The Systemic Approach: what is it all about?

Synthesis of the work conducted by the AFSCET group
"Dissemination of the systemic thinking"

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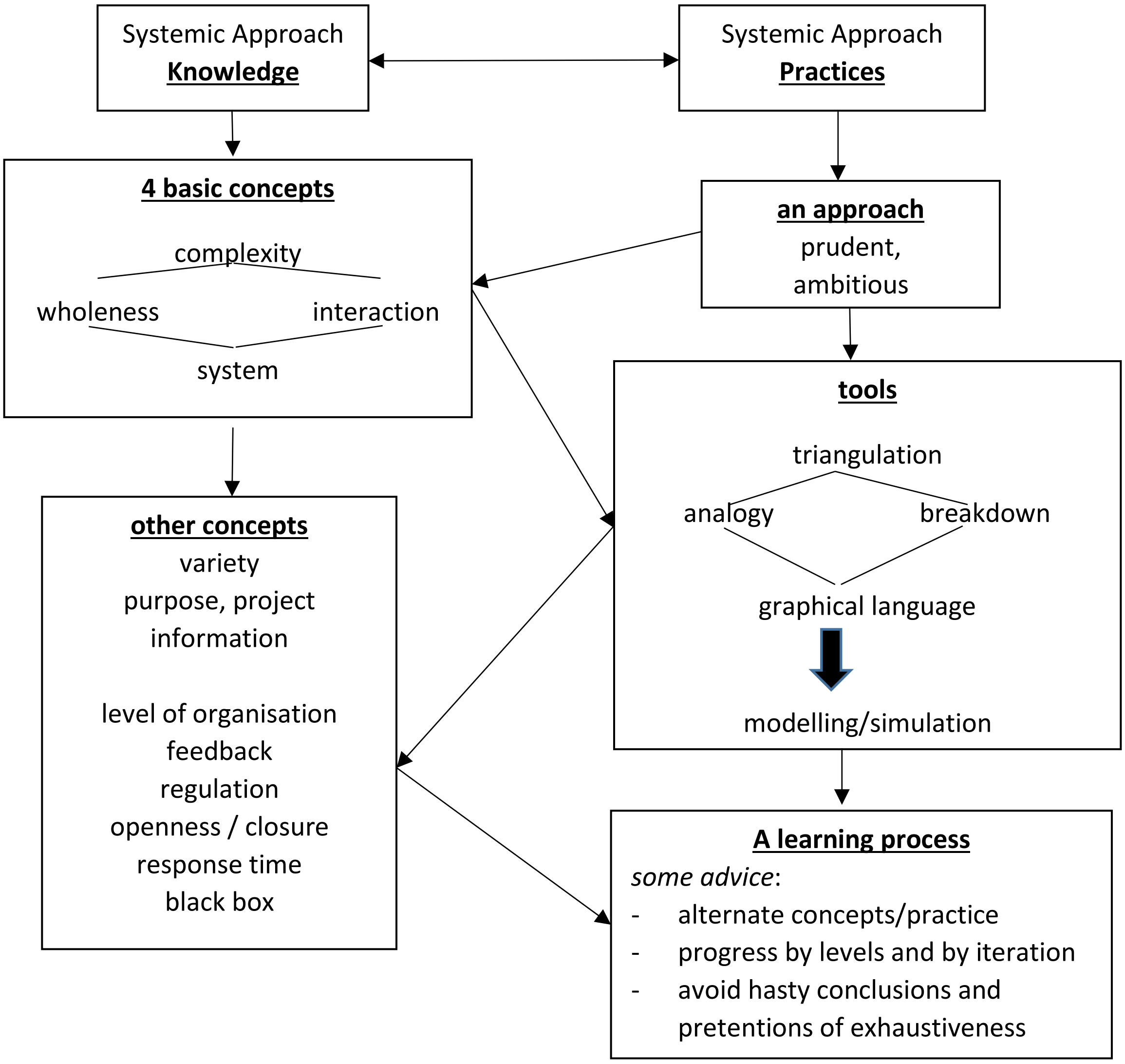
The great intellectual adventure of the end of the 20th century was the discovery of the extraordinary complexity of the world that surrounds us. The complexity concerns the cosmos, living organisms, human societies, but also all the artificial systems conceived and designed by people. These latter systems are, as is an economic enterprise, of technical, organizational, economic and social workmanship. The phenomenon of globalization of trade, whether commercial, financial or cultural, only accelerates this awareness of complexity and accentuates its effects.
Certainly, complexity has always existed even though its perception is recent. For a long time, in their quest for knowledge and wisdom, humankind sought out only simple and logical explanations for the luxuriance of the world. This was first the agenda of philosophy then, in modern times that of positive science based on the Cartesian method and characterized by the attempt to reduce complexity to its elementary components. A fabulous method, by the way, since it is at the origin of the great progress made by science during the 19th and 20th centuries.
This Cartesian method is perfectly adapted to the study of stable systems consisting of a limited number of elements with linear interactions (i.e. which can be described by continuous and additive mathematical laws) but it is no longer suitable when considering organized complexity as encountered in large biological, economic and social systems. Another approach is thus required, based on new representations of reality taking into account various occurrences of instability, openness, fluctuation, chaos, disorder, vagueness, creativity, contradiction, ambiguity, paradox. All these aspects that were once perceived as non-scientific by the prevailing positivism, are now considered as prerequisites for understanding the complexity of the real world. *"If we do not change the way we think, we will not be able to solve the problems we create with our current ways of thinking"*, said Albert Einstein. This new way of thinking has a name: **the systemic approach**.

