1

Decision-Making

Introduction: decision-making, the central issue of decision support

In an engineering approach to decision support systems (DSS), the technical aspects, however complex, must never forget that *decision-making* is the central issue of decision support. This chapter will explore the different dimensions of decision-making so that we can understand its content, its *sense*.

It is worth reiterating that decision-making is the prerogative of mankind and that a "decision" made by a digital machine is *not* a decision (however, complex, it is nothing but the result of a line of calculations).

Every human being, in their personal and professional life and in their life as a citizen, is almost constantly making decisions of varying degrees of importance. To illustrate (basic) decision-making, let us consider the following: a pedestrian walking from one place to another will decide which route to take, during the journey they will choose which pavement to walk on, where and when to cross the road, how fast to walk, etc., until they decide to stop when they think they have arrived at their destination.

Similarly, decision-making is an integral part of the life of human organizations (authorities, enterprises, the State, etc.). Complex systems are immersed in moving environments, and they must indeed be managed. Managing takes various forms, but in the end it always results in individuals or groups making decisions. Enterprises must, for example, choose suppliers, organize production, set the price of products, define a client segment, redistribute the tasks of an absent worker, recruit employees and define the axes of research and development, and so on.

This book will focus on the decisions made within organizations, and not those made in individuals' private lives.

Section 1.1 will present two different and opposing approaches to decision-making. The first approach is based on a rational view of decision-making and aims to optimize the final choice. The second approach, taken from research by Simon [SIM 60, SIM 77], takes the limitations of the decision maker's rationality into account and seeks to help them make the most satisfactory decision for them.

In the domain of DSS, decision-making is understood in several dimensions, which can be split into two categories: the first category concerns the individuals making the decisions (the decision makers) and the second category concerns the methods and the roles of decision-making in the life of organizations.

Section 1.2 will focus on the decision maker (or a group of decision makers). First, the decision-making process modeled by Simon [SIM 60] will be studied. Given that the process is partially determined by the degree of formalization of the problems being asked to the decision maker, we will then discuss how decisions are structured (including the specific case of undefined or "wicked" problems). Some specificities of group decision-making will conclude this section.

This book discusses decision-making within organizations; section 1.3 will focus on the organizational context of decision-making. Organizations can be seen as complex systems. Systems theory has presented a management model, which we will describe in detail. Out of its components, indicators play a vital role. A definition of indicators will be provided and then a typology will be presented. We will then reflect on the distinction that must be drawn between decisions that have an impact on the definition of the management system and decisions that operate within the framework of this system (action decisions). The section will conclude with an important dimension of decision-making within organizations: the level of management (operational, tactical or strategic).

Organizations are immersed in an environment and they interact with it. It has often been said that this environment has been constantly changing for the past 20 years. Section 1.4 is dedicated to analyzing these changes and their impact on the content of decisions. The different dimensions of these changes will be studied with regard to organizations: their connection with the environment, establishing their boundaries and their needs in terms of the information system (IS). Public institutions and their evolution will specifically be discussed.

1.1. Normative theory versus engineering theory

Economics, management sciences and computer sciences are interested in decision support design (whichever forms these supports take). These areas have taken two main approaches to decision-making. The first approach, which we will call *normative* decision theory [ALC 04], mostly comes from economic sciences and is based on a rational view of decision-making (for more details, see [KAS 93]). Decision-making is assimilated to calculations determining the best possible action (i.e. optimum). This approach is based on what Simon [SIM 76] calls *substantive* rationality:

> Behavior is substantively rational when it is appropriate to the achievement of given goals within the limits imposed by given conditions and constraints.

Defining the pursued objectives, defining the problem the decision needs to solve, choosing the relevant perimeter, identifying the necessary information, etc., are seen as exogenous to the decision-making process and as *given*. Simon *et al.* [SIM 86] wrote the following about subjective expected utility (SEU):

> SEU theory defines the conditions of perfect utility-maximizing rationality in a world of certainty or in a world in which the probability distributions of all relevant variables can be provided by the decision makers. (…) SEU theory deals only with decision making; it has nothing to say about how to frame problems, set goals, or develop new alternatives.

Lévine and Pomerol [LÉV 89] summarized the hypotheses based on normative theory as follows:

– all possible actions are identified before the start of the decision-making process;

– there is a total preorder for actions, which can be represented by an explicit utility function and can be given a mathematical expression;

– input (parameters and data) is digital and contains all useful information;

– the best decision is that which maximizes the utility function.

Normative decision theory has been undeniably successful for repetitive and well-defined problems, for which all the useful information is available. These situations most often correspond with operational decisions, rarely with tactical decisions and never with strategic decisions.

We can even question the *decisional* nature of the activities carried out in this context. For a decision maker, choosing the optimum, i.e. only accepting the best choice, is not really decision-making (which would imply a set of possible choices), but rather the ratification of what is essentially the result of a calculation. It should be noted that using normative theory to deal with strategic decision-making generates excessive risks of reducing complexity and losing diversity (this will be discussed in Chapter 3).

A large number of decision-making situations come out of the very restricted context of normative theory. These situations are characterized by the limitations of the decision maker's (substantive) rationality. These limitations are particularly visible in situations perceived to be *complex* by the decision maker.

Alcaras [ALC 11] shows that three types of factors contribute to this complexity, which he calls informational, teleological and computational, respectively:

– informational factors: information required for decision-making is difficult to define, collect or process in the time available;

– teleological factors: the end purpose pursued in decision-making is not always clear, nor shared by everyone involved in making the decision; consequently, the selection criteria are not very easy to set;

– computational factors: humans' computational skills are limited: attention span, calculation skills, short- and long-term memory, etc.

Following Simon, another approach was developed, which is based on *procedural* rationality rather than substantive rationality. The main focus shifted, therefore, from the result of the decision-making (which should "simply" be optimized) to the *process* of decision-making, which concludes not when the optimum is achieved, but according to the criterion of *satisficing* (see section 1.2.2). This position, which focuses first and foremost on the way in which decisions are made (including defining the problem), was called the theory of decision engineering by Alcaras [ALC 04]. This book subscribes to this approach.

1.2. The decision process

1.2.1. *Simon's IDC model*

The domain of decision support has, since its inception, been aligned with Simon's work and has, therefore, focused on the process an individual develops to make a decision.

Simon identifies the decision process as a problem-solving process. He focuses not on the choice but on the whole process [SIM 60] and takes issue with focusing on this one "final moment".

> [They] ignore the whole lengthy, complex process of alerting, exploring, and analyzing that precedes that final moment. In treating decision making as synonymous with managing, I shall be referring not merely to the final act of choice among alternatives, but rather to the whole process of decision.

To describe this process, Simon [SIM 60, SIM 77] proposes a generic three-phase structure known as the intelligence, design, choice (IDC) process, which is close, as the author specifies, to the problem-solving approach described by Dewey [DEW 10]:

> The first phase of the decision-making process – searching the environment for conditions calling for a decision – I shall call intelligence activity (borrowing the military meaning of intelligence). The second phase – inventing, developing, and analyzing possible courses of action – I shall call design activity. The third phase – selecting course of action from those available – I shall call choice activity [SIM 77].

