viable Systems Model (VSM)

Theory about systems developed by Stafford Beer based on the principles of cybernetics. The VSM has five subsystems as its components.

Stafford Beer

British engineer that developed the Viable Systems Model (VSM) following the principles of cybernetics.

this point of view systems are elements of the world that could be defined and controlled in order to perform a set of specific objectives. Perhaps the most influential methodologies embracing the hard systems approach are Systems Engineering (SE) and the Viable Systems Model (VSM). The following sub-sections describe both methodologies.

1.2.2 The Viable Systems Model (VSM)

The Viable Systems Model (VSM) developed by Beer is useful to represent a wide variety of complex-probabilistic systems. Such systems could be natural systems, like an animal, or artificial systems, such as machines or organizations. The VSM consists in five interconnected systems sharing resources, information and control loops. This section is dedicated to explaining the main features of the five systems of the VSM. Figure 1.1 shows a sketch of the VSM.

Click on the systems 1, 4 and 5 to show you the descripction of each one

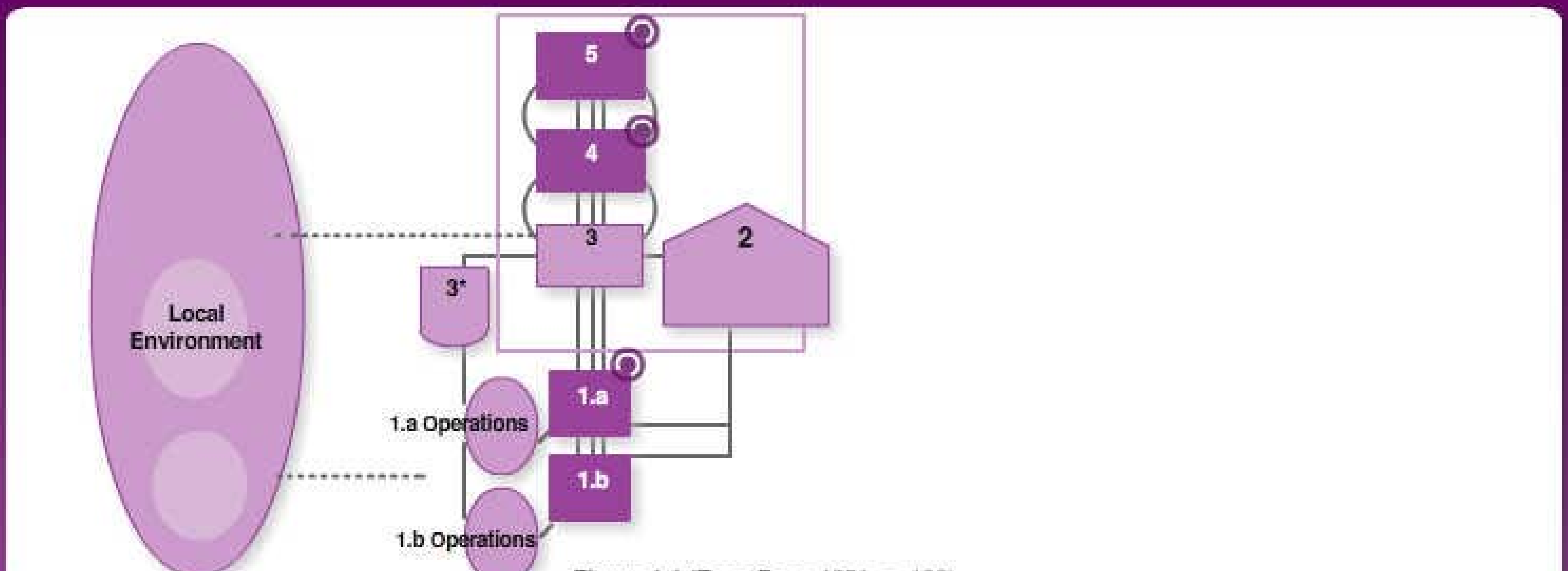


Figure 1.1 (From Beer, 1981, p. 130)

Glossary

System one of the VSM
Refers to the core function or functions that a system under study performs.

System four of the VSM
Is the function oriented to ensure future stability of the whole system by gathering and analyzing information about the global environment.

System five of the VSM
Generates the policies and rules of a viable system.

Apart from avoiding potential conflicts, system two is also responsible for generating synergy between the systems one it coordinates. Figure 1.2 shows how system two coordinates the managerial activities of several systems one in such a way that any change in a particular system one could be transmitted to the others in order to create synergy and avoid conflict (Beer, 1981).

Click on the system 2 to show you the description

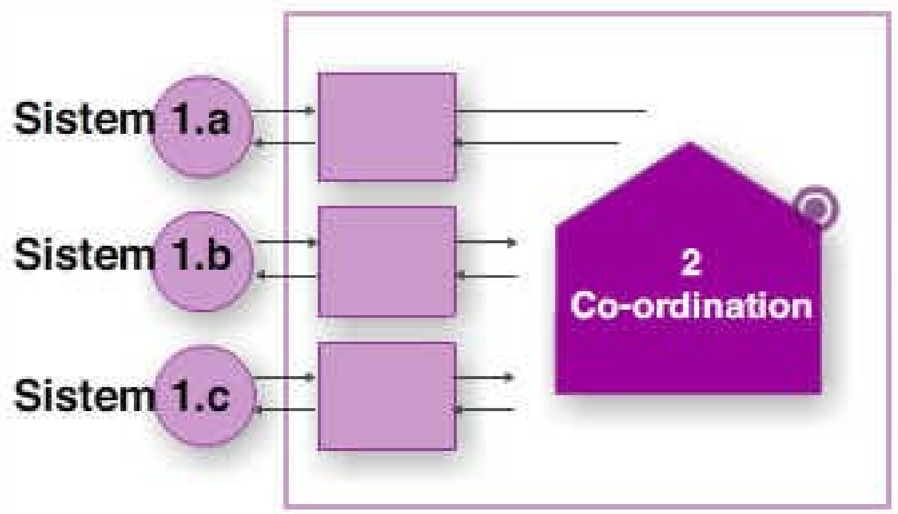


Figure 1.2

Click on the System 3 to show you the descriptcion

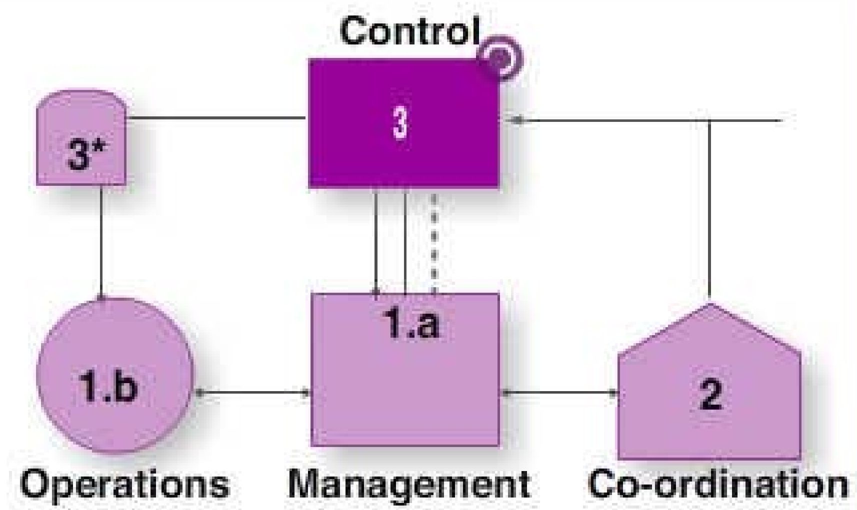


Figure 1.3

Glossary

System three of the VSM

Allocates resources, supports activities and interprets for systems one and two the policies generated by system five.

System two of the VSM

Is the function responsible to co-ordinate the

different systems one of a viable system.

One characteristic of the Viable System Model is its “recursivity”, which means that all viable systems contain viable sub-systems and are part of viable macro-systems. Figure 1.4 shows that system one is viable by itself because at a lower level of recursion it contains the five systems of another viable system (Beer, 1995).