The Systemic Approach: an attempt to define it

The systemic approach first arose in the United States in the early 1950s. It arrived and has been practiced in France since the 1970s. The systemic approach opens an original and promising path for research and for action. Its approach has already given rise to many applications in various fields: biology, ecology, economics, family therapy, business organisational management, town planning, land use planning, etc. It is based on the concrete apprehension of a number of concepts such as: system, interaction, feedback, regulation, organization, purpose, global vision, evolution, etc. It takes shape in the process of modelling, which makes extensive use of graphical language and goes from qualitative model development, in the form of "maps", to the construction of dynamic and quantified models, operable on computers and leading to simulation.
This is why the implementation of this approach requires a conceptual and practical learning effort that must be agreed upon by all (researchers, decision-makers, professionals and politicians, people of action but also simple citizens who want to understand their era) and who aspire to make a happy dive into complexity, in order to first orient themselves and then in a second time to be able to act on it.

Constantly combining awareness and action, the systemic approach is presented as the indissoluble alliance of knowledge and practices.



Taking into account the above summary graph will lead us very logically to present the systemic approach in of two parts:

- the systemic approach, knowledge and concepts
- the systemic approach, a method and a learning process.

But before we get to those two parts, the graph will have allowed us to understand the attempt at defining the systemic approach, without a doubt a little convoluted, given by the AFSCET (French Association of Sciences of the Cybernetic, Cognitive and Technical Systems), a reminder of which appeared in 1994 in the International Journal of the Systemic Approach (*Revue Internationale de Systémique*).

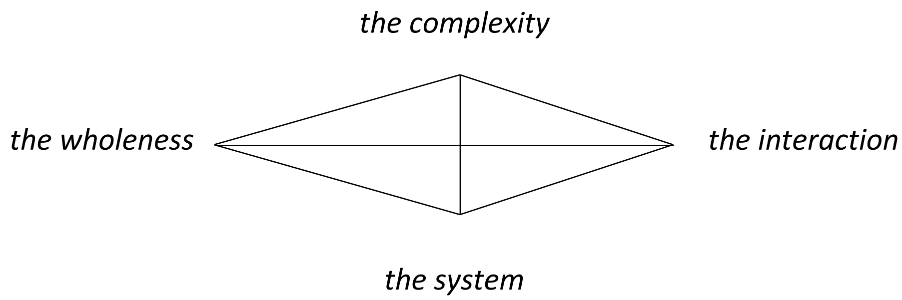
Definition of the systemic approach*: New discipline which brings together theoretical, practical, and methodological approaches, relating to the study of what is recognized as too complex to be approached in a reductionist way, and which poses the problems of borders, internal and external relationships, structures, laws or emerging properties characterizing the system as such, or the problems of: mode of observation, representation, modelling or simulation of a complex totality.*

The systemic approach: knowledge

To understand the complexity, the systemic approach uses a certain number of specific concepts that can be grouped as follows:

- four basic concepts of a general nature, articulated among them and capable, in advance, of being placed in a simple presentation,
- a dozen complementary concepts that are more technical and action-oriented.

