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Intelligent Model of Continuous Improvement Mechanisms Scope of QMS.

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***Abstract*—This work proposes a new methodology to evaluate and improve the QMS (Quality Management System) effectiveness and efficiency to succeed for a factual approach including all monitoring parameters. This idea is justified by the difficulties incurred by the organizations to establish a continuous improvement's system based on the objectives and the process approach. In addition, the guidelines defined by the FD X 50-174 part published by AFNOR to assess the QMS effectiveness, still guides defining the assessment criteria and progress levels. Indeed, to facilitate the continuous improvement system's integration, we propose a new methodology based on a broad range of monitoring tools (functional and operational indicators, audits, quality control, customer satisfaction) and including the requirements of the process and the system approach.**

***Keywords*—process approach, monitoring tools, effectiveness, efficiency, continuous improvement.**

I. INTRODUCTION

The performance evaluation is an activity that helps managers to achieve the predefined objectives derived from the strategic objectives of the company. Its based on the characteristics of the company's activities and presented by indicators quantifying process effectiveness and efficiency.

The strategic choice of the company is reflected by the results of various performance measures. It aims at increasing the probability of achieving the desired objective. Furthermore, we may adjust the specific objectives and strategic choices.

Companies interested in the QMS (quality management system) are based on ISO 9001 and ISO 9004 standard and even excellence models to achieve objectives linked to internal performance and customer satisfaction and others interested parts. That's why, a model based on the process approach was proposed in ISO9001 standard [23,24].

Moreover, this is similar to a regulation loop. This loop parts from the set points which are equivalent to the planned targets of the objectives. They are assigned to different supports and realization processes which can provide a benefits that can be measured through customer satisfaction, product quality and system efficiency. To compare the obtained results and objectives, the feedback loop is based on measurement and monitoring mechanisms. Thus, the gap and the measurements trends will be a capital data to activate a system of correction and improvement which will strengthen the processes capability and ensure the overall system performance.

In this order, our work aims at providing organizations a factual approach of decision-making that facilitates continual improvement while respecting the ISO9001 standard requirements. This can be applicable when many QMS, after an initial certification, fail to synchronize with the objectives evolution and customers requirements [23]. This observation depends on several factors: the objectives are not coherent, the means are inadequate and insufficient, the running business and performance system design, monitoring and measurement mechanisms are inefficient, lack of factual approach adapted to data treatment and of methodology permitting the making-decision for continuous improvement.

Thus, all these reasons reflect on the design of an intelligent system to ensure efficiency and continuous improvement of the QMS.

This paper is divided into two main sections. Section two presents a brief recall of QMS based on ISO9001 standard and gives an overview on existing methodologies for process monitoring and improvement. The section three details our new approach for assessment and improvement of QMS effectiveness.

II. GENERIC STUDY OF QMS AND USED METHODOLOGIES

Our study of the ISO9001 standard [23] reflected that its based on a model which can be divided into four interactive sections:

The first is dedicated to the management responsibilities, within this framework, its necessary to define planned objectives which must be coherent and measurable. Also, objectives must be deployed regarding different process. In addition, we have to define the responsibilities and necessary authorities as well as the communication mechanisms that ensure product quality and QMS effectiveness.

In the second part, we must identify and manage the sufficient material and immaterial resources to ensure efficiency and product quality. Effective management of human resources training and infrastructure maintenance as well as the environment translate this second section.

Indeed the objectives being fixed, the resources being available and adequate, the organization can engage the realization activities including the customer requirements. In this section, the activities of planning, design, manufacture,

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purchase, storage, handling and preservation proceed in the forms of process in interactions to satisfy the customer requirements.

The last section reflects feedback loop to ensure the regulation and automatic control the QMS. This section contains the various monitoring mechanisms as a sensor measuring the quality characteristics: the product conformity, customer satisfaction, QMS effectiveness and achievement of objectives initially established (Fig. 1).

According to the ISO9001 standard, monitoring is based on internal quality audits, products quality control, customer satisfaction measures, objective measures and data processes [23].

