Hospital Information System: Comparison of Three Devices of Modeling Directed Process

Sabrina Guetibi, Mohammed El Hammoumi, and Anas Chafi
Department of Industrial Engineering, Faculty of Science and Technology Fes; Laboratory of Industrial Techniques (LIT), Fez, Morocco
Email: {sabrina.guetibi, anaschafi}@gmail.com; m_elhammoumi@yahoo.fr

***Abstract*—The diffusion of the process approach led to introduce the concept of process into the definition of an information system; it has a positive influence on the management and the behavior of these systems. Most of analysis techniques give notions to model of an information system through its processes, but according to various sights and perspectives. In the present work, we begin first of all with a definition of hospital information system, its impact and these sources of ambiguity, then we linger over a presentation of the modeling of information system directed process. We try finally to establish a reflection about the devices of modeling by process approach by means of a comparison.**

***Index Terms*—process approach, hospital information system, information system directed process, modeling of information systems, modeling by process approach.**

I. Introduction

Information is in the center of everything at the dawn of the XXI century: the striking down development of multiple technologies of communication makes it possible to process the good data with the good moment for the good audience. The industrial sector benefited greatly from this incredible progress through scientific methods from operations research and computer science engineering, thus constituting the vast domain of the industrial engineering.

During the last twenty years, hospitals have evolved significantly: facing a socio-economic context of increasingly tough, they have to comply with new rules of management to minimize the costs while maintaining the quality of service.

The object of the scientific studies of these twenty last years is to bring to the hospital systems significant profits in terms of effectiveness and productivity by the installation of more efficient organizations, while ensuring the improvement of the quality of care. The application of scientific methods resulting from the field of the industrial engineering constitutes an excellent approach to achieve this goal.

This document aims to determine this concept and to put forward its characteristics. We will start first of all with a presentation and definition of the HIS[1], then we clarify the various concepts of this system (objectives, impact and problems). Then through a bibliographical study, we will present our synthesis on the modeling of the information systems, finally we will complete this work by a comparison between three methods of modeling directed process. We aim through this work to provide the benchmarks to better understand the HIS, as well as process-oriented modeling methods.

II. Hospital Information System

IS exceeded the tool stage to become the structuring element of an organization. “Ref. [18]” defines it as "an organized set of resources including hardware, software, personnel, data, procedures to acquire, process, store, transmit information (in the form of data, text, images, sounds, etc.) in organizations. "

Any system of health, whatever its level of development and its operating mode, suppose the existence of an IS. This one has as a task to produce the data necessary to the determination of the priorities for the resource allocation available, to evaluate the programs implemented, to measure health status and the needs for health.

A. Principal Objectives of the Hospital Information System

- To constitute all information, data base concerning the patients and all the other related activities of the hospital,
- To follow the care of patients,
- Assist in the management and control of risk situations,
- To perform the realization of studies and medical research,
- To appreciate the cost of care of responsibility of the patients,
- To optimize resource allocation.

The data collected will be used for the identification and calculation of operational indicators for each area of activity concerned and to evaluate hospital performance.

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1. HIS: Hospital information system, Intended for the management of the establishments of health (hospital centers, center of specialized care, etc.)

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B. Impacts of Information System in Hospital

Seen from the managerial perspective, the IS is a "support function" as well as the management of personnel or management control. It aims to ensure the best possible information processing, according to the demands of the activity leaders and beneficiaries. As a support function, the IS is influenced by the environment of the hospital, these characteristics and strategic options of its leaders.

The implementation of an IS exerts in return of the impacts on the organization. From where awaited impact of the IS "Fig. 1" at the hospital (Better services, added value, etc.)

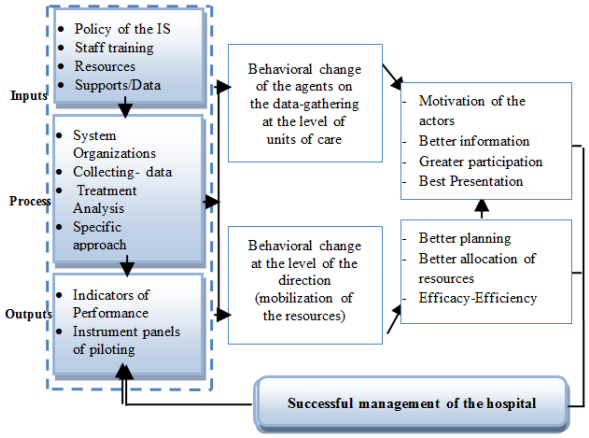

Figure 1. Impact of the information system on the medical organizations

C. Problems of the Hospital Systems

The problems encountered in hospital systems are different. Overall, for any system, the main motives hear the resolution of performance evaluation problems and system optimization problems.