Four basic concepts of the systemic approach



The complexity

As shown previously, the awareness of complexity is the cause of the slow emergence of the systemic approach. Without complexity, analytical rationalism could seem to be sufficient to apprehend the world and science.
This concept refers to all the difficulties of comprehension (vagueness, uncertainty, unpredictability, ambiguity, randomness) posed by the apprehension of a complex reality and which is perceived by the observer as a lack of information (available or not).

The system

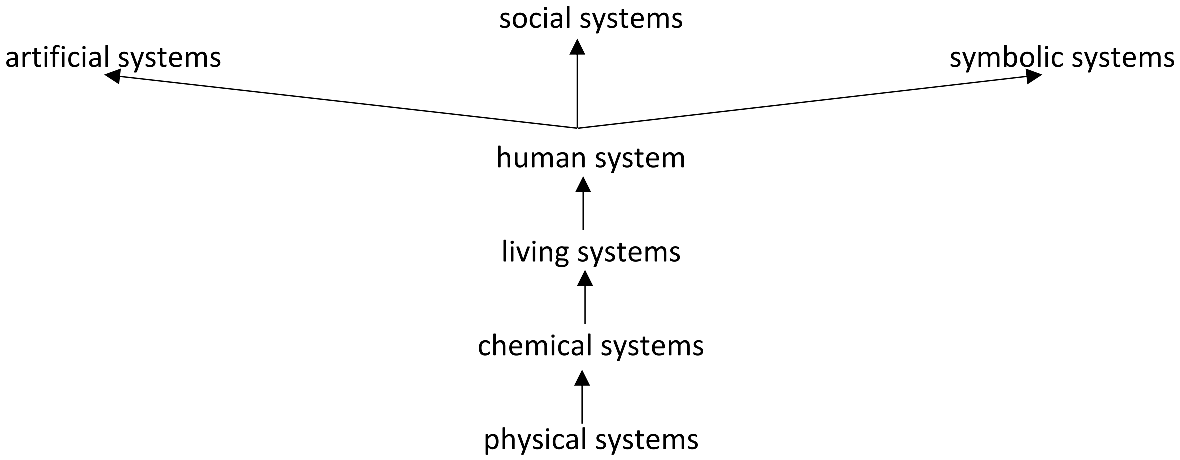
This concept is the foundation on which the systemic approach is based. Etymologically, the word comes from the Greek *sustêma* which means "*coherent whole*". Several definitions can be given and we will retain here:

- the "broad" definition given by Jacques Lesourne: *A system is a set of elements in dynamic interaction*.
- the "narrow" definition given by Joel de Rosnay: *A system is a set elements in dynamic interaction, organized according to a goal*. This definition focuses on the purpose or the aim of the system.

Numerous typologies of systems have also been proposed by researchers:

- open systems / closed systems to their environment,
- natural / artificial / social systems,
- hierarchically organized systems / networked systems,
- An interesting typology, according to the American M. Bunge, is based on the supposed order of appearance of different systems over time.

The graph below reads from the bottom to the top. From living systems, there is emergence of creative self-organization. Such systems are referred to as HCS: Hyper Complex Systems.



Wholeness

This is a property of complex systems, often translated by the saying "everything is more than the sum of the parts "and according to which one cannot really know the parts without taking them into account as a whole in their entirety. This wholeness expresses both the interdependence of elements of the system and the coherence of the whole. But this rich concept is unfortunately often superficially translated by the vague formula "everything is in everything".
Under the name of global approach, the concept also refers to the pathway of entry into the systemic approach. This means that progressively all aspects of a problem are addressed, but not sequentially: from a general (global) view to examine in depth the details with many iterations and backtrackings to complete or correct the previous vision.