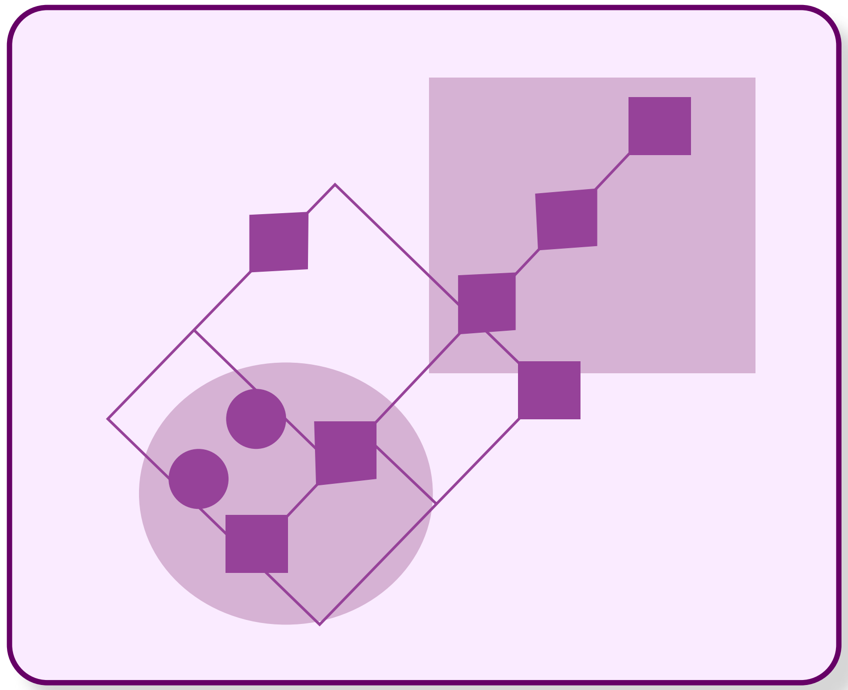


Figure 1.4 (From Beer. 1985, p. 19)

In summary, the viable systems model (VSM) could be defined as a set of necessary functions that any system must perform in order to remain viable. Such functions are: core operations and management, coordination, control, audits, information gathering and analysis, and policy generation. For example, the necessary functions could be located in systems that have proved to be viable such as animals, machines, some organizations and systems of governments. The viable system model also relies upon a series of feedback loops that communicate and control effectively all the functions of the system. The core aim of the five functions of the VSM and its feedback loops is to generate synergy in such a way that environmental variety is controlled (Beer, 1985).

A global overview of the Viable Systems Model as presented by Beer shows that the VSM, as an interpretation of the general systems theory, attempts to ground the systems ideal by describing the unique **structure** that all viable systems share. The modeling language is quantitative and structured-based (Wilson, 1990). The VSM relies heavily on the belief that this unique structure exists in the natural and social world. As a result, engineers and managers should wisely design or redesign their organizations following the principles of systems that have proved viability.

The following section describes another interpretation that grew from von Bertalanffy’s general systems theory. Such interpretation relies upon different assumptions about the nature of a system and the way to manage them.

Glossary

Structure

The set of variables and feedback loops that explain the emergence of events and patterns of behavior.

1.3 The Interpretive Approach to Systems Thinking

The last sections reviewed two approaches to systems thinking (systems engineering and VSM). Such approaches are characterized by models that attempt to optimize the objective of the system under study, mainly through quantitative and mathematical procedures. These approaches have proved their value in organizational settings because they provide methods and structures useful for managerial practice.

However, other members of the systems thinking community thought that the original intention to develop a holistic, interdisciplinary, experimental science addressing problems in social systems was betrayed and systematically mathematized. For example, **C. West Churchman**, an American philosopher and logician who was nominated for the Nobel Prize award in the social systems field, believed that systems thinking should be employed for the betterment of humanity (Churchman, 1987). He believed that the systems approach has the power to improve scientific practice. His contribution to systems thinking is summarized in the following sub-section.

1.3.1 The concept of system in soft approaches

Churchman's philosophy about systems thinking was based on four central ideas:

1. The systems approach is based on the idea that every point of view about social phenomena is unavoidably restricted. Therefore, the system's ideal is better approached when an individual (a systems thinker) attempts to see the world through the eyes of another individual. This may allow the systems thinker to understand the world from different points of view; of special interest are those views that embrace opposed philosophical positions. By bringing together different subjectivities, the restricted nature of any point of view can be overcome, and the "wholeness" of a system may be better appreciated (Churchman, 1987).

2. Since the only way a systems thinker can get a comprehensive view of a social system is to look at it from as many perspectives as possible, Churchman encouraged those in

Glossary

C. West Churchman

An American philosopher and logician who was nominated for the Nobel Prize award in the social systems field. He believed that systems thinking should be employed for the betterment of the humanity.

charge of managing social systems to accept different evaluations, purp and measures of performance of such systems. In other words, social systems are not restricted to one objective, but they have multiple objectives and serve several purposes (Churchman, 1987).

3.The problem is that individuals'world-views are usually highly resistant to change because they are unavoidably based on certain taken-for-granted assumptions; i.e. individual world-views are also "mental traps". Therefore, individuals' world-views cannot be seriously challenged unless individuals become aware of the taken-for-granted assumptions. The conclusion is that systems thinking requires a dialectical debate to help individuals to overcome their personal mental traps (Churchman, 1987).

4. In contrast with the systems idea of Systems Engineering and especially regarding the Viable Systems Model, C. West Churchman pointed out that the boundaries of a system are personal or social constructs that define the limits of the knowledge, that is, the definition of a particular system is not given but depends on the point of view of those affected or benefited by the system. Therefore, Churchman argued that there are no experts in the systems approach. When it comes to social systems, pushing out the boundaries of analysis may also involve pushing out the boundaries of who may legitimately be considered a decision maker of the system (Churchman, 1987).

In summary, Churchman proposed a radically different view about systems thinking. His view suggests that in order to understand social systems it is imperative to "sweep in" sufficient points of view about such systems in order to paint a rich and complex picture of them. In general, this view about the systems ideal has been labeled the "soft systems approach" to systems thinking (Flood and Jackson, 1991).

In the view of the author of this book, the difference between the "hard" and "soft" approaches to systems thinking is not trivial since it has effectively divided the systems thinking community in several research groups (Lane, 1984, Richmond, 1994). Although there are many breaking points between these two approaches, it could be argued that the main difference between the hard and the soft systems approaches is the way they understand the nature of systems (Flood and Jackson, 1991). "Hard systems thinkers" would prefer to understand systems as elements of the world, with a single purpose, which could be optimized through systematic methods. In contrast, "soft systems thinkers" prefer to think that systems are not entities of the world, but mental models or personal constructs that embrace subjective judgment. As a result, systems are not eligible for optimization but for learning (Checkland, 1981; Checkland and Scholes, 1990).

One of the most influential authors of the soft systems approach has been **Peter Checkland**, who followed Churchman's ideas and developed the Soft Systems Methodology also known as SSM which is explained in the following section.

1.3.2 Soft Systems Methodology (SSM)

Following Churchman's ideas, Peter Checkland developed the **Soft Systems Methodology (SSM)**. This methodology could be better described as a process of enquiry rather than a process for optimizing systems.

A starting point to understand SSM is recognizing the different nature of social and natural systems. Social systems are different from natural systems because in social systems actors inside them assign different purposes to such systems. For example, following this principle, a systems thinker may observe that a social system, such as an organization, fulfills different purposes for different stakeholders; organizations are multi-purpose rather and single oriented groups. Therefore, social systems do not have absolute definitions but their definition depends on the point of view or **weltanschauung**. Every stake-holder is motivated by his own point of view to generate actions in order to fulfill his own objectives. Such purposeful actions are called **human activity systems**.

Human activity systems embrace a particular interest which may be implicit to individuals or explicit to them; it may also be individual or shared. According to Checkland, social systems are necessarily better understood from different points of view; and since there are no privileged or unitary points of view in a system, it makes no sense to optimize them. Instead, soft systems thinkers, whom Checkland also called would-be-improvers, struggle to improve systems by learning about the different human activity systems and accommodate the interests each one embraces. Therefore, the aspiration of SSM is more oriented to learning than to optimizing.

Glossary

Peter Checkland

British scholar who developed the Soft Systems Methodology (SSM). This methodology could be better described as a process of enquiry rather than a process for optimizing systems.

Soft Systems Methodology (SSM)

Systems methodology that aims to improve problematic situations based on stakeholders perceptions and mental models. It could be better described as a process of enquiry rather than a process for optimizing systems.