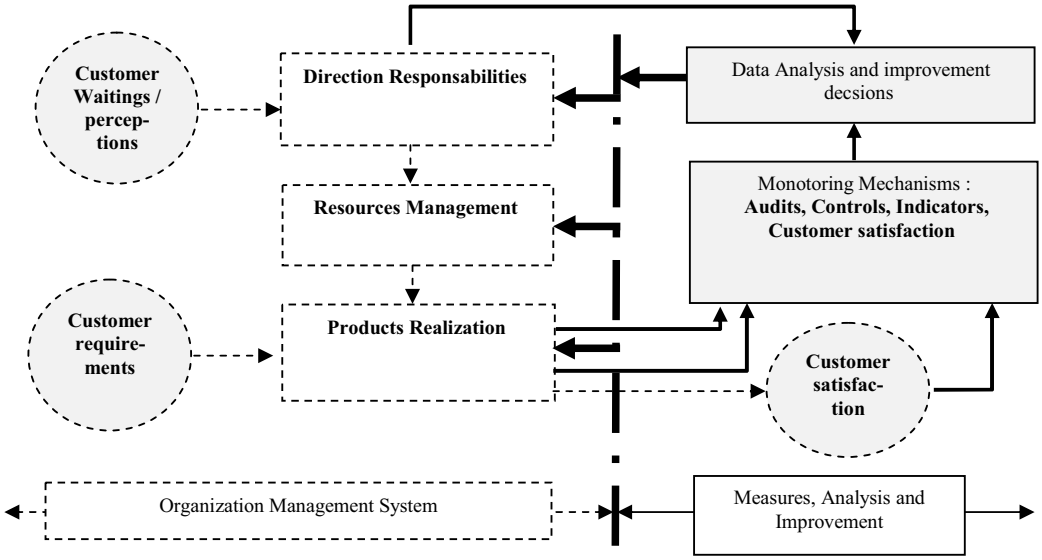

Figure 1. QMS Model proposed by ISO9001 standard

The Implementation of such QMS model requires an integration of adapted tools in order to make easy the decision-making for continuous improvement. This is located in tow level:

The first concerns the monitoring mechanisms effectiveness and the second is relating to the decision-making approach through data analysis.

A. Monitoring mechanisms

The use of monitoring resources and techniques (performance indicators, internal audits, quality control, and customer satisfaction measurement) is necessary to improve quality. This is an important sign for the TQM (Total Quality Management) maturity. Managers must well implement these tools in order to improve their performance results [1].

Referring to the ISO standard, monitoring is decomposed as follow:

1) Internal audit

It is a means determining the QMS performance and conformity scores regarding fixed criterion like as the activities importance, processes, the requirements arrangements and the results of previous audits. The role of this process is determining the audit frequency, audit planning and achievement.

In the literature, this process has been studied and methods have been proposed. Jae Kyu Lee et al. suggest a model optimizing the relationship between the audited company profits and the auditor priorities, and a multi-agent system to assist in the resolution of planning conflict [2]. In the same way, Ramy Elitzur et al. develop a multi-period model for the planning of optimal audit quality by external auditor, and examine three propositions concerning the relations between planned audit quality and : 1) the auditor's relative efficiency, 2) audit fees, and 3) the expected loss due to audit failure. The obtained strategy is in reducing the quality levels in all planning periods [3]. Moreover, Chrysovalantis Gagan et al. present a study exploiting the probabilistic neural networks advantages by developing a model explaining the qualifications of audit reports. Indeed, auditors can use a template to plan specific procedures of audit to achieve an acceptable audit risk level. Such a model can also be used as a tool for quality control for the audit process [4].

2) Customer satisfaction

Customer's examination to measure their satisfactions implies that we must:

- know who are customers;
- be really interested by their opinions;
- plan the measures frequencies;
- know to quantify satisfaction according to various data such as the investigations and the complaints treatment.

In addition, companies must take account of customer satisfaction during the planning objectives to develop more effectively their products and services and to continually improve their systems to achieve competitive advantages [5].

In this context, the majority of researches on customer satisfaction have focused on the design, measurement and testing theoretical models. And most quality practitioners collect data on customer satisfaction to take the necessary

and the appropriate decision [6]. As example, Athakorn Kengpol et al. have used artificial neural network to design an expert system to assess customer satisfaction on fragrance notes capturing expert knowledge (the perfumer) and customer requirements. The expert system has the tendency to make decisions in the classification of the fragrance notes scores based on a list of selected informations [7].