Interaction

This concept, one of the richest in the systemic approach, completes that of wholeness because its interest in the complexity lies at the elementary level of each relationship between the constituents of the system taken two by two. Initially borrowed from the field of mechanics where the interaction is reduced to a play of forces, the relationship between constituents in complex systems is most often one of influence or exchange concerning the flows of matter, energy, or of information.

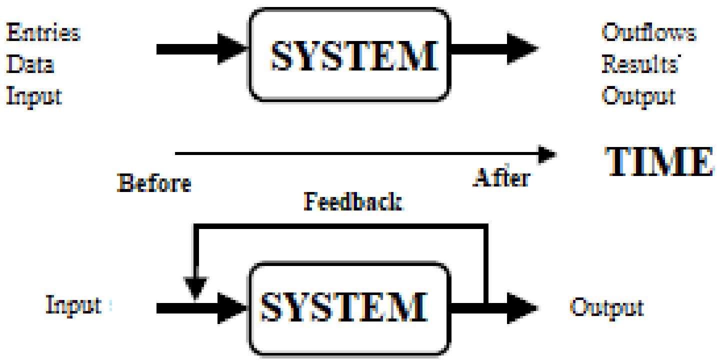
As the concept of feedback will show, the notion of interaction goes far beyond a simple cause-and-effect relationship that dominates classical science. And to know the nature and the type of interaction is more important in the systemic approach than to know the nature of each component of the system.

If these four concepts are essential, it is necessary to know a good ten others, more directly operational, to begin the learning process of the systemic practitioner.

Information: this concept, contemporary with that of cybernetics, preceded the birth of the systemic approach but today it is now included in it. Information is constantly exchanged between and within systems, along with the two other fundamental flows of matter and energy. The systemic practitioner distinguishes between *circulating information* (to be treated as a mere perishable flow) and *structuring information* (included in the system's memory, e.g. the chromosome DNA strands for a living cell).

Purpose (to which we can link the notions of project and goal): within the framework of Joel de Rosnay's restrictive definition, each system pursues a goal or purpose of its own. For Human or human-made systems, we will equally talk about projects.
This observation has a consequence when it comes to studying a system: when facing an "object" to be modelled, it is strongly recommended that the modeller asks himself the question "what for?" before wondering "how does it work?".

Feedback: in a system or subsystem that is undergoing a transformation, there are input variables and output variables. The inputs are under the influence of the system's environment and outputs result from its internal activity. We then call a feedback loop any mechanism which allows to return to the initial input entry to the system as data, information which is directly dependent on the output.



There are two types of feedback loops:

- **the positive (or explosive) loops** which are based on the *dynamics of the change*. Re-injection of the output results as input helps to facilitate and amplify the transformation already in progress. The effects are cumulative ("snowball effect") and we obtain a divergent behaviour that takes the shape either of an undefined expansion or explosion, or a total blockage of activity.
- **the negative (or stabilizing) loops**, are those on which *balance* and *stability* rest. Feedback acts in the opposite direction of the equilibrium difference of the output variable (which presupposes to have previously fixed the level sought for this balance, which in theory we call *the regulation of the set value*). If the feedback shows effectiveness, there is stabilization of the system which is shown as being finalized, that is to say reaching toward the achievement of a goal.

Ago-antagonism: certain loops encountered in living systems and social systems, can be positive as well as negative, without our being able to predict the timing of this change of polarity. They are said to be ago-antagonist. These loops make it possible to apprehend phenomena that are particularly difficult to conceive according to usual logic (exclusive and binary) and are quite counter-intuitive.
Thus paradoxical therapies, where the treatment consists in prescribing the hormone already in excess, allow to get out of the initial pathological equilibrium. And similarly in social strategies, well known to some managers and politicians who intuitively apply them, where one thing is combined

with its opposite. Even parents know that to make their child progress, they must practice both reprimand and reward.
The “middle of the road” pathway does not work to the extent that a child needs to be stimulated to learn, that is to say, to be reprimanded when he has not succeeded and rewarded in the opposite case. And if parents only use reprimands or only rewards, stimulation does not take place either.
The ago-antagonism is constantly present in inter-human communication; this communication is the basis for managing all social systems.