Weltanschauung

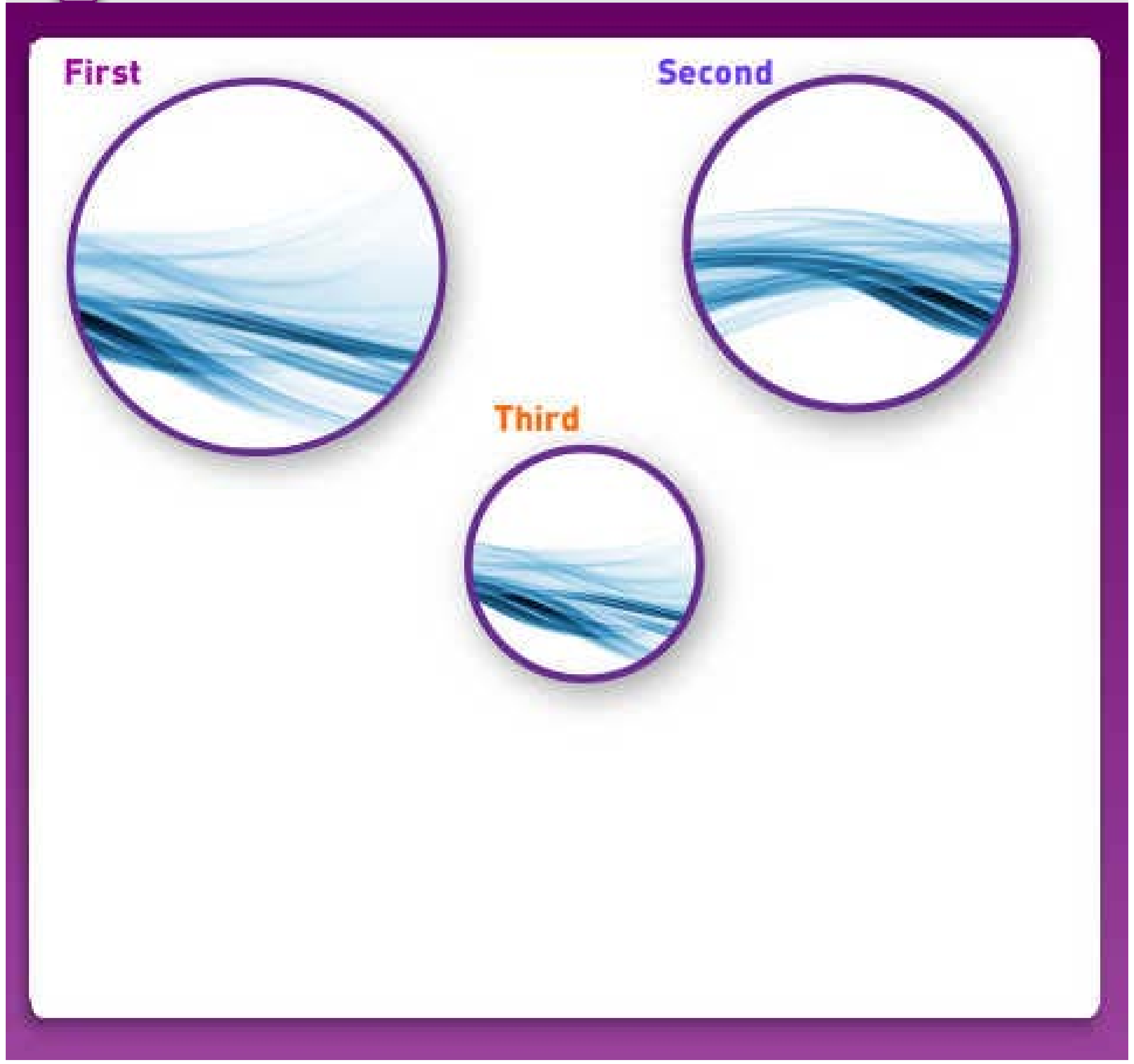
The point of view from which someone appreciates a situation.

Human activity system

Set of activities and actions that stakeholders of a situation take in order to fulfill their own objectives.

It could be argued that soft systems methodology is grounded in the following tenets:

Click on each wave to view the description.



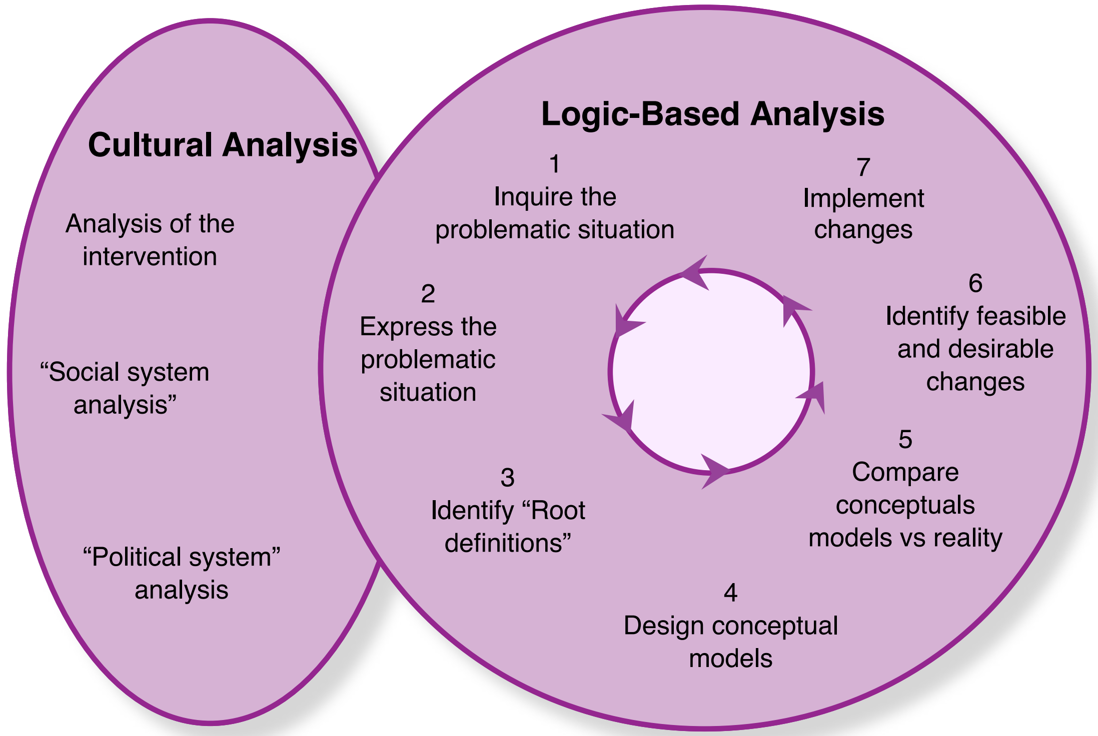
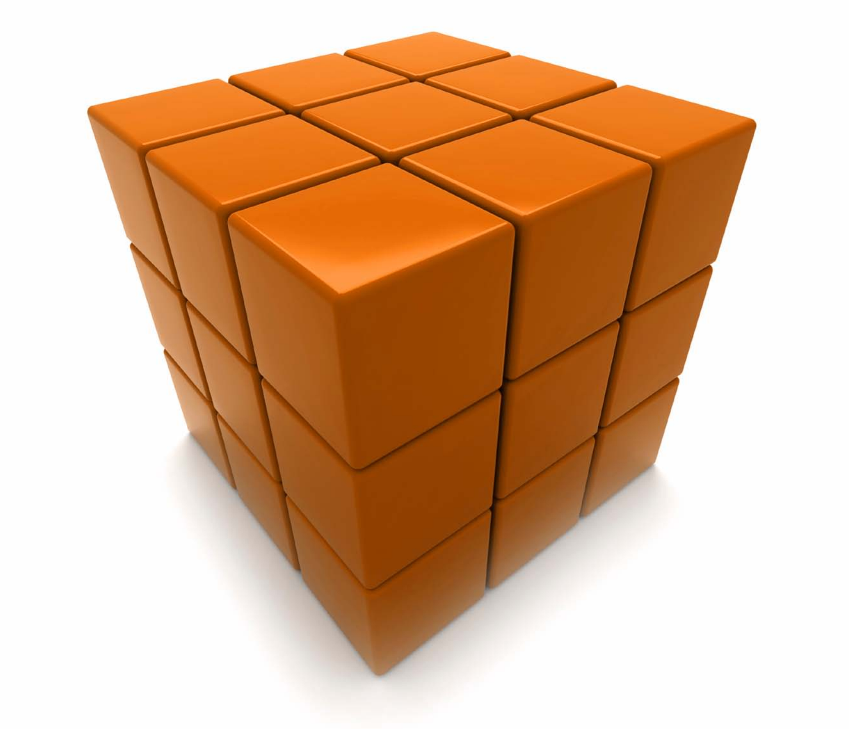


Figure 1.5 The process of SSM

Taken and adapted from Checkland and Scholes (1990)

Finally, improvement activities affect interests and change the way stakeholders appreciate a situation. Ideas for improvement that are implemented are likely to affect in some degree stakeholders' interests. As a result, such ideas may be welcomed or rejected. Therefore, systems thinkers should help stakeholders to accommodate their interests inside the problematic situation. This may be a never-ending approach to improve a problematic situation (Checkland and Scholes, 1990). The ideas stated in the last paragraph were presented by Checkland (1981) in a seven stage process format, which has been developed to the most recent version and is shown in Figure 1.5. It is worth noticing that Figure 1.5 represents a systemic process of enquiry rather than a systematic step by step process (Checkland & Tsouvalis, 1997).

According to Checkland and Scholes (1990), SSM process starts with one person or a set of people that would like to improve a situation in the real world that might be affecting their lives. Usually these people initially find it difficult to define a specific and well-structured problematic situation. Perhaps they only know that something about the problematic situation could be improved. According to Figure 1.6, systems thinkers may follow two different types of analysis simultaneously.



Cultural Analysis. The first part of the analysis suggests systems thinkers study the problematic situation as if it were a social system; i.e., a system in which individuals display norms, roles and values.

The second part of the cultural analysis encourages systems thinkers to study a problematic situation as if it were a political system; i.e., understanding stakeholders' interests and relations of power.

Finally, systems thinkers are encouraged to become aware that the single act of observing stakeholders of a problematic situation might change such problematic situation. Therefore, systems thinkers should understand the way in which their values and intervention activities affect the process of enquiry (Checkland and Scholes, 1990).

In summary, the aim of the cultural analysis is to help systems thinkers to understand the problematic situation from a cultural and political perspective; and to understand how their own values and activities affect the problematic situation.