The fourth and final phase (review), which evaluates the relevance of the choices made in the previous phases, is often omitted; yet, it enables a new decision-making process to be launched.

> "The fourth phase – assessing past choices, I shall call review activity".

Simon stresses that the transition from one phase to another is not really sequential, but rather that it involves an iterative or even recursive operation, where each phase is itself a decision process:

> Generally speaking, intelligence activity precedes design, and design activity precedes choice. The cycle of phases is, however, far more complex than the sequence suggests. Each phase in making a particular decision is itself a complex decision making process. The design phase, for example, may call for new intelligence activities; problems at any given level generate sub

> problems that in turn have their own intelligence, design and choice phases, and so on. There are wheels within wheels.

It should be noted that this process can be likened to spiral models [BOE 88] in software engineering and, more broadly, to agile methods (rapid application devepmenlot (RAD), dynamic systems development method (DSDM), extreme programming (XP), etc.).

The IDC model remains a point of reference for weakly structured or unstructured decisions (see section 1.2.3), notably in the domain of DSS design [POM 05].

1.2.1.1. *A few words on the intelligence phase*

The intelligence phase places the beginning of the decision process very upstream and starts with the understanding that a decision must be taken. It continues by constructing a representation of the perceived problem. Simon *et al*. [SIM 86] insist on the importance of this phase, which they believe is not well understood:

> The very first steps in the problem-solving process are the least understood. What brings (and should bring) problems to the head of the agenda? And when a problem is identified, how can it be represented in a way that facilitates its solution?

1.2.1.2. *The satisficing principle*

In opposition to normative theory, which considers decision-making to be searching for an optimum, Simon proposes the satisficing principle. The term *satisficing* is a portmanteau combining *to satisfy* with *to suffice*.

This principle describes decision makers' behavior when faced with a situation for which developing an optimal solution using a set of constraints (related to time, cost, availability of the information, the attention span of the decision maker, their limited rationality, etc.) is considered impossible. A decision is assessed against the satisficing criteria of the individual decision maker and their aspiration level for the decision in question:

> Stop searching as soon as you have found an alternative that meets your aspiration level [SIM 79].

Contrary to approaches aimed at optimization, not all of the alternatives are explored: the decision maker stops when they judge the solution to be *satisficing*, i.e. good enough. Over this decision-making process, the satisficing principle governs not only the stopping of the process at a final choice, but also all the internal decisions involved in the process (the "wheels within wheels"): stopping or returning to a task within a phase, moving onto the next phase, going back to the previous phase and so on.

1.2.2. *Supplementing the IDC model*

Simon's model has been supplemented by other authors such as Mintzberg *et al*. [MIN 76], who present a process model for unstructured decisions, in particular strategic decisions. This model, built from a field study on 25 strategic decision-making processes, has three stages, which the authors specify "resemble Simon's trichotomy", although it uses other terms ("identification", "development" and "selection"). An in-depth analysis led the authors to identify seven procedures within the three stages, which are supplemented by support procedures:

– the identification stage, composed of two routines: recognizing the need to make a decision and diagnosing the situation;

– the development stage, which constructs one or more solutions to the problem identified in the first phase. It uses two procedures: research to try to find ready-made solutions (for example, by benchmarking[1]) and design to create specific solutions or modify the ready-made solutions;

– selection, the last stage of the process, which is, as the authors commented, closely linked to the previous phase:

1 *Benchmarking* should be understood here in the broadest sense: a comparison not only of products, but also of methods, processes and even strategic choices. These studies can be conducted within one activity sector or outside reference in a specific activity.

> because the development phase frequently involves factoring one decision into a series of subdecisions, each requiring at least one selection step, one decision process could involve a great number of selection steps […] [MIN 76].

The iterative character of the decision process highlighted by Simon is confirmed once again. Furthermore, the authors query the sequential character and the clear demarcation of the three procedures, which normative decision theory recognizes in the last phase: the determination of selection criteria, evaluating alternatives with these criteria and selection. Mintzberg *et al*. [MIN 76] suggest describing the selection phase as an iterative process, which progressively analyses the alternatives in more detail over three procedures: filtering realizable alternatives to reduce the number of alternatives, evaluation-choice to analyze the remaining alternatives and choosing a line of action and, if required by the position of the decision maker, authorization so that the chosen line of action can be ratified by a superior.

The [MIN 76] model both corroborates Simon's model and improves the description of its different phases.

The weighting of the steps in the process (unveiled by the study) gives importance to the aspects of constructing the representation of the problem (recognizing the need to make a decision, diagnosing the situation and so on), which corresponds to Simon's intelligence phase. Like the latter, Mintzberg *et al.* [MIN 76] consider this phase to be a major issue, particularly if the very real risk of "solving the wrong problems precisely" is to be avoided [MIT 10].

Moreover, the description of the large majority of procedures focuses on their implicit, intuitive, not very rational, unrational or even *a posteriori* rationalized character. The importance of constructing the representation of the problem, such as the implicit and non-analytical character of the procedures, results in the central role of the mental models, representations and worldviews in decision-making to be recognized. We will return to this question later, particularly in Chapter 3.

1.2.3. *Structuring decisions*

The way the decision process described above is applied differs depending on the characteristics of the decisions concerned. Among the characteristics, the decision's degree of formalization is the subject of great interest in the domain of decision support. It can be described from the perspective either of the decision makers – we thus talk about structuring decisions – or of the organization – related to the standardization of decisions (see section 1.3.8).

In his decision process model, Simon draws a distinction between programmed and non-programmed decisions. He specifies that these two categories are not two disconnected units but rather are the extreme ends of a *continuum*. Programmed decisions are described as repetitive decisions, for which the organization or the decision maker has defined a clear procedure. Conversely, non-programmed decisions are for the most part new and there are no ready-made methods to deal with them. This is the case for previously unseen problems or when their structure is complex and/or changing, or when their potential impact is so great that it is worth paying them special attention.

Gorry and Scott-Morton [GOR 71] return to these categories to characterize decisions, but they rename them *structured* and *unstructured* decisions as the term "programmed" expresses too great a dependence on information technology (IT) tools. We will use their terms (structured and unstructured decisions) in this book. As will be seen in Chapter 2, DSS are intended to support weakly structured or unstructured decisions.

1.2.4. *Defined problems (tame) and undefined problems (wicked)*

The categories of structured and unstructured decisions are similar to the notion of defined (tame) and undefined (wicked) problems. The latter originally appeared in the domain of public policy [RIT 73], but today some researchers apply the terms more broadly, particularly in business management. Conklin [CON 01] describes defined problems (A tame problem) as having the following traits:

– has a relatively well-defined and stable problem statement;

– has a definite stopping point, i.e. we know when the solution is reached;

– has a solution which can be objectively evaluated as being right or wrong;

– belongs to a class of similar problems which can be solved in a similar manner;

– has solutions which can be easily tried and abandoned;

– comes with a limited set of alternative solutions.

In contrast, he summarizes the characteristics of undefined problems (wicked problem) as:

– the problem is not understood until after the formulation of a solution;

– wicked problems have no stopping rule;

– solutions to wicked problems are not right or wrong;

– every wicked problem is essentially novel and unique;

– every solution to a wicked problem is a "one shot operation";

– wicked problems have no given alternative solutions.