Inspired by the work of LIMOS "Laboratory of data processing, modeling and optimization of the systems" [13]-[14]

All these issues are classified according to the tactical and strategic operational time horizons [17] and the different levels of modeling macroscopic, mesoscopic and microscopic "Table I,"

The modeling of all system can thus be done according to various levels of aggregation:

- The macroscopic level indicates the higher level of observation (high aggregation). Of the "large" Greek and "to examine," the macroscopic adjective is also employed like the opposite of microscopic by indicating what is visible with the naked eye, without magnifying glass nor microscope. At the macroscopic level, the system is apprehended as a whole, the whole of the patients form a whole, just as the whole of human or material resources. A macroscopic modeling is generally used to solve even tactical strategic problems of planning [2]
- Contrary, at the microscopic level, each element is considered indecomposable. A microscopic modeling can also be used to solve problems of planning but generally at the tactical and operational level [5]
  This level of modeling is always necessary, in particular for simulation, if one wishes to act on the behavior of each entity in an individualized way (ex: assignment of a resource to a planning or a particular geographical zone) and if one wants to get results at the finest level (ex: time of occupation of each resource, detail of the resources allocated to each activity…).
- Intermediate stage, the level mesoscopic makes it possible to gather several individual entities having certain common characteristics and representing a sub-group of the macroscopic sight. This level of modeling is most frequent for the study of the hospital systems. It is frequently used to solve problems of planning at the tactical and operational level [16], and also, in a general way, for the performance evaluation of the systems [9]

The "Table. I" [19] represents the various sights of modeling for the principal entities of a hospital system. These principal entities are identified as being the material resources, human resources, the patients and the activities.

TABLE I. VARIOUS LEVELS OF MODELING OF THE PRINCIPAL ENTITIES OF A SYSTEM.

	Macroscopic	**Mesoscopic**	**Microscopic**
Material Resources	Material resources are combined in a single set	Material resources are grouped into subsets (Rooms...)	Each material resource is considered in its individuality. (Bed 1 of room 1…)
Human Resources	Human resources form a whole without distinction	Human resources are grouped into subsets. (Doctors, nurses ...)	Each human resources are considered in its individuality and with its specificities. (The doctor n°1…)
Patients	Only one type of patient is modeled	Characteristic patients in the same way (Pathology, treatment…) are gathered in subsets.	Each patient is modeled (Attributes, behavior ...)
Activities	An activity is seen as a whole	A total activity is broken up into elementary sets of treatments. Specificities of the activity are not taken into account	An activity is decomposed in the finest in elementary treatments. All the specifics of the activity can be considered

On the levels strategic and tactical, the identified problems are found for a system to conceive as for an existing system.

III. MODELING IS

Modeling is the representation of a real system in appropriate language, for the formalization and capitalization of knowledge in an understandable and usable form by various people or software, such as to

reproduce operation or predict behavior d 'other conditions [10]

According to an expression from "Ref. [15]," the objective of modeling is not to reproduce reality, but rather to understand the mechanisms that link causes to phenomena.

In the "Ref. [22]," author remind that modeling is the first stage of the decision support: without model no analysis possible of the situation, no simulation to evaluate alternatives and to make a decision. The model allows to know the consequences of decisions before applying.

Within a framework general, the modeling of a system with for object design of models of whole or part of this system to explain the structure and operation of it or to analyze the behavior of it.

In practice, the main reasons that justify a modeling study are:

- Understand and analyze the structure and operation of the system;
- envisage the behavior and the performances of the operational processes before their establishment;
- Identify implementation risks to manage;
- Justify the choice of location on criteria related to resources and costs (methods of activity-based costing, for example);
- Building a shared vision of how the system and be able to communicate easily.