Logic-based analysis. The logic-based analysis encourages systems thinkers to express the problematic situation based on the different points of view that stakeholders have about such situation. Some points of view may present the situation as beneficial, while other points of view may judge the situation as impartial or even detrimental (phases 1 and 2).

Phase 3 of the logic/based analysis encourages systems thinkers to select a set of stakeholders' human activities that reflect interests that are believed to be relevant in order to modify the problematic situation. These activities are called relevant systems and they are useful to formulate root definitions. In general, we can classify root definitions in two categories:

[1] Primary task root definitions express a notional human activity system whose system boundary might be expected to coincide with real world organizational boundaries. For example, 'official' tasks. [2] Issue based root definitions boundaries do not in general coincide with real world manifestations (Checkland & Tsouvalis 1997, p.154)

Checkland (1981) encourages systems thinkers to select primary task and issue based root definitions in order to conduct the enquiry process. Naturally, the selected relevant systems depend on the perception of the systems thinkers, and no method may guarantee the selection of the 'best' root definitions. Therefore, it could be argued that root definitions could be treated as heuristic ideas to explore the system (Checkland and Tsouvalis, 1997).

According to Checkland and Scholes (1990), one way to express root definition is the **CATWOE** 'formula', which has as its center piece the transformation process as seen by a particular stakeholder. Table 1.1 presents the CATWOE "formula".

C	clients	Who are the victims or beneficiaries of the transformation process?
A	actors	Who perform the transformation process
T	transformation proces	Which seems to be the transformation process that these activities pursue?
W	weltanschauung	Which World view makes the transformation process meaningful?
O	owners	Who have the power to stop the transformation process
E	environmental constraints	Which elements outside the transformation process are required?

Table 1.1 The CATOWE "formula"

Phase 4 of the logic-based analysis encourages systems thinkers to think about the ideal activities that are required in order to achieve the transformation process stated in the root definitions. Checkland (1981) calls this activity "modeling relevant systems", and it is important because the list of activities is the source of ideas for change. Phase 5 encourages systems thinkers to verify if the ideal activities generated in phase 4 are performed in the real-world situation. Those ideal activities that are not currently performed could be ideas for improvement only if the stakeholders consider them culturally desirable and technically feasible (phase 6). The last phase of the logic-based analysis invites stakeholders and systems thinkers to implement feasible and desirable actions in order to improve the situation perceived as problematic. Naturally, such implementation would affect the problematic situation and some stakeholders may change their perception of it. As a result, the seven phases are subject to second review and implementation.

In summary, soft systems thinking as an interpretation of the **General Systems Theory (GST)** have the following characteristics: First, it does not accept an absolute definition of a system or of a problem; instead, the recognition of equally valid points of view is privileged. Second, systems are not structures of the world, but personal constructions that are useful in order to orchestrate a debate (Midgley, 2000). Third, in contrast with the "hard" approaches to systems thinking, the "soft" approach uses verbs describing

Glossary

CATWOE

"Formula"which means customers, actors, transformation process, owners and environmental constraints.

General Systems Theory (GST)

Set of principles aimed to develop unifying principles and theoretical frameworks applicable to different disciplines. At its maximum manifestation, the general systems theory attempted to create "a general science" concerned with discovering laws that applied to all systems regardless of their scientific background, and to discover the principles of organization at its various levels.

purposeful activities as its main modeling language (Wilson, 1990); mathematics and quantitative analysis are kept to a minimum. Forth, the true source ideas for systems' improvement come from the stakeholders involved in such systems. Stakeholders are the experts that could validate actions for improvement. Finally, according to Checkland (1995) the most important outcome of the "soft" systems approach to systems thinking is learning about a particular system, rather than optimizing it.

The following section introduces the systems dynamic approach to systems thinking and its relation with the hard and soft tradition explained above.

1.4 The Systems Dynamics Approach

Section 1.1 described the General Systems Theory (GST) of Ludwig von Bertalanffy as the foundation theory of systems thinking. Sections 1.2 and 1.3 described two interpretations of the GST. On the one hand, the "hard" interpretation of systems thinking has favored the emergence of methods based on clear definitions about systems and their problems. This interpretation tends to use mathematics and structures as its main modeling language. In contrast, the "soft" interpretation of systems thinking refuses the idea that systems are elements of the world, and embraces the belief that systems are mental models that individuals use in order to make sense of the world. This interpretation of systems thinking uses verbs as modeling language and its improvement methods tend to favor debate between stakeholders (Wilson, 1990).

This section introduces the basic concepts of system dynamics and its relation with the General Systems Theory. It describes System Dynamics as an influential field of study and why it is considered a grounded interpretation of the General Systems Theory.

1.4.1 Events, patterns of behavior and structures

A useful starting point in order to explain the core ideas of system dynamics is to explore the notions of events, patterns of behavior and structures. According to Anderson (1997), an event represents a single occurrence which is different from the regular behavior of a system. Examples of events in organizational settings are: single breakdown of a machine, an employee leaving the company, and the appropriation of a new contract. Such events occur isolated and are often regarded as non-important.

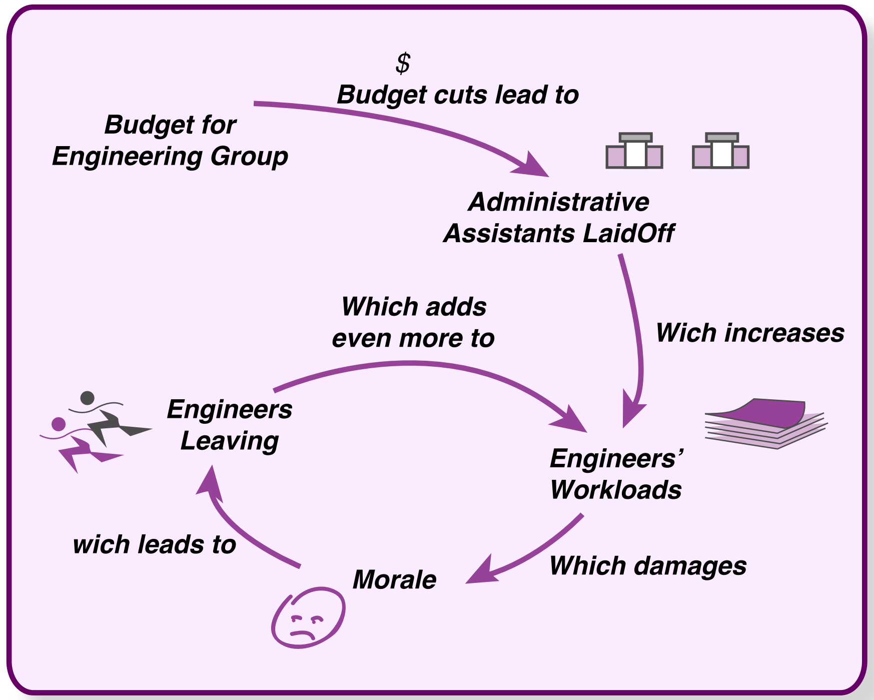


Figure 1.6 "The enginners exodus"

Taken from Anderson (1997)

However, when events occur continuously and seem to repeat with certain regularity, they stop to be considered as trivial because they have evolved into patterns of behavior. Patterns of behavior are noted more often than single events because they cause constant annoyance and their cost tends to be higher. For example, patterns of behavior in organizational settings may include continuous machine breakdowns; several employees leaving the company in the last year; and winning several profitable contracts in the last five years.

A core difference between events and patterns of behavior is that the latter call for an explanation and a feasible enduring solution. The set of reasons that explain the emergence of patterns of behavior is called structure (Anderson, 1997). A robust structure not only explains why an event evolved into a pattern of behavior but also suggests an enduring solution. Figure 1.6 exemplifies the concepts of event, pattern of behavior and structures.

System dynamics is a systems thinking approach that attempts to explain the complexity of systems by understanding structures that create patterns of behavior of events.

1.4.2 Accumulation and circulation

While differentiating between events, patterns and structures, systems thinkers may notice that some factors of a problematic situation seem to accumulate tangible or intangible entities, while other factors facilitate or block such accumulations. For example, a problematic pattern of events that a firm may face is lack of sales. Lack of sales usually causes firms to accumulate inventory. The firm may react by decreasing the amount of shipments that it receives from its suppliers in order to keep its inventory from accumulating products. Figure 1.7 describes such a situation.suppliers in order to keep its inventory from accumulating products. Figure 1.7 describes such a situation.

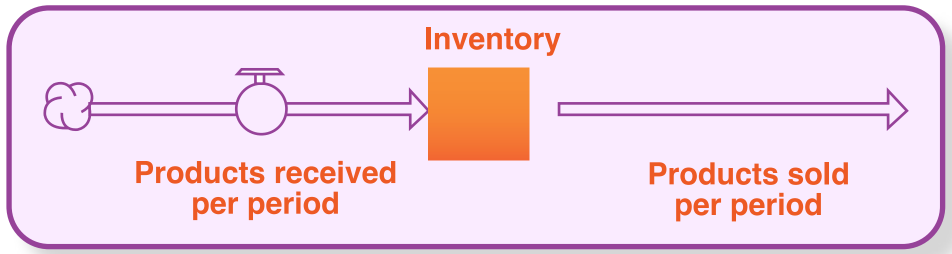


Figure 1.7 Accumulations and Circulations

Systems thinkers may infer from Figure 1.7 that inventory is a factor that accumulates the history of sales and shipments received in the last periods. In system dynamics, factors that accumulate entities are called “stocks” while factors that allow circulation of entities are called “flows”. **Stocks** and flows are central concepts in system dynamics theory because they represent, in a quantitative way, how events evolve into patterns.