Stressing the crucial character of the representation of the problem, Ritchey [RIT 05] adds:

> "The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution".

It should be noted that decisions about undefined problems are mostly unstructured decisions.

1.2.5. *Group decision-making*

Originally, the IDC model was built to represent an individual's decision process. Collective decision-making complicates this process in several ways. How groups function when making decisions collectively is the subject of a large amount of research across different disciplines, in particularly psychology and decision support.

In psychology, group functioning has notably been studied by Lewin [LEW 47], the founder of dynamic group theory, and in France by Anzieu and Martin [ANZ 86] and Mucchielli [MUC 13]. Research on groups focuses on their cohesion, power and influence relationships, locomotion methods (changes to the group's psychological state) and the ways in which decisions are made.

In the domain of DSS, Marakas [MAR 03] identifies five components that have an impact on group decision-making:

– the structure of the group, which is determined by the number of people in the group as well as the existing relationships between group members (hierarchical group, group of pairs, informal group, etc.);

– the different roles existing within the group and their definitive (a person holds one position which does not change) or evolutionary (a person can change their position) character;

– the processes implemented by the group and their degree of formalization and explicitation;

– the style of the group and, specifically, the type of management practiced by the group leader (authoritative, participatory, democratic, etc., management);

– the group's standards, which relate to representations and, more broadly, to the beliefs shared by the group, as well as to the rules set by the organization.

The question of shared representations (those which the group had at the beginning and those which it must build to reach a joint decision) is therefore, once again, essential.

1.3. Decision-making within the organization

We have already discussed decision-making from the perspective of one or a number of decision makers; in this section, we will focus on decision-making in its *organizational context*.

1.3.1. *Managing a complex system*

This section will briefly describe the main components of the management of a complex system, drawing inspiration from systems theory and more specifically research by Mélèse [MÉL 72], whose management model is still incredibly robust.

Henceforth, the unit considered in analysis will be called the *system*. An enterprise, a State service and an authority can, therefore, all be seen as systems, as can one of their branches or one of the services of a branch.

Systems theory divides all types of systems into three subsystems (which for reasons of simplicity we will call "systems"): the management system (which some authors call the "decision system"), the production system (in a wider sense) and the IS. To clearly identify decisions made from the general framework in which they are made, we will use the term "management system" (rather than decision system).

The *management system*:

– sets objectives (effectiveness, costs, etc.), in respect of which the mission must be carried out, and the resources devoted to it ;

– transmits them to the production system (in a comprehensible, realizable and controllable way);

– checks the stage of completion of the objectives and the degree to which the constraints have been respected (which involves, via feedback, a new management cycle: decision-making to correct the action of the production system).

The *production system* definitively realizes the mission of the system following the conditions (objectives, constraints and financial resources) set by the management system.

The *IS* conveys representations of the organization about itself, its environment and about the relationships it has with the latter.

An enterprise's IS is perceptible through, for instance:

– the types of entities which are decisive for the operation of the enterprise (enterprise activities, clients, products, suppliers, market segments, categories of client, families of products, etc.) or its development and even survival (competitors, partners, the enterprise's key technologies, categories of consumers, etc.); in territorial authorities, these entities can be: the population, the territory and resources (financial, staff, real-estate patrimony, movable heritage, etc.);

– characteristics considered relevant for describing these entities (a client is described with a reference number, their business name, address, the names of the contact persons, the normal delivery address and the billing address; it is possible to find out the year of their first order, the total revenue from this client, the list of payments, etc.);

– stables names (the list of products sold by the enterprise, its hierarchy and the list of different departments and services it contains, the accounting system and its accounts, etc.);

– formalized procedures and rules (purchasing procedures, rules for calculating discounts, security rules, confidentiality levels, etc.), etc.

The IS expresses the representations needed by the production system for the mission to be realized, as well as those required for management. These two types of representation overlap only in part.

For instance, though the aforementioned information describing a client is useful for billing or contact (about a sale) purposes, it cannot help the user interpret information showing that revenue from this *client has dropped nor help him or her determine which decisions to take to rectify the situation.*

Another example: a region can distribute assistance to enterprises and use an IS to manage the action (application file including the name of the enterprise, its activity code, its revenue, its workforce, etc.; attribution procedures and; system for managing budgets), however, the information that is collected and processed cannot manage territorial economic development policies. Management may require the following, for example, to be known: the current skills of the enterprise and the skills it intends to develop, the partnerships it has sealed with other players and the sectors in which it is likely to intervene, etc.

It is important to note that it is through the (unique) representation of the real available in the IS, and particularly in its digital part, that the management is performed. Entities types, entities, characteristics and dimensions that are absent from the IS will, therefore, not be taken into account during management. It should be noted that data mining techniques only partially compensate for these absences, in particular at the levels of tactical and specifically strategic management. This includes Big Data, which will be discussed in Chapters 2 and 3.

1.3.2. *The main components of the management system*

The main components of the management system are shown in Figure 1.1 and are briefly described below. The components are numbered as they are in the diagram.

1.3.2.1. *The mission of the system*

The first element, which is common to the system in question as a whole is its *mission,* i.e. the system's purpose, the reason it exists. The mission is often expressed as an end purpose, which according to Mélèse is "the representation a group built of the system missions, in very general rather than operational terms".

The mission of enterprise X is to produce and sell airplanes.

The mission of region Y is to enable inhabitants in the territory to live harmoniously via *sustainable development.*

It should be noted that the definition of the system's mission can vary, and sometimes a great deal, within the organization in question from one type of stakeholder, group or person to another. Changes in the economic environment, which will be described later, have often profoundly changed the definition of an enterprise's mission. In the current economic situation, one of the ways in which particularly large enterprises have changed is that their mission and objective or method have been reversed.

The mission of enterprise X, which was to produce products Z with the objective (among others) of increasing share value, has evolved, by financialization strategies, into a mission to increase share value by the method (among others) of producing products Z.

1.3.2.2. *The system of objectives*

Three levels of expressing the objectives can be identified according to their degree of precision:

– the end purpose or mission of the system (see above);

– goals, which realize the end purpose by breaking them down into operational components;

– objectives, which specify the goals via evaluation criteria along with a level that must be met and a time horizon.

All these end purposes/goals/objectives constitute the *system of objectives* as defined by Mélèse [MÉL 72].

NB: the numbers at the end of the following section titles refer to elements in the diagram below (Figure 1.1).

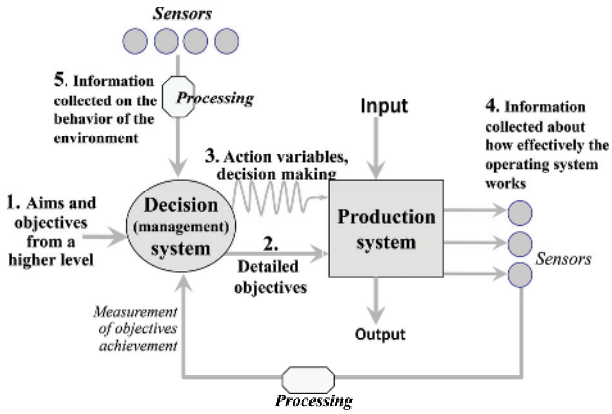

Figure 1.1. *Model for managing an organization (inspired by [MÉL 72]*

1.3.2.3. *Goals and objectives coming from a higher level (1)*

Objectives (and constraints) are imposed on the manager from a higher level.