"Ref. [1]" The chart below shows graphically what has been said:

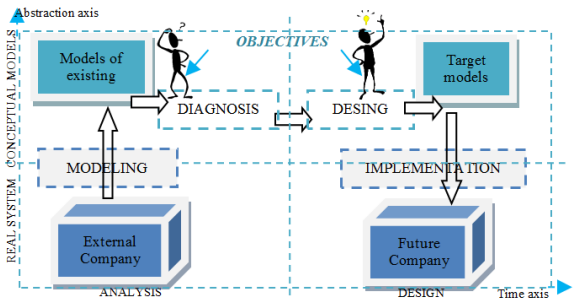

Figure 2. Modeling: Axis of abstraction of the model based on the time axis

The methods of modeling are thus used for, initially, analyzing the existing information systems, and second time, conceiving the future systems. The methods which exist propose each one their models of analysis and design. It is then advisable to choose the method according to the laid down objectives well.

A. Modeling Process-Oriented

In the case of process-oriented modeling, a model is formed by a set of processes which interact. Drafted during the first phase of construction of the model, it is at the interface between the physical system and the simulation program (one of the tools to support the decision that is to conduct experiments on a model a real system). So it has a dual purpose: to allow easy validation by the non-computer user while facilitating the coding of the program.

From it flow the essential features of such a model; it must be easy to read and understand (and preferably presented in graphical form), and to use coherent concepts with those of the software of simulation used for its coding (a many software, and it is the case of SIMAN, privilege the approach process).

Grimaud summarizes the steps of building a logic model as part of a process approach in several stages, in successive principle listed below [7]:

- Identify the entities,
- Identify the process,
- Identify resources,
- Identify the state variables,
- Describe the process.

Trilling and all (2004) proposes to classify the main approaches, methodologies, architectures and reference modeling frameworks into four categories, among these categories finds the approach process of it [20]

The process approach that seems most natural for the description of hospital processes and in particular the pathways followed by patients facing. ISO 9001 defines a process as an organized system of activities that uses resources (personnel, equipment, materials and machinery, raw material and information) to transform inputs into output elements whose awaited final result is a product. Many tools and languages are oriented process: ARIS[2], SCOR[3], MECI[4] , BPMN[5], etc.

The approach of organization ,process-directed, has in recent years increasingly popular, particularly with the implementation of the recommendations of ISO 9001, Analysis of the organization operates out of the process, including administrative, which contribute to the realization of the product or the preparation of the service: design, procurement, procurement / processing of information, processes to customers, production or service provision, control and monitoring devices for measuring, etc. The formalization of business processes, both operational and support, indeed helps to provide a broad vision cross-functional activities and allows us to consider the company as a whole [3]-[6]

The model of organization by approach process, very in vogue currently, is seriously shaking the pyramidal structures by centering the change on the need for more integrating the various activities in company, and by suggesting, for example, a recourse more pressed on the collaborative work in network.

What comes is a description of three techniques of modeling directed process (already quoted) based on this step, noting: ARIS, MECI, and BPMN.

B. ARIS

ARIS is the abbreviation of Architecture for integrated Information Systems. This architecture of integrated

2. ARIS : Architecture of Integrated Information Systems, (Sheer, 2001)
3. SCOR: Supply Chain Operations Reference, (SCC, 2003)
4. MECI: Mod disation d'Entreprise pour la Conception Int gr e (Pourcel and Gourc, 2002)
5. BPMN: Business Process Management Notation (Rojo and al., 2008)

information systems refers to a concept of integration based on a global vision of the processes of the company.

Initially, a model containing all the principal characteristics necessary to the description of process of company is developed. The result being a complex model, it is then broken up into several sights (function, information, organization, control). This allows to describe the content of these views by using specially adapted method. This description is done by not taking account of the relations and bonds which the sights can maintain between them. It is only then that the relations come into play, to be gathered without redundancy in order to obtain a general sight of the chains of process [8]

The complexity can be further reduced. In a second phase, a distinction is made between different descriptive levels. These descriptive levels are classified according to a concept of life cycle (steps describing the history of an information system) based on the degree of closeness with the techniques of information processing [8]. Thanks to this method, one can have a thorough description of all the aspects, of the problems of Management Company to the technical transposition.