Circular causality: the existence of feedback makes it difficult to distinguish between the effect and the cause of a phenomenon within a system. This is the famous paradox of the chicken and the egg: the effect retroacts on the cause that becomes effect and it is impossible to say which is at the origin! It is even a false question and such a problem does not make sense.
This is why one should never open or cut a feedback loop. In the systemic approach, this is a major and unforgivable mistake. A loop must always be studied in its dynamic wholeness all the while refusing to disjoin the poles. Therefore, a feedback loop should always be taken (examined) in its wholeness, being careful not to open it. This is called **circular causality**. One of the consequences is that of unexpected and unpredictable behaviour of complex systems, facilitating the appearance of certain spontaneous reactions-responses that take the shape or form of *perverse effects*.

Regulation: the functioning of a system is based on the existence, in the deepest part of its core, of multiple *feedback loops*, some negative, others positive, and others still are ago-antagonist. Articulated together according to a network logic, these loops combine their actions to maintain both the stability of the system and to allow it to adapt to changes in its environment. This is thus of what consists the process of regulation.

Structure and levels of organization: the structure describes the network of relations between constituents of the system and in particular the network of regulatory chains. It materializes its organization. This structure is generally hierarchical according to several levels organization, for example the organizational chart of functions in a business enterprise or company.
Organizational levels have the advantage of allowing to order the data of a complex problem, which greatly facilitates the study of it. The confusion of the levels or the apprehension of the problem at an inadequate level, are classic mistakes that handicap understanding it.

Variety: it is given by the number of configurations that the system can take. The *principle of required variety*, due to the biologist and mathematician Ross Ashby, states that a system S1 can regulate an S2 system only if its variety is greater than or at least equal to that of S2.

Openness / Closure: a system that exchanges (flows of matter, energy, information) with the outside is said open to its environment. It can maintain its organization, and even make it more complex. Conversely, a closed system does not exchange anything with its environment.
In accordance with the principle of entropy, it can only destroy itself (entropic death).

The black box / white box: this is an observation technique that consists of selectively considering:

- either the external aspect only, ignoring the makeup of the system (vision in a black or opaque box) taking into account only its inputs / outputs and the effects of its action on the environment;
- or the internal aspect only, by looking at all of the elements in mutual interaction (vision in a white or transparent box) in order to highlight how the system functions or operates.

Synchronism and diachrony: synchronous behaviours (movements that occur at the same time) of a system are those which are observed during a structural level or stage (where there is an absence of evolution of the structure). It is more difficult to understand the dynamics of evolution, or diachrony, because it is not only historical but it may also include a "possible" and prospective dimension. A good method is to first examine the diachronic aspect and to make note of the successive synchronic stages.

The Systemic approach: a method

The systemic approach is not only knowledge, but also practices, a way to enter into the complexity. The pedagogy to be implemented must be innovative both in its general approach and in the tools used.

1 - The general approach

The approach takes place in stages: observation of the system by various observers and from various angles or aspects; analysis of interactions and regulatory chains; modelling that takes into account the lessons learned from the evolution of the system; simulation and confrontation to reality (experimentation) to obtain a consensus. Such an approach must be both prudent and ambitious:

- *prudent* in that it does not start from pre-established ideas but from observed facts that we must take into account,
- *ambitious* in that it seeks the best possible apprehension of situations, without being contented by neither approximations nor by a rapid synthesis, but that aims at understanding and enriching the knowledge.