For commercial managers, the higher level is the CEO. The CEO is in turn given goals and constraints from the board of directors. And finally, the expectations of financial markets, national or international regulations and countries' cultures provide the (sometimes implicit) constraints and objectives that are imposed on the board of directors.

1.3.2.4. *Detailed objectives (2)*

Managers deliver the objectives given to them from a higher level by adapting and breaking them down so that they are achievable, their achievement can be verified and they can be understood by the production system being managed.

Transposing the objectives received from a higher level is a major task for decision makers: it must enable them to improve their ability to control their production system and consequently, meet objectives by breaking them down into smaller objectives (in accordance with the potentially highly varied dimensions).

A commercial manager is given the objective of increasing revenue by 10% in a year. This objective can be broken down into a revenue objective per month, type of client or any other dimension devised by the commercial manager. It should be noted that a decision maker's skill can (in part) be measured by their ability to innovate with regard to breaking down the objectives they receive in order to form the detailed objectives to convey to their teams.

A typology of objectives (and indicators) is presented in section 1.3.4.

1.3.2.5. *Action variables and decision-making (3)*

Action variables relate to the options the decision maker has within the limits of the *decision-making latitudes* that have been imposed on him or her (e.g. the option to recruit or not to recruit, to use a budget freely or not freely, to change the way prices are set, services are organized, etc.).

Within the framework of these decision-making latitudes, the decision maker makes *effective decisions*, which are then implemented (employing workers, allocating a budget to an action, commissioning research, reorganizing the service, etc.).

The decision maker uses these action variables, which correspond to effective decision-making, to rectify the functioning of the production system to optimize the achievement of objectives in the short or medium term.

In the aforementioned example – to meet the objective of a rise in revenue – the commercial manager might decide to put a product on promotion, and/or change its packaging, and/or change the composition of the commercial teams so as to strengthen the action for certain client segments, etc.

1.3.2.6. *Sensors and indicators measuring the functioning of the production system (4)*

These sensors provide information about how the production system and its immediate environment work. They allow the production of indicators that will measure the achievement of the objectives set by the higher level (No. 1 in the diagram), as well as that of internal objectives (No. 2) set by the manager.

In the previous example, the indicator of the objective is clearly the total revenue achieved and its progress, but additional indicators are also required to measure whether detailed objectives have been met (revenue per type of product, client segment, sales advisor, etc.).

1.3.2.7. *Sensors and indicators measuring the environment (5)*

The aforementioned sensors often need to be supplemented with measurements of the broader environment so that predictions of future evolutions can be improved and, where necessary, some objectives can be redefined.

In our example, information about the environment may relate to competitors' (with the same type of products) revenue, competitors' current and future new products, the financial situation of important clients, new consumer behaviors, regulations being studied at the European level, etc.

1.3.2.8. *Conclusion*

Various research and applied research projects have testified the very high operationality of this simple model. For illustration purposes, decision supports can be categorized according to the components of this model: support to define objectives, support to break them down, support to understand the state of the production system, support to interpret the environment and support to choose an action variable (i.e. support to make decisions in the current sense of the term).

From our perspective, this model also has a major benefit: it draws a distinction between decisions that define the management system and decisions that result in real actions (we will return to this point in section 1.3.5).

1.3.3. *Indicator, index and information useful to the decision maker*

Figure 1.2 shows the relationships we establish between the notions of the indicator, the index and the information useful to the decision maker, which will be presented in this section.

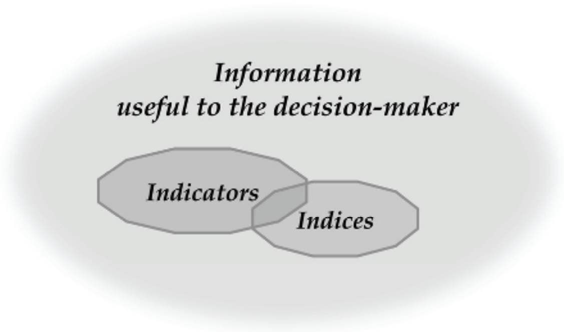

Figure 1.2. *Information, indicators and indices*

1.3.3.1. *Indicator*

The majority of existing definitions consider an indicator to be a direct or calculated measurement which is expressed either quantitatively or quantifiably. These numerous definitions mostly differ according to the degree of restriction of what an indicator helps assess.

An indicator can, therefore, measure the achievement of a given objective and is, as such, a key performance indicator (KPI). In addition to measuring performance, *indicator* also designates "any significant, relevant or irrelevant measurement used to assess results, the use of resources, the stage of work progress or the external context" [SCT 03].

For Fernandez [FER 05], the notion of indicator is extensive: it is "a piece of information or a set of information that help the decision-maker assess the situation".

We would like to put forward a more restricted definition of an indicator: *an indicator is a piece of formalized information which is produced regularly and which measures the realization of an action or the achievement of an objective.*

An indicator is, therefore, necessarily linked either to an action variable (i.e. the concrete implementation of a decision) or an objective (according to the management model presented above).

1.3.3.2. *Index*

In addition to the notion of indicators, we would like to put forward that of indices: *a piece of formalized information (a measurement) that is not directly linked to an objective or to an action variable will be called an index (and not an indicator); an index is either a one-off or a regular measurement.*

An index, therefore, focuses on:

– either an subject for which an objective cannot be set (for instance, an element of the environment that cannot be controlled: competitors' performance, the rate of change, the availability of rare raw materials, the socio-professional distribution of a population, etc.);

– or an subject that we have not, or have not yet, decided to control (for example, the numbers of a rare species of amphibians).

An index (either one-off or regular) can be used to help build the representation of a problem by taking stock of the existing situation.

It should be noted that this type of index may become an indicator if the organization sets an objective intended to change the situation and thus the value of the index. In the context of territorial economic development policies, a territorial authority can, for instance, use an index measuring the employment rate of young graduates to build a representation of the economic situation of the territory. It can subsequently create a policy whose objective is to increase the rate of employment in this category. The measurement, therefore, becomes an indicator of the achievement of this objective.

Another example is an enterprise which has production problems (for instance, the number of faulty products is too high). To identify the cause of the problem, measurements can be taken at different points in the process. Like in the previous example, one or more indices may become indicators if, for instance, a quality objective is set for a certain section of the production process.

1.3.3.3. *Information useful to the decision maker*

To gain an understanding of this notion, let us look at Mélèse's definition [MÉL 79] of information[2]:

> For a human being (or an automaton) any signal, message or perception that has an impact on their behavior or cognitive state is information.

Information useful to a decision maker will, therefore, for us be: *any signal, message or perception that has an impact on the behavior or the cognitive state of the decision maker and helps them with the various phases of their decision process.*

Information useful to a decision maker can be formal or informal, oral or on hardware support (including digital), text or not text, verified or unverified, etc. According to the definition we have put forward, indicators or indices are specific cases of information useful to a decision maker.