1.4.3 Loops not lines

A third central element in systems dynamic theory is the concept of feedback. Following the basic tenets of the General Systems Theory, system dynamics attempts to understand the complexity of systems. A common mistake that constraint understanding of complex systems is to think that events have a single cause, or that causes create only one **event**, such as the following figure illustrates:

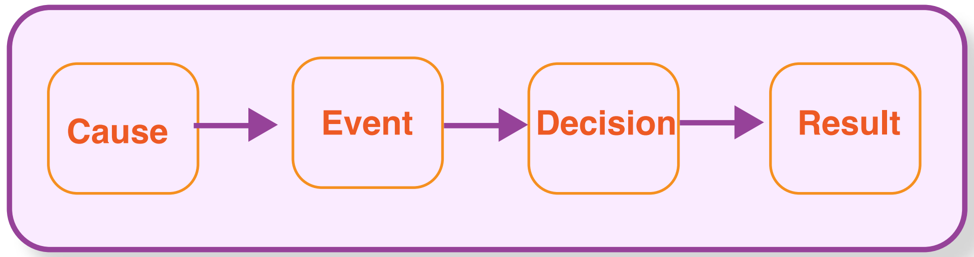


Figure 1.8 Event-oriented view fo the world.
Taken and adapted from Sterman (2000)

Sterman (2000) calls the type of thinking depicted in Figure 1.8 “event-oriented view of the world”. Such type of thinking creates two illusions: First, it leads to believe that “a problem” has a single cause and that such problem could be solved by removing such cause. Second, it leads to believe that actions taken in order to solve a problem only deliver intended consequences.

Glossary

Stocks

Stocks are variables that accumulate or store tangible or intangible entities of the same type.

Event

A single occurrence which is different from the regular behavior of a system.

In contrast, system dynamics theory is based on the belief that events evolve into patterns of behavior because such events have a regular cause and such a cause often has its origin in the event itself. The result could be understood as a cycle or loop in which causes and events influence each other. Figure 1.9 illustrates the mutual influence between cause, events, decisions and results due to feedback loops.

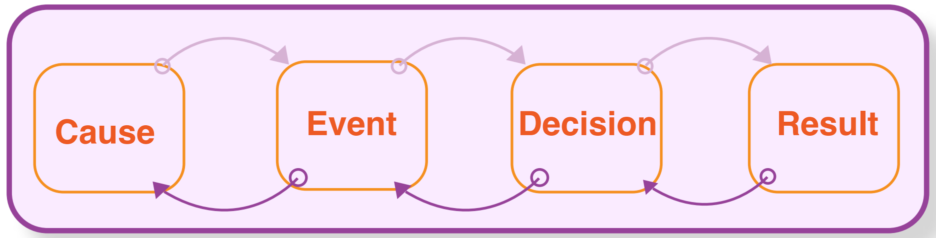


Figure 1.9 Feedback view of the word

Systems thinkers following the System Dynamics approach avoid the event-oriented view of the world and endeavor to understand the complexity of systems by uncovering the feedback structures present in such systems. This view about systems thinking leads practitioners to believe that the complexity of systems is caused and found within the systems themselves. In Meadows (2008) words, systems are the cause of their own behavior.

1.4.4 Relation between GST and SD

When systems thinkers join the concepts reviewed in the last subsections (events, patterns of behavior, structures, accumulations, circulations, and feedback loops), they engage in the systems dynamics approach to systems thinking.

According to Sterman (2000), System Dynamics could be understood as a method to enhance learning about complex systems. In the view of the author of this book, System Dynamics is not only a method but a methodology, i.e., a "set of theoretical ideas that justifies the use of a particular method" (Midgley, 2000; p.105). Perhaps System Dynamics methodology is mostly known due to diagrams such as the one shown in Figure 1.10:

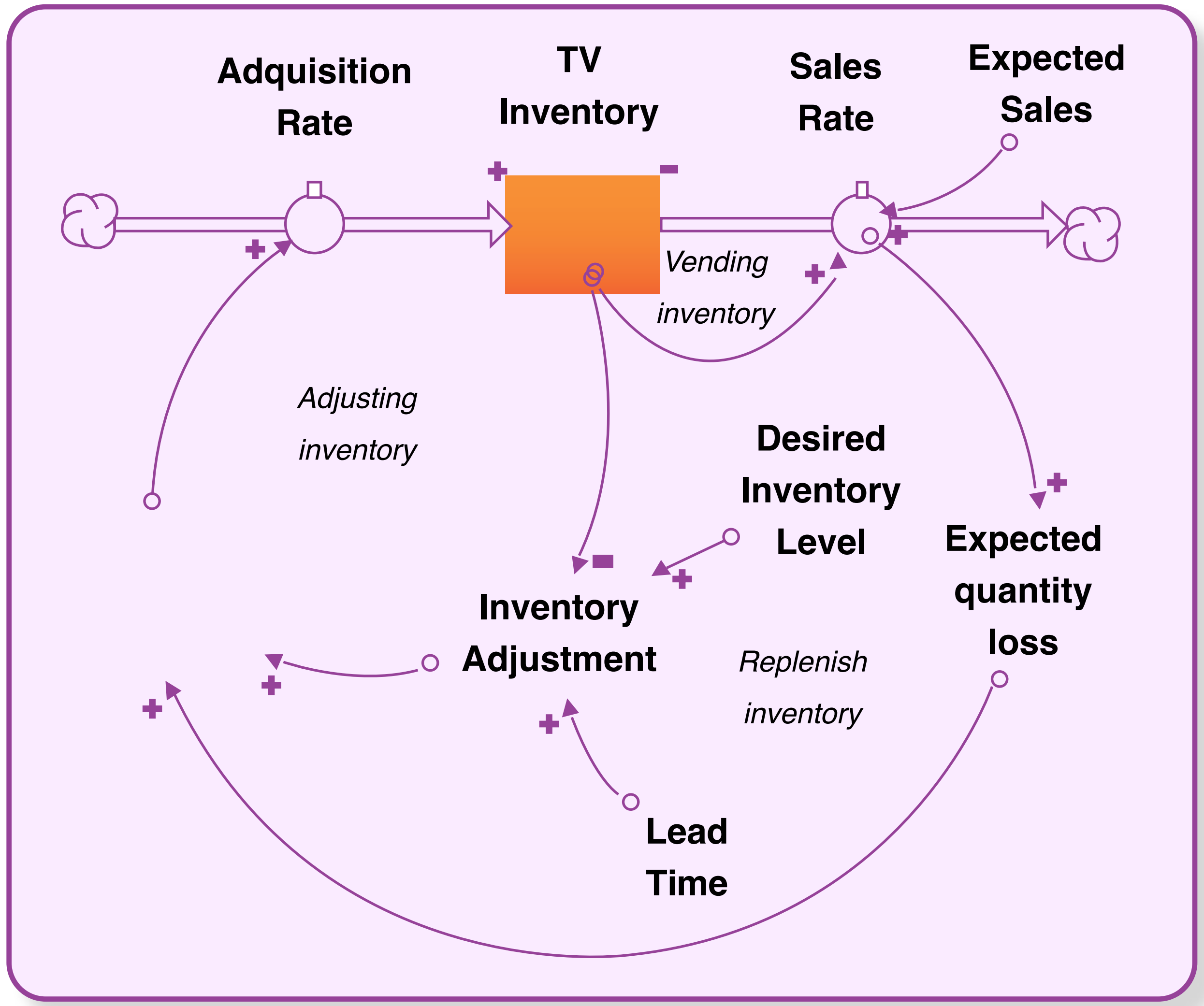


Figure 1.10 Stock and flow diagram with feedback loops

The stock and flow diagram shown in Figure 1.10 contains a model with variables that accumulate entities, and variables that allow the circulation of such entities. The model contains feedback loops in which variables affect each other. Overall, the intention of the model is to present a structure that could help to explain why certain events have evolved into patterns and why the system behaves in certain ways. In brief, the aim of the model is to help engineers and managers understand up to which point the system under study is responsible for its own behavior.