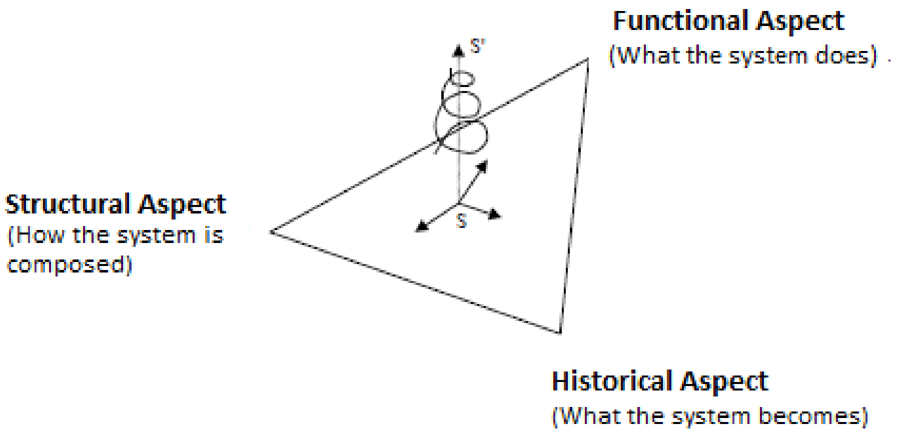
2 - The tools

We will present three basic tools, before touching on the graphical language which is the natural language of the systemic approach, followed by the presentation of modelling that, better than a tool, is at the heart of the Systemic Approach.

Systemic triangulation
Remarkably adapted to the investigation phase of a complex system, the triangulation will observe the system from three different but complementary aspects, each linked to a particular point of view of the observer.

- **The functional aspect** is especially focused on the purpose or the goals of the system. Spontaneously we try to answer the questions: what does the system do in its environment? What is it used for?
- **The structural aspect** aims to describe the structure of the system, the arrangement of its various components. Here we find the analytical approach with however a weighty nuance: the emphasis is much more on the relationships between components than on the components themselves, on the structure rather than on the element.
- **The historical (or genetic or dynamic) aspect** is related to the evolutionary nature of the system, with a memory and a project, capable of self-organization. Alone, the history of the system will quite often reflect some of the aspects of how it operates. For social systems, it is through their way of functioning that it is best to begin the observation.

Naturally, systemic triangulation develops by combining these three angles or aspects. More exactly, we move from one aspect to another during a spiral process that allows each passage, to gain both in depth and in comprehension, but without ever letting one believe that one has reached the end for this comprehension.



Systemic breakdown

Unlike analytical decomposition, we do not try to go down to the elementary components but concentrate on identifying the subsystems (modules, subsets, ...) that play a role in the functioning of the system. This assumes that one must clearly define the boundaries of these subsystems (or **modules**) so that subsequently will be visible the relationships that the subsystems maintain with one another as well each one's purpose with respect to the system as a whole. It is to note that this problem of borders also arises for the system itself: how to define it with respect to its's environment, where does one set the cut-off point for the border?

The question of breakdown is always accompanied by a certain amount of arbitrariness and an unequivocal answer cannot be given. However, to achieve the breakdown in the most pertinent way possible, we can rely on a several criteria, suggested by the systemic approach itself, the first two are taken from the triangulation:

- *criterion of purpose*: what is the function of the module in relation to the whole?
- *criterion of history:* do the components of the module have a shared history of their own?
- *criterion of the level of organization:* in relation to the hierarchy of levels of organization of the system, where is the module to be studied situated?
- *criterion of structure:* some structures are repetitive and can be found at multiple levels of organization. In this case we speak of fractal structures or of holograms. To analyse these structures, it is thus sufficient to focus on only one of these holograms and subject it to magnification known as *a zoom* or *magnifying effect*.

This magnifying effect can be widely used. It is important, however, to remain aware of its limits. The approach postulates the existence, in the system, of redundancies or regularities related to the Whole through a relationship of circularity. And it is not sure that these conditions always exist and that they exist throughout the whole system.