1.3.4. *Typology of objectives and indicators*

The management model presented by Mélèse [MÉL 72], whose effectiveness is in part due to its simplicity, does not suggest a developed typology for objectives or indicators. Yet, it is important to have an elaborate understanding of these elements to get closer to the meaning of the decisions, while the DSS is being designed, in particular during the requirement engineering phase (see Chapter 2).

2 Chapter 3 (section 3.2.4.3.) draws a useful distinction between data, information and knowledge.

The Balanced Scorecard offers an advanced typology for objectives and their related indicators.

In their Balanced Scorecard method, Kaplan and Norton [KAP 96] consider that current indicators are no longer suited to modern enterprises as they reflect past performance (whereas future performance is most important). Moreover, they are mostly quantitative (whereas management also needs to be based on qualitative evaluation). To these *a posteriori* indicators, the authors propose adding qualitative indicators as well as indicators about the determinants of future performance (*a priori* indicators) which they organize into four perspectives. These perspectives relate to both objectives and indicators, which must measure their achievement. The first two perspectives are determinants of future performance (levers) and the last two perspectives are the results.

1.3.4.1. *Key structural levers: learning and growth perspective*

These objectives relate to the components of the organization, which determine the sustainable performance of the latter: people (skills and motivation), IS and methods for developing procedures.

1.3.4.2. *Key operational levers: internal business processes perspective*

The objectives of this perspective focus on the processes in which the organization must excel if it has to meet the objectives of its intermediary and final results (e.g. delivery times, quality of post-sales service, innovation, etc.).

1.3.4.3. *Intermediary results: customer perspective*

The objective of this perspective aims to improve the satisfaction of players who are in an environment close to that of the organization and who determine the final results. For Kaplan and Norton, this principally concerns the enterprise's clients.

1.3.4.4. *Final results: financial perspective*

Depending on the type of organization and its end purpose, these objectives tend to satisfy one or a number of stakeholders who may or may not be part of the organization. An enterprise can set itself financial objectives (aiming, for instance, to satisfy shareholders alone), which is, in fact, the definition Kaplan and Norton gave to this perspective. An enterprise may, however, set final goals which are not financial (for instance, enterprises operating in the social and solidarity economy). A territorial authority may set objectives that aim to improve the living conditions of all or part of the population in a territory.

1.3.4.5. *Strategy map linking the objectives*

There is a causal chain between the objectives of the different perspectives. The realization of objectives of the key structural levers enables performance at the level of key operational levels (key processes) to be improved, which, in turn, make it possible to achieve intermediary results, which are necessary if the final results are to be met (the final results being the organization's ultimate goal). Figure 1.3 shows an example of a causal chain in a (fictional) enterprise.

1.3.5. *Support to define the global management system or support for action decisions?*

Studying the literature in the domain of DSS shows that the difference between support to define the global management system (defining the system of objectives, decision-making latitudes, indicators, etc.) and support to make decisions resulting in an action[3] (decisions, therefore, made within the management system) is rarely explicitly established. This distinction is partially (though not specifically) dealt with in the description of the categories of management activities that are described in the following paragraph. The two problems overlap only in part.

3 For reasons of simplicity, we will, henceforth, call decisions whose direct result is an action: *action decisions*.

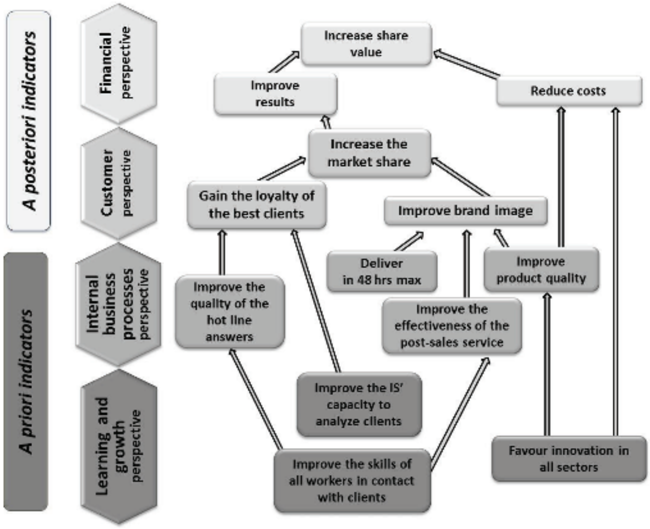

Figure 1.3. *Example of a strategy map for an enterprise*

Decisions that define the global management system determine the *framework* (objectives, constraints, resources, methods, measurement criteria, etc.) within which the action decisions are made. The former can be called meta-decisions as they are decisions concerning other decisions.

It is not always easy to draw a distinction between these two types of decisions. Simon [SIM 97] stresses that objectives, constraints and resources are positions that move and interchange over the course of the management process.

Moreover, defining the management system is not (as a superficial analysis may conclude) the prerogative of the senior management of an organization; rather, it operates on every level of the organization, i.e. for each subsystem comprising the global system (which could be an enterprise, territorial authority, a State service, etc.).

In the context of DSS design, we maintain that it is advisable to draw a distinction (as far as is possible) between decisions that define the management system and decisions that implement it.

We maintain in particular that decision support requirements are not, or not for the most part, the same for both types of decisions. Illustrations of these differences are provided below. The range and the frequency of decisions for defining the management system differ from the range and the frequency of action decisions. The same distinction can be made for the importance of representations or the evaluation of the management system.

The *range* of the former is by definition larger than the range of the latter as they define the *framework* within which the latter are made. Decisions that design the management system always have an impact on the IS. The impact can be great and result in structural evolutions of the IS (e.g. changing the representation of the organization's missions or end purpose resulting in an upheaval of the entities represented in the IS and/or a significant change of the perimeter of the IS). This impact can be (only) significant (e.g. methods evaluating the achievement of objectives are changed resulting in new columns being added to databases, indicator and dashboard calculations are changed throughout the organization as a whole). The impact may, however, be more limited (e.g. the decision-making latitudes of a manager are changed resulting in their dashboards being updated).

The *frequency* of decisions concerning the management system is irregular but generally lower and their range is larger, which goes hand in hand with limited reversibility. Action decisions (with the exception of some strategic decisions) are made at a faster pace than decisions that define the managing system (this pace may be very high for decisions made at the operational level).

Conceptual high-level *representations* (general views) produced by the organization (about itself, its missions, environment, position within the latter, the trajectory it will follow, etc.) have a significant impact on the organization of the management system (particularly objective setting). The design of a DSS intended to support the definition of the management system must, therefore, consider these representations, which are in part implicit and may vary or contradict each other within one organization. With regard to action decision-making support, the question of global representations is less important as these decisions (with the exception of strategic decisions) are made within an already-established system of objectives which express a set of representations. Naturally, the idea of the representation also applies when the decision maker *represents the problem* (the first phase of the decision-making process), although its range is noticeably reduced.

Our final example, the *evaluation* of the management system, is a complex, highly iterative and even recursive process. It is generally much more complex to assess the relevance of an objective to define the management system than it is to measure the effectiveness of an action helping to achieve an objective. The former are for the most part undefined problems (wicked problems): structuring them requires a great deal of effort and information – which is diverse and covers a broad spatial and temporal perimeter – to be collected and produced.