According to Sterman (2000), in order to build models such as the one presented in Figure 1.10, systems thinkers require to follow some phases that resemble a process such as the one shown in Figure 1.11:

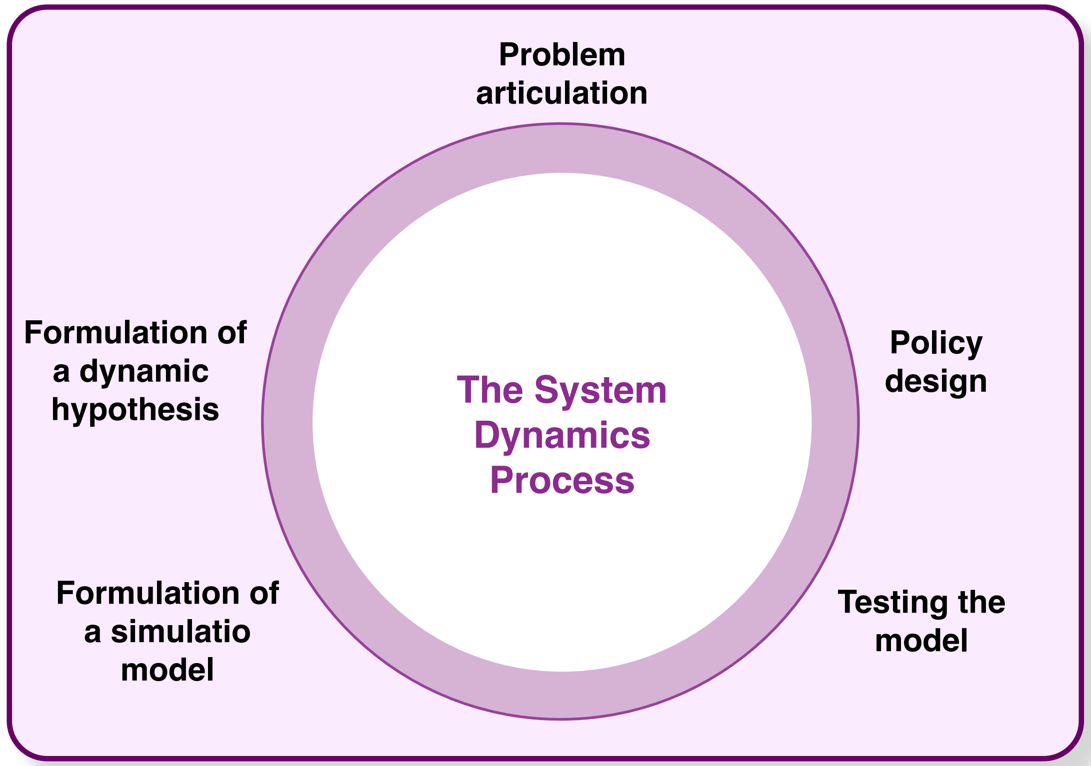


Figure 1.11 The System Dynamics process acording to Sterman (2000)

The aim of the process depicted in Figure 1.11 is to help systems thinkers to better organize their interventions and ensure understanding about complex systems.

In the view of the author of this book, the System Dynamics approach to systems thinking reflects and exceeds the ideals proposed by Ludwing von Bertalanffy in his **General Systems Theory (GST)**. This is due to the following arguments:

- **System dynamics theory and practice promotes the use of concepts and models that could be useful in different disciplines.**
- **System dynamics professional associations, such as the System Dynamics Society, encourage the dissemination of theoretical models among researchers and practitioners of different disciplines.**
- **System dynamics practitioners endeavor to find structures and behaviors that could be applied in different fields, therefore minimizing duplication of efforts.**
- **It promotes unity of science through the use of a common language; the language of stock, flows and feedback loops.**

Glossary

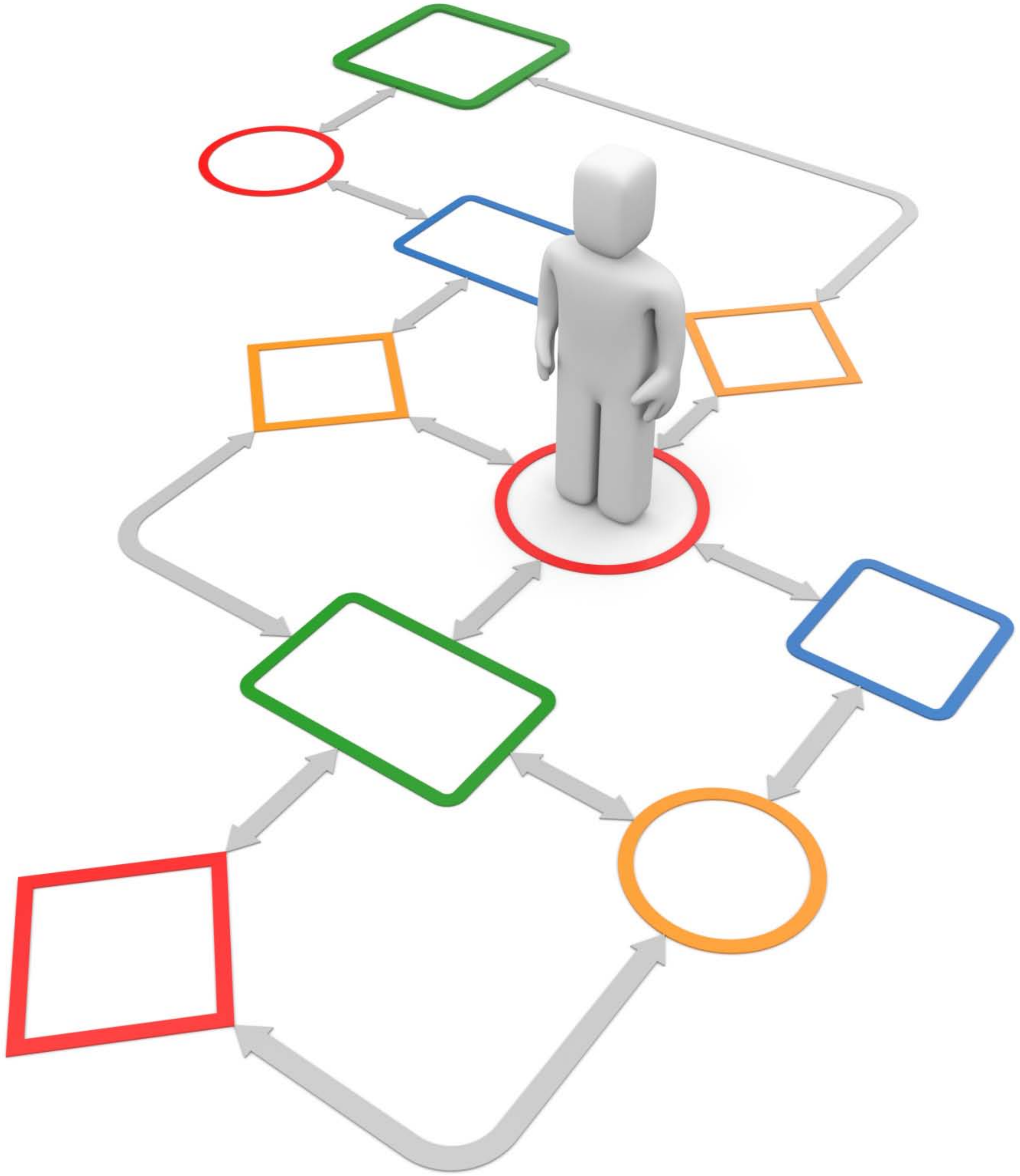
General Systems Theory (GST)

Set of principles aimed to develop unifying principles and theoretical frameworks applicable to different disciplines. At its maximum manifestation, the general systems theory attempted to create “a general science” concerned with discovering laws that applied to all systems regardless of their scientific background, and to discover the principles of organization at its various levels.

Authors such as Flood and Jackson (1991) argue that System Dynamics as a field of study identifies and resembles the "hard" approach to systems thinking. Their argument is based on the idea that system dynamic models replicate simple systems, and that system thinkers have a unitary relationship leading to a single view of a system under study. In the view of the author of this book, such understanding about system dynamics is limited because dynamic models could simulate simple and complex systems, and system thinkers and practitioners may have different views and interpretations of systems and their dynamic models.

This book acknowledges the value of the different approaches to systems thinking, but places its attention on the System Dynamics approach. System Dynamics is a field of study strongly grounded in academic programs, professional consultancies, academic publications (such as the System Dynamics Review) and professional associations (System Dynamics Society). System Dynamics has become a well-respected field of study and has proved its value in several disciplines such as engineering, management, natural and social sciences.

The following section of this chapter argues that, although there are several interpretations and approaches to systems thinking, they have certain common tenets that make of systems thinking a remarkable approach to understanding and learning.



1.5 Systems thinking: Common Tenets

It is widely accepted that systems thinking has evolved in two major schools of thinking: The hard and the soft systems thinking schools (Checkland, 1981). While the hard systems school emphasizes the use of quantitative modeling in order to optimize systems that could be found in the world; the soft systems school highlights qualitative analysis in order to improve systems from different points of view. This section explores those concepts that the author considers the common philosophical tenets of the systems thinking approach; as a result, this section explores those ideas that the hard and soft approaches share and make of systems thinking a worthwhile scientific endeavor.

1.5.1 Improvement of scientific methods and methodologies

At the core of its origin, systemic thinking represents a reaction towards simple-minded and misguided practices to create knowledge and disseminate science. Literature on the "hard" and the "soft" approaches to systems thinking have emphasized rigorous validation of systems ideas and methods in order to improve scientific practice, just as von Bertalanffy attempted to achieve through the General Systems Theory.