It is a modeling framework shown in the following figure built on a multilevel approach (conceptual, technical, implementation) and multi-sights (the sights are specified in the first paragraph). Then a model ARIS is formed of diagrams of process allowing a representation of the system according to several sights: each level of each sight is represented by a whole by a set of diagrams.

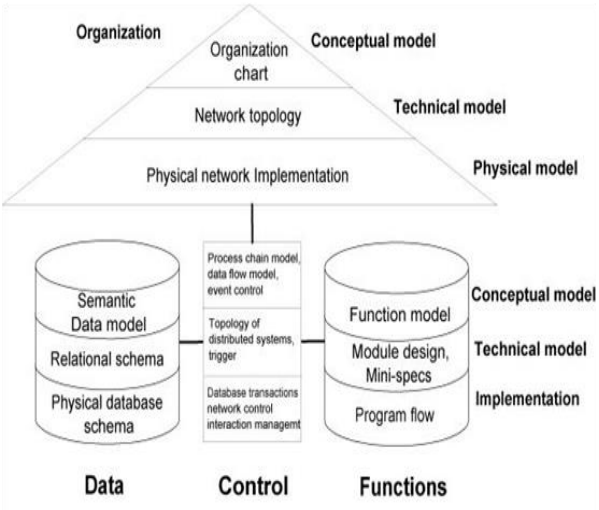

Figure 3. The architecture ARIS

ARIS underlines the analysis and the definition of requirements and the needs during the two phases of design of IS and management. A well-documented methodological generic platform is proposed. ARIS is often associated with SAP [6] because the migration of models for incorporation is possible into SAP [12]

Finally, ARIS is a language without methodology. ARIS model can not be immediately converted into the simulation model, but it can be run with a software tool developed through ARIS suite [8]-[12]

C. MECI

This method allows us to identify the activities realized within a system a system. Indeed, the process approach being centered customer, it adapts particularly well to the systems of production or of services, generally, the customer is a major actor. We point out that in the particular case of the establishments of health the principal customer is the patient.

The concepts brought into play in this method are those of task, activity, process or resources. The method of modeling MECI proposes two sights: a functional sight and an internal sight.

The functional sight makes it possible to jointly present what must be made (task) and what is made (activity). A process is composed of activities; this principle is formalized in the functional sight of method MECI [4]

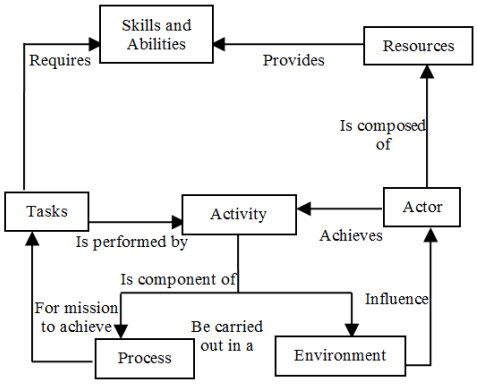

Figure 4. Functional view MECI

MECI proposes two different organizational sights, the external sight which translates the various elements into interaction with an organizational unit and the sight interns “Fig. 5” [4], which makes it possible to represent a system and the various elements which make it up.

It also clearly reveals the concepts of piloting or of measurement/order. The interactions between the various elements constituting of this internal sight also allow a first representation of the various exchanges of physical flows and information.

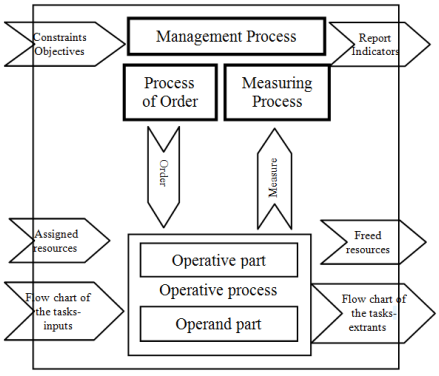

Figure 5. Internal view of the organizational unit MECI

D. BPMN

Le BPM[7] is the activity which consists to represent and model the processes of company. It has for vocation to

6. SAP: Systems, Applications and Products for data processing.

7. BPM: Business Process Modeling

provide a current modeling or in the state of the process for then being able to analyze it [11]

As it thereafter will be seen, it makes party of the initial stage of a more total discipline the BPM; it is also used to chart the sight trade of a company which is employed in the steps of urbanization of the information system.