A further distinction concerns the type of decisions in terms of their subject, range and effect on the organization: in brief, their *management level*.

1.3.6. *Management levels*

The domain of management science has identified a number of categories of decisions based on their impact on the organization. Three levels are generally recognized. Borrowing military terminology, they are often known as the operational, tactical and strategic levels. The respective content of the three levels varies from one author to another, particularly with regard to the strategic level. That said, these categories have remained relatively stable over the past few decades.

Anthony [ANT 65] and then Ansoff [ANS 88] presented the categories of different types of decisions, which have since been very widely used. We will now present Ansoff's description of the levels. Ansoff mostly reiterates Anthony's categorization of levels 2 and 3, although his definition of strategic decisions deviates from Anthony's. For Anthony, the strategic level exclusively involves defining the management system, whereas for Ansoff it primarily involves defining the enterprise's relationship with its economic environment:

1) strategic decisions mostly concern the – external now rather than internal – activities of the enterprise and more specifically the choice of products they will produce and the markets where they will sell;

2) administrative decisions whose objective is to manage resources so as to obtain the best possible results. Administrative problems consist of, on the one hand, organizing the enterprise's structures (authority and responsibility relationships, work and information flows, communication channels and appointments) and, on the other hand, ensuring that resources are purchased and developed (namely, staff training, financing and purchasing equipment);

3) operational decisions' objective is to make the process of transforming resources as efficient as possible, in other words, to obtain maximum profits from current business.

Like many other authors, Ansoff specifies that the three categories are interdependent and complementary. The strategy requires operational measurements and the administrative structure must provide conditions to implement the strategy.

It is not always easy to fit a decision into one type of category. Mintzberg [MIN 94] remarks that:

> Decisions made for immediate purposes under short run pressures (…) can have the most long-range and strategic of consequences (…). Likewise, seemingly momentous "strategic" decisions can sometimes fizzle like a punctured ballon.

Systems theory [LEM 77] identifies several different types of ways a system evolves based on whether its relationship to the environment, and its end purpose and goals, is stable or changeable.

Four different ways of evolving a system have been identified, which can be interpreted as being either at the management level or at the decision level:

1) Regulation or stabilization (stable goal and stable environment);

The system is stable in a stable environment. The system of objectives and the organization as a whole remain unchanged. Only, the values of the adjustment parameters are changed to respond to slight disturbances in the environment. Regulation is an adaptation without memory, and therefore without learning.

> *Examples of regulation decisions: adjusting a machine when production changes, re-allocating resources in the short or very short term, dropping a price during negotiations between a salesperson and their client, deciding to deliver products to a client depending on their solvency and choosing an intern.*

2) Functional adaptation (stable goals and changing environment);

Lasting modifications are identified in the environment. Management modifies the organization without calling into questions its end purpose or goals. This management level (like those below) involves learning.

> *Examples of functional adaptation decisions: reorganizing production into 2 × 8 h, reorganizing the workload of a commercial team (distributing prospects, the number of client visits, commercial documentation, etc.).*

3) Structural adaptation (changing goals and stable environment);

The user recognizes that the environment is going through a stable period and decides to modify the end purpose of the system within certain limits. The system's inscription in its environment (mission) is modified, though it is not completely called into question.

> *Examples of structural adaptation: targeting a new type of client (e.g. private individuals for an enterprise who hitherto worked in business-to-business), innovative technology in the production process, launching a new product and changing pricing methods (particularly in services).*

4) Structural evolution or morphogenesis (changing goals and changing environment).

To continue to exist in an environment that is evolving strongly or to seize an opportunity offered by this situation, the system decides to radically change its end purpose.

> *Examples of structural evolution: vertical integration, withdrawal of a significant part of business activity (e.g. keeping only commercialization activities and research and development (R&D), diversification outside current sectors and modifying the logic of client relationship (e.g. offering access to a commodity rather than ownership of a commodity). A number of strategic actions recommended by Porter [POR 85], the effects of which modify the structure of an entire sector, are typical of structural evolution.*

These four levels and the aforementioned typology (operational, tactical and strategic) correspond as follows:

– the operational level is that of regulation;

– the tactical level is that of functional adaptation and structural adaptation (in part);

– the strategic level is that of structural adaptation (in part) and structural evolution.

1.3.7. *Toward decision support for the three management levels*

From very early days, the domain recognized that the requirements of decision support, and more broadly information, differed a great deal depending on the decision level [GOR 71, SIM 60]. In the same way that it is difficult to differentiate between decisions and actions [SIM 97], the decision levels are closely interconnected. In fact, any strategic decision will be conveyed by a set of tactical decisions, each of which is, in turn, the subject of a number of operational decisions. A large number of pieces of research into DSS have, however, failed to specify which level(s) of decisions they were seeking to support. Meanwhile, the majority of tools available on the market have shown themselves to be principally focused on operational decisions.

Since 1980, Sprague, defining a general framework for DSS design, has pleaded that:

> DSS should provide decision making support for managers *at all levels* [our emphasis], assisting in integration between the levels whenever appropriate.

This book subscribes to this approach: it is an ambitious goal for the domain and, for the most part, has not yet been achieved. To try to achieve this objective, research into decision support should always specify the level(s) of decisions they concern.

1.3.8. *Standardizing decisions*

The organizations within which decisions are made determine in part, of course, not only the content of decisions, but they also influence the extent to which they are *structured*. At the extreme end of the continuum mentioned by Simon (between non-programmed and programmed decisions or unstructured or structured decisions), the organization may have produced decisions which are made via a totally standardized process. Structured decisions may, therefore, have been the subject of *standardization* (by internal or external standards).

For example: the decision of an airline's customer service to authorize or not authorize the modification of flight dates (a procedure inscribed in tariff-types); a buyer's decision to place an order (related to stock levels depending on the period, etc.) and; a commercial manager's decision to accept or not accept an order (checking the solvency of the client).

Some decisions may be structured (the decision maker in question can describe the structure of the problem the decision must solve as well as the process for solving it), although they have not yet been the subject of standardization within the organization.

For instance, choosing a new supplier, recruiting a new employee, etc.

By definition, unstructured decisions cannot be the subject of standardization.

Nowadays, highly standardized decision-making is often part of production software (in the broad sense) and, therefore, no longer appears as decision-making but rather as a simple procedure (which may sometimes make adjusting to an unexpected situation difficult).

1.3.9. *Taking into account the dynamic of organizations and their environment*

Over the past 30 years, enterprises, like all institutions, have witnessed big changes in the way they and their environment operate. In the field of decision support, many papers justify the growing interest in DSS by the need of enterprises to adjust to a constantly changing economic environment, characterized by the globalization of all exchanges (commodities and services, financial flows, human resources and information).

For some authors, these changes to organizations' environment have a strong impact on decision-making, particularly given that the numbers of undefined problems and unstructured decisions have multiplied. Mitroff and Linstone [MIT 93] therefore believe that business leaders must radically change their way of thinking to tackle these new situations. Following in their footsteps, Courtney [COU 01] suggests that research into decision support should "change paradigm" to take new dimensions into account during DSS design (organizational, personal, ethical, etc.).