Systems thinkers tend to consider that the following ideas and practices limit the outcome of scientific research:

- **Isolating and fragmenting physical and social phenomena into several parts in order to understand each part separately, assuming that the fragmentation of phenomena is not relevant.**
- **Problems are best approached from one perspective, and that other perspectives are only complementary instead of necessary.**
- **Technical applications of science are affected by "accidents". This idea does not contemplate that non-considered side effects emerged as a natural consequence of technical applications.**

Together, these practices deliver knowledge and policies that often amplify problems instead of attenuating them. As a result, the general public tends to remain indifferent to science (Midgley, 2000).

1.5.2 Maintaining the whole picture

Hard and soft approaches to systems thinking encourage a broad, wide and comprehensive view about systems or problematic situations. In Richmond's (2005) words, systems thinking promote a 10,000 meters view about systems and their problems. Reducing phenomena to several simpler components in order to improve understanding may facilitate useful insights and, ultimately, some degree of control. However, separated components of phenomena may bias researchers and practitioners to think that components have limited relationships between them. Often, the lack of understanding about the relationships between components brings "unexpected consequences" and a certain degree of failure.

Let us consider the following example: The last decades have witnessed wild debates around the issue of drugs legalization; at least in countries that aim to reduce the drug effects in their society. The debate has reached eastern and western nations, and it is widely accepted that the outcome of such debate and its resulting policies and programs will have global effects. A mammoth volume of information is available to the general public presenting clear and decisive positions towards accepting or rejecting drug legalization.

Many stakeholders claim that rigorous information gathering, scientific analysis and conclusive evidence back up their arguments.

A "traditional science" approach to the drug legalization issue would attempt to split and analyze it through different disciplines. For example: Physiology, psychology, sociology, pedagogy, education, criminalistics, economy, politics and ethics, to name a few. By setting artificial boundaries (represented by each discipline and its methodologies) around the drug legalization issue, the whole picture is likely to fade. In its place, radical and limited perspectives are likely to emerge with recommendations that may amplify the problem instead of attenuating it.

In summary, in order to build a whole picture about a problematic situation or a system, systems thinking calls systems thinkers to "sweep in" different views (Churchman, 1987).

1.5.3 Systems as a cause

Systems thinking encourages the idea that the origin of problematic situations are the systems themselves, i.e. systems are responsible for their own problems (Meadows, 2008). The origin of systems' problems is better appreciated when considering the definition of a system and its environment. Setting artificial boundaries around systems un der study has two confusing implications:

- **First, boundaries define the elements that are "inside" a system and "outside" in the environment. This separation between system and environment is helpful in order to keep an issue within the human capacity of analysis. However, it often makes scientists forget that this separation is artificial; therefore, the scientific outcomes of one discipline represent only outcomes of one discipline represent only one (limited) perspective about an issue.**

- **Second, boundaries define if interactions between elements are internal or external to the system. Internal interactions are considered to depend on the elements of the system, while the external interactions coming from the environment are considered to be out of the system's control. A natural conclusion is often that internal interactions are more easily corrected or re-designed; while the system has little capability to affect external interactions. Again, this artificial boundary creates the distorted idea that a system is limited to a small set of interactions under its control; and that causes of failure are usually found "out there".**

As a result, a systems thinking approach to the drug legalization issue would encourage a multidisciplinary approach to understand the issue. It will encourage research on the several natures that cause drug abuse in the society; and the possible consequences on several social dimensions if certain courses of action are taken. It would encourage the dissemination of information in such a way that the general public could understand the several faces of drug abuse and unavoidable implications that any course of action would bring. A systemic approach to research drug legalization would help authorities and the general public to accept the idea that no single policy will "solve" the issue and that every policy will require individual and social sacrifices. It would avoid the idea that one discipline has an advantageous or preeminent point of view over other disciplines; in contrast, it will encourage the complementarity of research and results. Finally, a systems view on the drug legalization debate would avoid explanations pointing out "external forces" as the main responsible for drug abuse and would place responsibility for the causes and consequences of such abuse on all the interactions between stakeholders of the situation.

1.5.4 Feedback and consequences

Hard and soft approaches to systems thinking avoid a mechanistic view of the world. According to Midgley (2000), mechanicism is the belief that physical and social phenomena could be approached in the same way that an observer watches the properties of a machine: reliable, predictable, functional, and divisible. Typically, a machine works due to a set of conditions; and when it fails, it is possible to locate the failing component and replace it. A mechanistic view influences scientists to believe that a cause has only one effect; and that every effect is mainly explained through one main cause. This mechanistic view has also been labeled as an event-oriented view of the world (Sterman, 2000). The mechanistic or event-oriented view of the world may be appropriate to understand how a machine works but, with physical and social phenomena, it would generate limited knowledge because these phenomena are of different nature.

Figure 1.12 shows a diagram representing a mechanistic view of science.

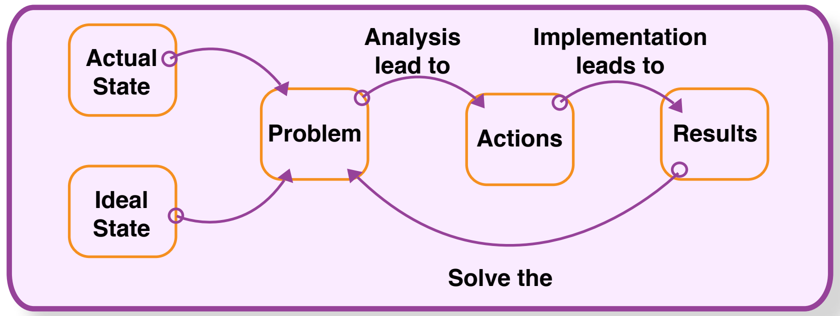


Figure 1.12 Event-oriented view of the world. Taken and adapted from Sterman (2000)

A problem emerges when the actual state of a system differs from an ideal state. The problem is clearly defined. A well-defined problem is objectively analyzed and such courses of action are taken. These actions deliver the expected results, which in turn diminish or solve the problem.

The mechanistic view of science presented in Figure 1.12 has two implications that may mislead scientific practice: Simple causality and isolated transformation process. First, it creates the illusion that what is considered to be "a problem" has a single cause and that a problem could be removed by removing such cause. This idea is known as causality. Causality often motivates scientists to isolate the most critical variables that create a problem and to find ways to gain control over them. Although this may appear as a convincing argument, it overlooks the notion that the selection of critical variables tends to be subjective, because it depends on the values and training of scientists. Causality also underestimates the fact that a situation that is considered a problem from a certain point of view may be an advantage from another point of view. In other words, causality assumes that there is a unitary view of a problem.

Second, a mechanistic view of science suggests that actions taken in order to solve a problem are like a transformation process that only delivers intended consequences; researchers' feedback is designed to find the effect of those intended consequences. Systems thinkers would argue that while feedback about intended consequences is important, other type of feedback is also critical: feedback about un-intended consequences. A mechanistic view of science often overlooks the fact that actions often create re-actions by other stakeholders; those who were comfortable within the previous status quo react in order to restore balance. As a result, a mechanistic view of science underemphasizes the actuality and power of feedback and the emergence of re-actions and un-intended consequences.

Figure 1.13 shows what the author considers a systemic view of the world (based on Sterman, 2000) in which a problematic situation is appreciated and judged not by one but by several stakeholders. It includes the idea that what is defined as a "problem" leads to different actions that create intended and un-intended consequences which, in turn, affect several stakeholders and encourage them to react.

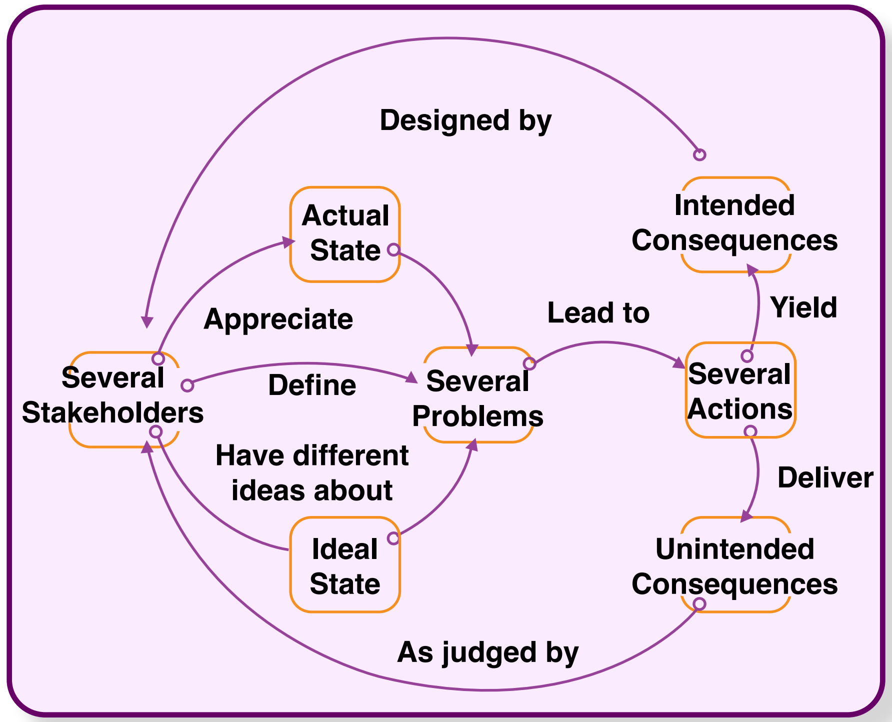


Figure 1.13 The System Dynamics process according to Sterman (2000)

1.5.5 Understanding and learning

Finally, in the view of the author of this book, the "hard" and "soft" approaches to systems thinking emphasize that learning about systems under study is the main outcome of systems' theory and practice.