To describe in a unified way the processes of company, a standard of language of modeling of the processes appeared the BPMN. It was developed by the BPMI[8]. This language is supported by the principal editors of solution SOA[9] [11]

BPM is the discipline which provides the whole of the methods, technologies and tools intended to improve the effectiveness, the traceability and the agility of the processes trades in which collaborate of the systems, software, people and also customers, suppliers and partners… BPM treats cycle of engineering of the processes; The "Fig. 6" below summarizes this definition:

Figure 6. Definition of BPM

The principal objectives of the BPM are:

- To have a common language between the "Project Ownership" (control of work is the entity carrying the need, defining the objective of the project, calendar and budget devoted to the project.) and the "Project Management" (control of work indicates the entity retained by the building owner in order to carry out the project under the conditions of times, of quality as well as fixed costs);
- To allow convergence between trade need and IS;
- To obtain a reference frame of the processes trade;
- To improve the agility of companies (trade and IS).

BPM is often associated with SOA approach because "the SOA vision is used to return the business process at the heart of the IS architecture," Or even the convergence of the two approaches BPM and SOA is source of IS optimization and also source of agility for the company.

To achieve the goals of architecture SOA, it is necessary to break up the IS into layer of services:

- Trades;
- Functional;
- Techniques.

The deployment of a business process on this type of architecture IS is easier because each task of the sequence trade uses a reusable service of architecture SOA. It is thanks to the principle of architecture SOA: the services do not belong to any particular application which makes that the use of services to the maximum is uncoupled [20] One can change for example a task and to redeploy the process without modifying the services layers of IS (so that these last always satisfy the need), we say that there is decoupling between these two aspects from where flexibility of the business and IS expected.

E. Comparison of Methods

Whatever the formalisms used by the devices they have in common to offer different levels of abstraction (conceptual, organizational, and operational) and different views to be more or less detailed depending on the purpose or improvement project continued. Furthermore, the proposed methods are based on the same approach: model the existing to diagnose and then model the target system (what the system should look like to meet the objectives) to develop an action plan.

To compare these methods we were inspired by the comparative study "Ref. [1]," we used criteria reviewing three aspects: representation, methodology and adaptability.

1) The representation

The aspect representation is associated two criteria, the first presents the principles on which bases the methods for construction of their models and the second presents the form under which these models are represented.

2) Methodology

The methodological aspect is associated with seven criteria.

- The type of approach of the method,
- The various stages which the methods cover,
- The level of detail of these stages,
- The type of cutting which is carried out to apply the method,
- Points of view approached by the method,
- The cover or not of the temporal aspect of the method,
- Approach *of method development.*

3) Adaptability

The aspect adaptability is associated with five criteria:

- The difficulty in applying the method,
- The learning difficulty of the method,
- The existence of software support or not.

With the sight of this table, we can notice a large number of similarities between the three methods although their respective objectives are not the same ones. The concept of process is present everywhere. This direct correspondence between the models is not surprising, insofar as the representation of a sequence of operations or activities is at a low level of abstraction and must stick to reality.

So we can say that at this level, the three techniques can be used interchangeably to a modeling process approach and the transition from one technique to another can be done easily. After our comparison, we think the abstract level of MECI is too general to be really useful, whereas ARIS and BPMN are richer on the level of the representation. We can even say that ARIS is the most detailed method, because the concept of entity external makes it possible to take again the definite actors and that

8. BPMI: Business Process Management Initiative
9. SOA: Service Oriented Architectures.

it is the only one to be interested more in circulation and the way of information we noted an important difference between pair ARIS and BPMN, where the methods of modeling of the IS properly spoke, and the approach MECI which is rather intended to model the processes. Thus the choice of a method will depend on the field of application of methodology of modeling, in order to be able as well as possible to use the respective features of these three techniques of modeling.