Analogy
Known to philosophers of antiquity and to medieval theologians, this mode of reasoning was decried in the 19th century by positivism ... even though it continued to permeate the heuristic approach of researchers. In terms of analogy, three levels can be distinguished:

- **The metaphor** establishes a correspondence, often external, between two series different phenomena or two systems of different nature. Because it is based on appearance, the metaphor is dangerous. Well used, it is precious because it stimulates the imagination and facilitates the creation of new models.
- **Homomorphism** establishes a correspondence between some features of the system being studied with the features of a theoretical model or a more simple real system easier to study (which is then called *a reduced model*). By observations performed on this second (reduced) system, it is possible to foresee certain aspects of the behaviour of the first system.
- **Isomorphism** is the only acceptable analogy in a traditional analytical approach. It aims to establish a correspondence between all the features of the object studied and those of the model, where nothing is forgotten or left out.

Usable for systems with little complexity concerning physics and chemistry, isomorphism is not useful for complex systems. By an inevitable shift, we have come to accept the imperfection of the homomorphic model and even to see in this imperfection the necessary condition for all access to knowledge. The model is without a doubt simpler than the real system, but that's why we understand it and we can use it to guide our actions.

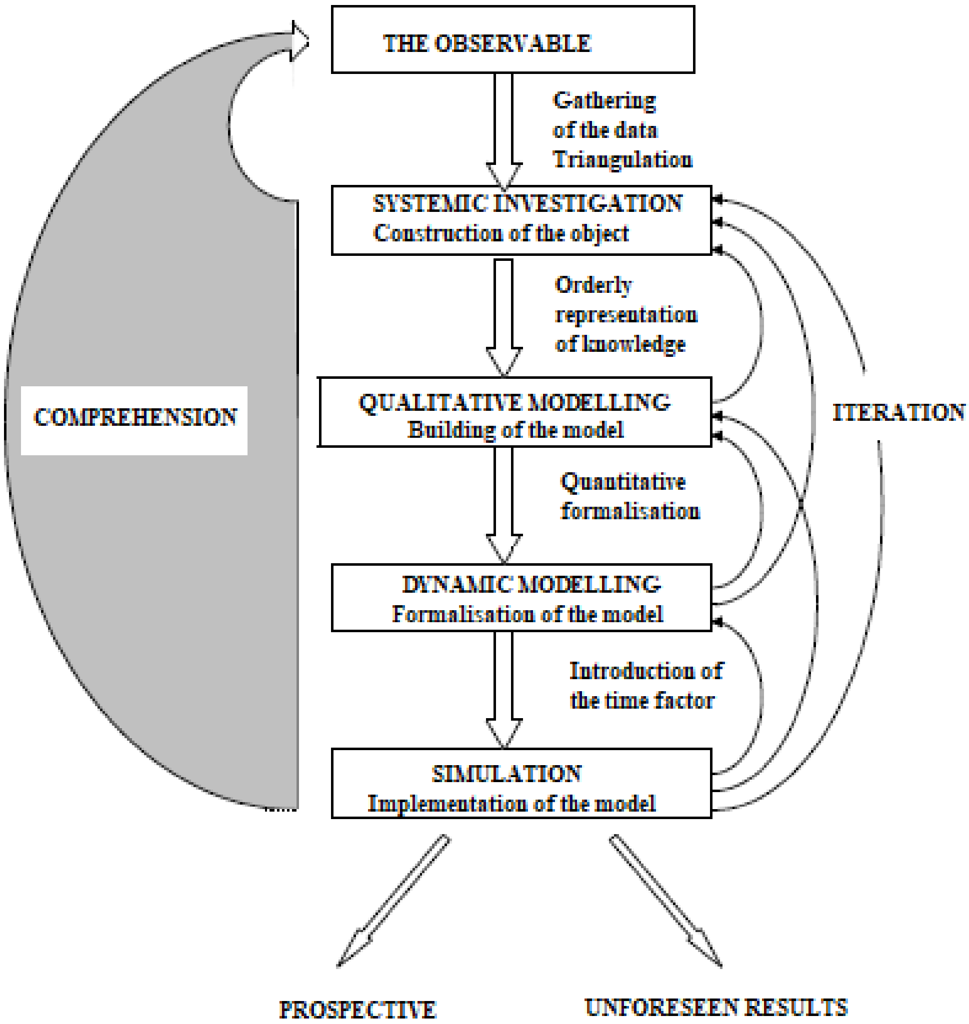
Graphical language
The graphical language is widely used in technical fields (the map is universally used, and it is the convenient representation of a territory, it is part of this graphical language). Note that this is indeed a real language, alongside natural discursive languages, written or spoken, and formal mathematical language. All these languages use graphical language with schemas and ideograms as well as geometry and graph theory.
There are four advantages to the graphical language:

- it allows a global and rapid apprehension of the represented system (after being trained),
- it contains a high density of information in a limited space (economy of means),
- it is mono-semic (single element or sign) and semi-formal (low variability of interpretation),
- it has a good heuristic ability (especially for group work)

Modelling
Modelling is first and foremost a technical process that can represent, for the purpose of knowledge and action, an object or a situation or even an event deemed complex. It is used in all scientific fields concerned with complexity.
But modelling is also an art by which the modeller expresses his vision of reality. In this sense, we can speak of a constructivist approach. The same reality, perceived by two different modellers, will not necessarily lead to the same model.
However, if the modeller wants his model to be operational, that is to say it allows the user to navigate (in) the complexity and act effectively on it; he must take into account certain criteria and respect certain laws when constructing his model.

Such a process is shown in the diagram below which highlights the four iterative steps that are essential to any modelling. The approach is highly recommended for the study of hyper-complex systems, in particular social ones.

The steps of the systemic approach



3 - Some teaching tips

As Bonaparte said of war, the systemic approach, and especially the modelling, is an "*art of execution*". Before letting you dive into it blindly, it is nonetheless possible to offer some preliminary tips and words of advice:

- admit that you cannot know everything and agree to “jump into the water” (*the pathway is made by walking it* according to the Spanish poet Antonio Machado),
- know how to alternate theory (concepts) and practices (learning),
- specify at the beginning the goal that one aims for and set one’s limits (in terms of means, duration) to avoid losing focus or exceeding deadlines,
- learn to break down the system (according to a few precise criteria) into levels of observation, in subsystems and in functional modules, and to recognize its boundary in order to be able to distinguish what is part of the system from what belongs to the

environment, do as many iterations as necessary to avoid the pitfalls of linearity, and at lease to ensure functional/structural coherence, global/local, synchronic/diachronic and external vision/internal vision,
- know how to detect the weak signals, which sometimes provide more information about system evolution trends that massive changes,
- it is needless to pretend to be exhaustive and better to aim for relevance. Stop the exercise as soon as the degree of satisfaction is sufficient and leave the door open to explore other paths. It is not necessary to have figured out (understood) everything to make a decision, provided we take care to include the possibilities of improvement. "*We can do more than we know*," said Claude Bernard.

To conclude

If we were to characterize, in a few words, the systemic approach with respect to the traditional analytical approach inherited from Descartes is in reality very much more complementary than opposed, we could say that it is:

- more dominated by a ternary or conjunctive logic (which connects) than by a binary or disjunctive logic (which separates)
- more focused on the goal to be achieved (purpose) than on the search for causes (causality)
- more relational and global than analytical
- more oriented by the present-future (prospective) than by the past-present (determinism)
- more open to the diversity of realities and the plurality of solutions than to the quest for certainties and "universal" answers (the one best way),
- less reductive finally because it embraces the emergence of novelty and invention.

An effective instrument to try to understand how a living cell works, the human body, an economic enterprise, the economy, the society, the systemic approach is particularly suited to do so in order to inform and guide the action of decision-makers, whoever they may be: politicians, business leaders, trade unionists, experts, heads of associations, etc. The systemic approach is also able to provide the "honest person" of our time (one who seeks to understand and situate one's self) with the keys for understanding the world in which he lives. Effective content can thus be given to the formulas that describe the remedies that our society needs (participation, decentralization, communication, citizenship, etc.) but because our society lacks rigorous concepts and appropriate methodology, those needs remain unfulfilled like a useless piece of paper or a dead letter.

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