3) Products quality monitoring

According to the ISO9000 standard, control is a "conformity assessment through observation and judgment supported by measures, testing or calibration if necessary" [22].

As such, many methods have been used like as the sampling techniques, statistical process control, control charts etc.

In parallel with these technical, there are methods have appeared to judge the manufacturing processes capability, in this case, the Six Sigma method. These methods give the QMS a certain reactivity to ensure the product conformity.

Following the treatment of products, defects, capability of the instruments and methods, the quality control process provides a products conformity score regarding to its requirements in inspections planning and determining the inspections frequencies.

In this context, Ming Zhou et al. propose a mathematical model based on heuristic algorithms to optimize the decision in quality control operations planning. It is a tool of decision-making support which improves considerably quality of their decisions and reduces the cost and increases the production effectiveness [8]. Thus, the quality control process parameters can be imprecise, expressed in intervals and in the presence of several characteristics. With this intention, Mohammed Sadok Cherif et al. developed a multidimensional goal programming model to incorporate several qualities characteristics and to integrate several priorities of the decision maker simultaneously [9]. In the same way, E.P. Paladini conceived an expert system of decision-making support permitting the user to select the adopted control type. In addition, quality control tools (causes effect diagram, chart control, Pareto diagram, Histogramme,…) are numerous, so the choice of the appropriate tool becomes difficult by considering the material and human limits of resource [10]. Masood A. Badri proposes a AHP/GP model allowing to weight the quality indicators using the AHP method and to select the best whole of quality control tools using the GP [11].

4) Process Monitoring

Among the suitable methods for the monitoring and measurement of the QMS processes, we find the performance indicators which are subdivided in two categories: functional indicators concerning the resources processes (human and material) and the operational indicators for the realization processes. These indicators are measured regarding to an importance level, objectives, processes, targets and periods. These tools allow to determine the process performance score by considering measurements frequencies, their planning and achievements [22,25].

Within this framework, many studies propose PMS (Performance Measurement System) models in fact:

The SMART model (System Measurement Analysis and Reporting Technique) proposes to break down the objectives of the company along four levels – company, business units, business operating units and departments and work centers – according to ten measures such as delay, quality, customer satisfaction [12].

The activity based costing/activity based modelling ABC/ABM (Activity Based Costing/ Activity Based Modelling) model identifies the activities and processes which generate value in the company [13].

The PPMS (Process Performance Measurement System) proposes to measure the company performance according to five aspects—financial, innovation, customer, societal and employee [15].

The ECOGRAI (ECOnomie Graphe à résultats et Activités Inter-reliées) approach identifies three criteria – delay, quality and cost – for the definition of multi-criteria performance, and this for all the processes/activities of the company [21].

It is noted that all these models are flexible in the direction where the considered criteria can change according to the organization needs. However, performance expressions can be precise or imprecise, certain or uncertain, and even expressed by numerical or linguistic values [16]. The major problem faced for the PMS development is the respect of the performance expressions aggregation which is the combination of them.

B. Data analysis and making decision

The QMS effectiveness assessment is the essential element in the process approach. Indeed, the aim of the analysis of data translating the monitoring and measurement results is to prove the QMS effectiveness in order to improve it. This analysis provides informations on customer satisfaction, conformity with the product requirements, processes and product state [25].

In the literature, many approaches were developed to evaluate the QMS effectiveness through data analysis systems:

Benito and al. have proposed a technique based on linear programming to optimize the effectiveness and efficiency of production processes, conducting techno-economic analysis [17]. Also, the BSC (Balanced ScoreCard) is a beneficial tool to evaluate the effectiveness that permets monitoring the results on four areas (financial results, customers, organizational learning, internal process), to estimate and express in figures the used strategy [14,18].

In addition, Ahmet Öztaş and al. have developed two models of matrix (a matrix of principles and a matrix of objectives) combining several quality factors to quantify the QMS effectiveness. Both of models assess respectively the company effectiveness to achieve a specific requirement of the QMS and other prescribed quality objectives. The final score determined by these matrices reflects the rate of QMS effectiveness of the company. The limits defined by the quality manager or the auditor present the reference of this score [19].

Finally, H.C.W. Lau and al. have applied the search data to develop an intelligent QMS. This system provides all levels of employees the ability to understand the relationship between processes and to specify the quality problems [20].