TABLE II. MATRIX COMPARISON OF PROCESS ORIENTED MODELING TECHNIQUES

Comparative matrix	**ARIS**	**MECI**	**BPMN**
Objectives	Design of IS & Reconfiguration of the Processes	Analysis and Design of production control system	Analysis in an urbanization approach of IS
Representation Aspects			
Construction principle	Data	Data	Data
	Treatments	Treatments	Treatments
	Activities	Activities	Activists
Formalism	Graphic	Inexistent	Graphic
Methodological aspects			
Type of approach	Process	Process	Process
Life cycle	Analysis	Analysis	Analysis
	Modeling	Modeling	Modeling
	Design	Using by way of simulation	Implementation
	Implementation		Execution
			Piloting
			Optimization
Level of analysis	Total	Total	Total
Conception level	Total	Partial	Total
Division	By level of abstraction	By level of abstraction	By level of abstraction
Point of view	Organization	Function	Organization
	Function	Decision	Activities
	Data	Flow	Data
	Management	Organization	Management
	Service		
Notion of time	Yes	No	Yes
Approach of development	Downward (Bottom-up)	Downward (Bottom-up)	Downward (Bottom-up)
Adaptability aspect			
Application	Affordable	-	Affordable
Learning	Affordable	Difficult	Affordable
Software support	Yes	Yes	Yes

We judge however that ARIS is the method which ensures best the connection between the models and the level abstracted thanks to the various sights. "Ref. [8]" this technique presents the following strong points:

- ARIS offers an attractive and intuitive chart.
- The organization sight structures the model and ensures coherence between the sights.
- The representation distinct from activities, data and resources in the same model is possible.
- The integration of dynamic information is possible (operational durations for example).

It remains to be said that it is not easy to choose the most effective language for a specific problem. If language ARIS makes it possible to carry out rather

complete sights of the studied systems, one also identifies many gaps not allowing to recommend a method or a language rather than another.

More we wish a detailed modeling of the system, more the choice of the tools and languages allowing to consider the whole of specificities of the studied field is difficult and made up.

IV. Conclusion

Many tools and methods of analysis and of modeling of the industrial systems exist, and even if each one brings solutions to several problems, none is sufficient to analyze and model complex systems. We face the same problem with hospital systems, since the hospital is a complex socio-technical system. Then the methodology to conduct a study in a hospital is crucial: the cultural differences between the medical and industrial fields involve the implementation of practices appropriate for the analysis, modeling and presentation of results.

Through this article, we tried to define three concepts, the definition of HIS, the modeling of these systems, and process-oriented modeling method best suited for IS. Having like starting point the bibliographical references, our contribution was to reveal out the various points between three methods ARIS, MECI and BPMN, by having a vision centered on the modeling of the information systems.

In order to apprehend a complex system, we noted that it is necessary to have a reading-guide and of comprehension of the system in the intention to prepare a model close to reality and exploitable. A groundwork which describes the various formalisms (methods) to use to be able to achieve the aim of the study, which is in our case the implementation of an IS while being based on a process approach, in order to answer the continuous improvement in a complex system with character sociotechnical, which is hospital.

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Sabrina Guetibi was born in 03/13/1991 in Fes, she is Moroccan. Sabrina Guetibi is a PhD student in Industrial Engineering at the University Sidi Mohamed Ben Abdellah (USMBA) / Faculty of Science and Technology Fez. She unhooked her engineering degree in July 2013; in analysis and quality management at the University Hassan 1 / Faculty of Science and Technology Settat.

Miss GUETIBI has an Excellence Scholarship (2014 edition) granted by the National Commission on Excellence Scholarships & National Centre for Scientific and Technical Research. Her research interests are mainly in Quality Management and Information Systems.

Mohammed El Hammoumi is a Professor of higher education at the University Sidi Mohamed Ben Abdellah (USMBA) / Faculty of Science and Technology Fez. He is Head of Department of Industrial Engineering and Director of the Laboratory of Industrial Techniques. He got his doctoral degree in 1994, specializing in Fluid Mechanics at the National Polytechnic Institute of Grenoble.

Mr M. EL Hammoumi is head of the research team "Tools of decision support in maintenance" and is Instructor in Industrial Engineering techniques.

Anas Chafi is a Professor of Higher Education, Department of Industrial Engineering at the University Sidi Mohamed Ben Abdellah (USMBA) / Faculty of Science and Technology Fez (FST). He got his degree in engineering state at the National School of Mineral Industry in Rabat and his diploma of the thorough studies in the INSTN to the Commissionership of the atomic energy in Paris..

Mr. A. Chafi is a senior member of the research team management of production systems, quality and logistics / Laboratory of Industrial Techniques.