In our opinion, these considerations do not go far enough. We believe it to be impossible to work in DSS design without focusing on the *sense* of decisions (their content). The latter is, in fact, a direct function of the dynamic of the organization within which the decision is made; this dynamic is itself closely connected to the dynamic of the environment.

Although, as previously mentioned, the importance of changes to the environment is broadly recognized in the domain, very few studies do more than merely take note of its existence. Our position is that to improve decision makers and organizations' understanding of current requirements, it is essential to conduct a detailed analysis into the nature of these evolutions and the type of impact they have on organization management. This analysis can only be conducted via *interdisciplinarity*, i.e. by borrowing the elements required from other domains, in this case for the most part from economics.

1.4. Changes to management within organizations

This section will describe the changes to management within organizations. Four dimensions will be the focus: connections with the environment, the stability of boundaries, innovation and requirements linked to IS.

1.4.1. *Connections with the environment*

In terms of the basic strategic choice of "to make or to buy", enterprises have successively adopted three types of response.

The dominant strategy during the *Glorious Thirty* (1947–1974) was to seek to be independent from the environment and opt for vertical integration (upstream and/or downstream). Connections with the environment were therefore reduced, stable and not very complex. The roles of different players (clients, suppliers, competitors, research partners, etc.) were well defined, stable and had little or no overlap. The logic of commercialization was totally focused on expanding the enterprise's part of the market (keeping clients seemed obvious). In this first phase, understanding the environment was relatively easy.

In the *second* transitional *period*, there was an intensification in external procurement [MOA 08]. Known as quasi-integration logic, enterprises contracted out part of their production on the basis of precise specifications. Even though they maintained expertise about and control over their subproducts, enterprises had to contend with a new type of player and partner (subcontractors).

Demand grew fast both in intensity (characteristic peaks and falls) and content (expectation of variety at the level of the offer). Consumers were no longer a global mass that could be lumped into the one dimension of buying power. New categories emerged besides the socio-professional categories. Market segmentation, therefore, became a key factor for enterprises: markets were broken down into increasingly smaller markets (which later became “niche markets”). Environment analysis mostly focused on consumer behavior and their evolution.

In the *third period,* which started in the 1980s and is currently ongoing, there has been a shift from a logic of integration (or quasi-integration) toward a logic of *outsourcing*, which is accompanied by a pronounced financialization of strategies (particularly for large groups). The control of its by-products is no longer provided by the company, which relies on co-contractors, on the basis of functional needs or problems to be solved, rather than on the basis of complete technical specifications. A central concern is determining the enterprise’s core skills and thus the knowledge and skills the enterprise must continue to hold. A detailed understanding of changes to the environment across all levels (client requirements, competition, trends in scientific and technical research, etc.) becomes essential. This process of understanding requires large volumes of reliable and often qualitative information and involves the complex task of interpreting it, which must often be done in a group.

1.4.2. *Boundaries*

The nature of the enterprise’s boundaries has changed a great deal over the three periods, whether they be boundaries separating the enterprise from its environment, boundaries separating the different markets and boundaries demarcating the activity sectors.

In the *first period*, boundaries were stable, airtight and easy to identify. This is true for the boundary separating the enterprise from its environment, even the closest environment. Similarly, sectors (as defined by the National Institutes of Statistics) were based on a stable triptych (one market, one product and one technology) [GUI 71] and constituted a division from the economic activities. Enterprises, with a few rare exceptions (very large enterprises), operated on a local, regional or national level.

In the *second period*, the market and sector boundaries remained relatively stable, but there was a clear shift toward the international (markets, competition, looking for subcontractors, etc.).

It is during the *third period* that there has been a radical change in the question of boundaries. The enterprise's boundaries shifted to embrace the system it had formed with all its partners and thereby defined the space in which the enterprise operated, made decisions, was organized and structured its IS [SHI 02].

The development of key enabling technologies (e.g. digital) has destabilized the aforementioned triptych (one market, one product and one technology) [SAL 07b]. Boundaries between the sectors, as determined in classifications, lose much of their relevance [COL 10] and become porous. Market boundaries are blurred and the markets are thus "questionable"[4] [BAU 82]. There is a shift from a logic of the product, production process or market to a logic of skills which induces greater movement in business activity. For the enterprise, this produces both opportunities (new markets, new requirements leading to the design of new products, new technologies, etc.) and threats (new competitors with the same products or with substitute products, fast and radical obsolescence of manufacturing processes, etc.).

In line with a picture of activities and markets that are in constant flux, an enterprise's competitors are a changing group. New incomers arrive from "foreign" sectors and from countries which had not hitherto operated in the nation in question. Competitors offering substitution products, rather than identical products, pose the biggest

4 When an enterprise can cross the boundaries of a market when the dominant technology is the same (e.g. IT toward telecommunications).

threat. Identifying current and potential competitors requires a mass of information and excellent analysis skills.

In this period, operating spaces became international for all players: clients, suppliers, subcontractors, workers, researchers, standards, etc. Players and flows (of information, funding, materials, products and workers) are moving, sometimes extremely fast, and are in operation over a global space. Once again, knowledge of the environment is decisive.

1.4.3. *Innovation*

Over the *first two periods*, innovation was mostly conducted internally. At the end of the second period, there was a shift from innovating the product and processes toward innovations concerning all sectors in the enterprise.

By the *third period,* there is no doubt that innovation became the primary factor for competition [MOA 08]. All sectors in the enterprise are obliged to innovate: product definitions, manufacturing processes, market segmentation, methods, the organization, the IS, etc. This approach focuses more on *creation* (new processes, new products, new markets, etc.) than on *conquest* (part of an existing market). A condition of this creation is the enterprise's ability to generate innovative representations (of its skills, markets, products, economic environment, etc.). In our opinion, one of the key roles of decision support (and more broadly IS) is to help managers to build these innovative representations.

1.4.4. *Requirements linked to information systems*

In the *first period,* as the enterprise's performance was based on factors (namely capital and work), information requirements principally concerned operational functioning.

The economic environment was considered stable in that the way it evolved was known and could therefore be predicted. Information on the environment was not specifically sought: it was considered to be obvious and/or available without effort.

Strategic decisions were made and applied over a long period. Many concerns were concentrated on decisions at the intermediary (tactical) and lower (operational) levels and focused on production organization. Problems often recurred and were mostly well defined. Decision-making was relatively easy and a high number of decisions could be optimized.

In the *second period*, the existence of production partners (subcontractors) complicated production management. In addition, more active competition gave a new importance to managing production projects (checking deadlines, costs, etc.).

The problems that needed to be solved remained relatively standardized. Logics of optimization were still possible for some decisions at the higher (choice of where to locate an establishment) or intermediary (defining the range, setting prices, scheduling production, etc.) levels. A part of operational decisions was spontaneously included in the procedures automatization software.

With the exception of information about consumer behavior, knowledge about the environment was not the focus of enterprises' concerns.

In the *third period,* the situation became much more complex and consequently there was a need for information and interpretation support. The rapid metamorphosis of the economic environment, the blurred and moving nature of all boundaries, the versatility of the positions of players and the constant search for innovation multiplied the number of previously unseen and unstructured problems at all levels of the enterprise's management. Solving these problems required creating new knowledge. This required information to be provided about the environment, the internal operations of the enterprise as well as about knowledge that had already been created (knowledge base, return on experience, etc.). In this context, the figures of the cognitive worker [COL 08] and the knowledge worker [ROS 08] became essential.