Learning is about reinforcing or modifying individuals' mental models. Mental models could be defined as the ideas that individuals have about the world. Mental models are important because they define the way individuals behave. As a result, mental models have an impact in the individuals' environment. Systems thinking encourages individuals to share and test their mental models in order to foster learning (Senge, 1990).

Mental models could be modified in two ways: The first type of learning modification refers to the situation in which individuals learn to set goals and detect deviations from such goals. Argyris and Schon (1996) have called this level of learning **single-loop learning**. The second type of learning modification refers to the situation in which individuals challenge and reflect the goals that they have set. The outcome of this challenge is often a change in the governing values of the individual. This type of learning is called **double-loop learning** (Argyris and Schon, 1996) and it is the most significant for systems thinking because it changes individuals' patterns of behavior.

Since learning is the most important outcome of systems thinking, systems thinkers struggle to become aware of those factors that inhibit learning. Some of these factors were mentioned above: Rigorous validation of ideas and methods, studying phenomena by splitting it; placing responsibility out of the system; maintaining an event-oriented view of the world. Above all, systems thinkers struggle to become aware of their values and preferences which influence the way they appreciate systems and their problems.

Glossary

Single-loop learning

It refers to the situation in which individuals learn to set goals and detect deviations from such goals.

Double-loop learning

It refers to the situation in which individuals challenge and reflect the goals that they have set.

The outcome of this challenge is often a change in the governing values of the individual.

Chapter 1. Review Activity

Which of the following approaches to systems thinking do you consider that fulfills more adequately the four goals of the Society for General Systems Research?

In your opinion, what are the strengths and weaknesses of the cybernetic approach to systems thinking?

In your opinion, in which type of problematic situations is more useful the interpretive approach to systems thinking?

Why concepts such “event, “pattern” and “structure” are so important in the system dynamics approach?

In your opinion, which is the most important idea that systems thinking has contributed to the knowledge about the world?

Chapter 1. Conclusion

The main objective of this chapter was to explore the fundamental concepts of the field of study called “Systems Thinking”, and its relationship with the subject matter of this book: System Dynamics. The chapter described how Ludwig von Bertalanffy’s General Systems Theory split into two main approaches to systems thinking: The hard and the soft approaches. Due to its quantitative models, System Dynamics has often been classified as part of the “hard” approach to systems thinking.

The chapter presented the Viable Systems Model and Soft Systems Methodology as the main interpretations of systems thinking within the hard and soft approaches. It also presented the basic concepts of System Dynamics: Events, patterns, behavior, structures, stocks, flows and feedback loops. Finally, the chapter summarized the most basic tenets of systems thinking. This book acknowledges that system dynamics as a field of study is part of the rich tradition of systems thinking, and the rest of the book explains with more detail the basic concepts of system dynamics and their application in organizational settings.

Chapter 1. Glossary

A B C D E F G H I J K L M N Ñ O P Q R S T U V W X Y Z

C

CATWOE

"Formula"which means customers, actors, transformation process, owners and environmental constraints.

C. West Churchman

An American philosopher and logician who was nominated for the Nobel Prize award in the social systems field. He believed that systems thinking should be employed for the betterment of the humanity.

Cybernetics

The science of communication and control in animals and machines

D

Double-loop learning

It refers to the situation in which individuals challenge and reflect the goals that they have set. The outcome of this challenge is often a change the governing values of the individual.

E

Event

A single occurrence which is different from the regular behavior of a system.

Chapter 1. Glossary

A B C D E F G H I J K L M N Ñ O P Q R S T U V W X Y Z

G

General Systems Theory (GST)

Set of principles aimed to develop unifying principles and theoretical frameworks applicable to different disciplines. At its maximum manifestation, the general systems theory attempted to create “a general science” concerned with discovering laws that applied to all systems regardless of their scientific background, and to discover the principles of organization at its various levels.

H

Human activity system

Set of activities and actions that stakeholders of a situation take in order to fulfill their own objectives.

I

Inflows

Are variables that allow material or entities to get inside a stock. The more open an inflow is, or the more time an inflow remains open, the more material a stock will accumulate.

J

Jay Forrester

American engineer and scholar, founder of the system dynamics approach to systems thinking.

Outflows are variables that allow material or entities to get out of a stock. The more open an outflow is, or the more time an outflow remains open, the less material a stock will accumulate.

P

Patterns of behavior

When events occur continuously and seem to repeat with certain regularity.

Peter Checkland

British scholar who developed the Soft Systems Methodology (SSM). This methodology could be better described as a process of enquiry rather than a process for optimizing systems.

R

Reductionism

Represents the idea that physical and social phenomena could be better understood by separating such phenomena into several simpler components.

Chapter 1. Glossary

A B C D E F G H I J K L M N Ñ O P Q R S T U V W X Y Z

S

Single-loop learning

It refers to the situation in which individuals learn to set goals and detect deviations from such goals.

Soft Systems Methodology (SSM)

Systems methodology that aims to improve problematic situations based on stakeholders perceptions and mental models. It could be better described as a process of enquiry rather than a process for optimizing systems.

Stafford Beer

British engineer that developed the Viable Systems Model (VSM) following the principles of cybernetics.

Stock

Stocks are variables that accumulate or store tangible or intangible entities of the same type.

Structure

The set of variables and feedback loops that explain the emergence of events and patterns of behavior.

System five of the VSM

Generates the policies and rules of a viable system.

System four of the VSM

Is the function oriented to ensure future stability of the whole system by gathering and analyzing information about the global environment.

System one of the VSM

Refers to the core function or functions that a system under study performs.

System three of the VSM

Allocates resources, supports activities and interprets for systems one and two the policies generated by system five.

System two of the VSM

Is the function responsible to co-ordinate the different systems one of a viable system.

V

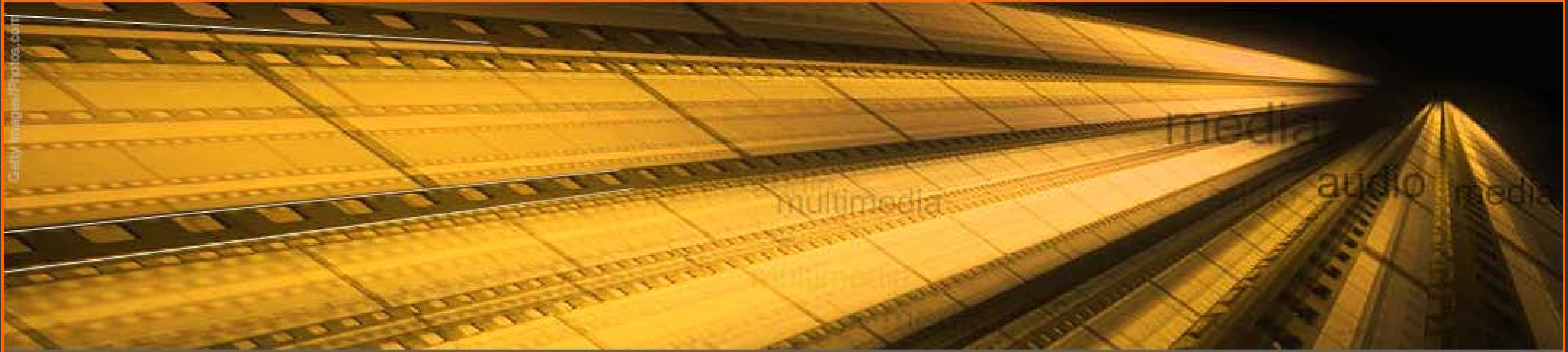
Viable Systems Model (VSM)

Theory about systems developed by Stafford Beer based on the principles of cybernetics. The VSM has five subsystems as its components.

W

Weltanschauung

The point of view from which someone appreciates a situation.



Chapter 1. Recommended Links

» Software ITHINK

ftp://eBook:4gf7whf@ftp.iseesystems.com

» Video of Dr. Russell Ackoff on Systems Thinking Part 1

http://www.youtube.com/watch?v=IJxWoZJAD8k

» Video of Dr. Russell Ackoff on Systems Thinking Part 2

http://www.youtube.com/watch?v=UdBiXbuD1h4

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System Dynamics for Industrial Engineers and Scientific Managers / Roberto E. Villaseñor Roldán

p. 172 (número de pagínas totales en InDesign) cm.

1. Engineering Economy 2. System Analysis

LC:TA177.4 Dewey: 658.15

eBook editado, diseñado, publicado y distribuido por el Instituto Tecnológico y de Estudios Superiores de Monterrey.

Ave. Eugenio Garza Sada 2501 Sur Col. Tecnológico C.P. 64849 | Monterrey, Nuevo León | México.

ISBN en trámite

Primera edición.