The constant need for internal and external coordination results in the need for specific technologies. In the event of a crisis, the latter must be capable of enabling players to solve complex problems together [HAN 12, BÉN 08], even if they have never cooperated together in the past.

Defining ranges, segmenting clients and setting prices have become very complex due to newcomers (potentially) entering the market and consumer movement, which is sometimes extreme. The IS used for decision support must provide both the necessary information (collected from internal and/or external sources) and interpretation support (data mining, simulation models, heuristics, etc.).

With regard to consumers, winning client loyalty is of primary importance. There are two reasons for this: first, the cost of keeping clients is much lower than the cost of expanding the client base and, second, only a long-term relationship can enable the enterprise to conduct an in-depth analysis into the needs and aspirations of consumers so as to constantly offer them new services based (or not based) on new products. In-depth knowledge about behavior (which tends to consider each client individually) becomes an essential factor for competition. IS, and specifically their digital part, must therefore store and process very detailed and historic information about clients and prospects (particularly using data warehouses).

In the third period, the industrial sector of business intelligence emerged (in the early 1980s) and then, logically in terms of the aforementioned requirements, experienced rapid and continued development. More modestly, technology intelligence moved away from R&D services alone and reinvented itself as strategic intelligence and then competitive intelligence. Its principal role was, therefore, to support the construction of innovative representations of the enterprise's environment and the inscription of the latter in the former.

Recent developments in the economic situation have given rise to new requirements, which can be categorized into two types. First, the financialization of strategies, which makes raising share value the mission of the enterprise and tends to some degree to uniformalize management and decision-making methods and, consequently, requirements for decision support. We believe that the great interest in Big Data originates from this trend (see Chapter 3). The second type of new requirements is concerned with group decision-making. This involves a large number of stakeholders, knowledge sharing about the enterprise's environment and taking ethical questions into account during decision-making.

1.4.5. *Changes to public institutions: territorial authorities*

Territorial authorities have experienced changes similar to those mentioned above. This section will describe some of the impacts of these changes.

1.4.5.1. *From government to governance*

In territorial authorities, there has been a shift from a logic of local or regional government – involving only elected representatives and services, on the one hand, and the State, on the other hand – toward a logic of governance, involving a diverse array of players (the European Union (EU), devolved State services, public institutions, enterprises, advice services, representatives of civil society, intermediary bodies, etc.).

1.4.5.2. *Expansion of the environment*

Territorial authorities, and especially the regions, have experienced a considerable expansion of their environment. When looking for foreign direct investment (FDI), they find themselves in competition not only with other regions in the country, but also with regions from other countries, which are often outside Europe. The same is true with regard to attracting qualified workers or looking for partners. In addition, the systematized practice of benchmarking results in authorities comparing themselves or being compared to authorities that are sometimes very distant (in all senses of the word).

1.4.5.3. *From territories with defined borders to the revelation of territories*

Alongside the need for governance and the expansion of the environment, defining the borders (of territories) has become more complex. For many years, invariant and hierarchized administrative borders (town, councils and counties) or borders produced by the National Institutes of Statistics (living zones and employment zones) have been the only borders used to identify territories. Nowadays, new types of non-hierarchized and evolving administrative entities are appearing: provinces (which can straddle several counties or even regions), communities of towns or urban areas, etc.

However, more crucially, there has been a change in paradigm: nowadays a territory (e.g. where a project is to be launched) can no longer be considered to be preexisting in the state; on the contrary, it is the end result of the players' actions throughout a project. The territory is, therefore, no longer identified before the project begins; it is revealed during the project.

1.4.5.4. *Requirements related to information and decision support*

The complexity produced by the aforementioned changes, the expansion of authorities' missions and simultaneously the reduction of their financial resources make reflecting on the definition of the management system an unavoidable task. The system of objectives must be explained, action variables determined, sensors defined, etc. A specific and very significant case is that of indicators. Evaluation needs can respond to regulatory requirements (e.g. issued from the State or the EU) relating to the use of received funds. The evaluation format is, therefore, set by the authority and the use of indicators is specifically required. Evaluation needs do, however, go well beyond this framework and refer to global issues of territorial development and to governance requirements (return toward the internal and external players in the authority, toward "normal" citizens, etc.).

New needs relating to information and decision support also arise from governance, which presupposes that the territorial authority cooperates with multiple players. The authority must be capable of identifying players, understanding their needs, defining projects in cooperation with them, managing their multi-party implementation, conducting a shared evaluation, etc. This implies, on the one hand, a territorial IS that is really capable of producing a formalized representation of all or part of the resources in the territory and, on the other hand, a set of collaborative and decision support tools.

Recognizing territorial authorities' need for specific information about the environment has resulted in the notion of territorial intelligence, which developed out of competitive intelligence [ADI 03]. A specific market offer rapidly succeeded this arrival: intelligence tools, information sources, advice, etc. This relatively recent activity has not yet (for the most part) been assessed, but territorial intelligence is without doubt one response to the needs resulting from changes to how territorial authorities function.

Conclusion: key points for DSS design

Choice of the general approach

The first point is the choice of the general DSS design approach. This approach can either be *normative* decision theory or the theory of decision *engineering*. Normative theory considers decision-making to be looking for the optimum: all useful information is known and available. The theory of decision engineering, in line with "historic" definitions of DSS, concentrates on weakly structured or unstructured decisions. The focus is thus on the *process* of decision-making throughout all its phases. The type of DSS and engineering requirements for its design differ a great deal depending on which of these two approaches is adopted. The first approach is actually more of an automatization of decision-making rather than decision support.

Main phase addressed by the DSS

A second positioning element concerns the phase (or phases) of the decision-making process that is considered central for the development of the DSS and/or that we are primarily seeking to support. In previously unseen and badly or undefined decision-making situations, the problem definition phase takes center stage. Conversely, in repetitive situations corresponding to structured and even standardized decision-making, the final phase – choice – will be the focus.

Decisions that define the management system or action decisions

A distinction must also be made between decisions related to the partial or global *definition of the management system* (defining the system of objectives, decision-making latitudes, indicators, etc.) and *action decisions* (action variables). In the majority of cases, decision support needs, decision support tools and the consequences of decisions are not the same for the two types of decisions.

Management level

It is also useful to determine the *management level* of the decisions we want to support. Decisions have very different goals and impacts depending on their level (operational, tactical or strategic). Similarly, decision support needs are mostly specific to each level. An understanding of the distinctive traits of each of the three levels must be included in any engineering requirements for DSS. The level(s) of decisions a DSS seeks to support should be clearly stated.

Innovation in decision-making

Finally, the relationship the DSS we are designing has with *innovation in decision-making* must be established. The organization within which the decisions are made is itself immersed in an environment with which it interacts. Over the past 20 years, this environment has experienced structural changes which have had a large impact on organization management. The extreme densification of connections with the environment, the constant questioning of all boundaries, the multiplication of players and the instability of their respective positions create new problems, which call for new and innovative decision-making. Supporting innovation in decision-making implies going beyond what already exists in decision-making to help decision makers build *new representations.*