Following this generic review of the monitoring tools in the quality management field, we notice that the undertaken researches are focused primarily on a precise field, in fact, the audits, controls and the customer satisfaction assessment. In other words, there is not a model integrating all these tools in only one hybrid system in order to benefit from the contribution of each one.

Thus, our idea consists in developing a total and intelligent system to determine and improve the QMS effectiveness in considering all monitoring parameters dictated by ISO9001 standard. This approach will be detailed in the next section.

III. Intelligent Model For QMS Effectiveness Assessment And Improvement

From the previous study, we can structure a new model presented on the Fig. 2 that is divided into four levels:

- A definition and planning level of objectives and expectations in which we insist on coherence and deployment in relation to the process;
- A control and monitoring level in which we specify the parameters and quantification methodology of measures and assessments;
- A data analysis and decision support level to assure the performance, effectiveness, efficiency and improvement;
- A self adaptive learning level to assure the system optimization.

A. Objectives definition and planning

The strategic objectives reflect the customers and shareholders perception, and public authorities. They require an optimized planning to quickly reach the overall efficiency with fewer resources. In our future work, we propose a new structured methodology to relate and transform the company's vision and strategic objectives in specific objectives for each process to improve quality. Multi-objective techniques and genetic algorithms can be used. These tools are systematic methodologies that provide a mechanism to facilitate the simultaneous establishment of deployed objectives and optimize their planning. This mechanism must take into account the correlation, coherence and influence between objectives and sub-objectives.

B. Monitoring system

In this part, it is necessary to design a hybrid monitoring system which controls in parallel the quality system audits, products quality controls, processes performance measurement and customer satisfaction.

Piloting involves planning, implementing and quantifying the monitoring results.

The output data will be performance scores assigned to the product conformity, process performance, the system effectiveness representing the measured quality by internal sensors, and the customer satisfaction level representing the measured quality by an external sensor.

As such, many issues may be raised, namely:

- The methodology for choosing the monitoring frequency depending on the type of used sensor, depending on the process importance or activity field and previous results. The studied frequencies are therefore considered a dynamic aspect which must be coherent with the risks of drift against fixed objectives and failures and non-conformities frequencies.
- The methodology of monitoring activities planning according to the activities and objectives planning.
- The methodology for the measurement results quantification that can be linguistic, numerical and may be imprecise or uncertain. As such, fuzzy logic, neural networks and multi-criterion techniques will help to the design and the implementation of such system.

C. Data analysis and decsion-making

The process system performance and effectiveness are not the sum of performance or efficiency of individual processes that compose. This means that the performance and efficiency of individual process does not automatically lead to the product and system efficiency. In addition, we must ensure that the measured data are coherent to help an effective decision making. For example, a Medium customer satisfaction score, an audit giving Excellent score and a Good process performance score can not succeed to an effectiveness improvement. The review of the monitoring system is essential.

Thus, we propose a new analysis method that will be based on the factual approach for measurement and the compromise between these measures. The algorithm of the proposed approach is summarized in the Fig. 3.

IV. Conclusion

This article proposes a new approach to evaluate and improve the QMS efficiency and effectiveness. Our approach revolves around three sides. The first deals the objectives, their planning and their deployment in relation to process. The second is interested to the design of an efficient monitoring system taking into account the ISO 9001 requirements [23]. The last focuses on data analysis and decision support with a view to improve the QMS. The three parties combined to simplify the implementation of quality systems and assist policy makers in their improvement efforts within the framework of a multi-variable, multi-criterion and multi-objectives system.

The proposed approach allows:

- Planning and choice of Measured frequencies (internal audits, customer satisfaction survey, performance indicators, product quality assessment, deployed objectives) according to delay, quality, cost, process parameters, and previous measured results;
- Auditors assessment quantification by scores permitting the judgment of process performance;
- State estimation of controlled product quality development;
- Determination and planning of Improvement actions :
  - Change frequency, audit method and process indicator measures;
  - Change frequency and product assessment;

- Reinforce the complaint customer treatments;
- Improvement of material and human resources;
- Increasing or elimination of resources…

Finally, the detailed study of the each monitoring mechanisms will be the subject of our future work.

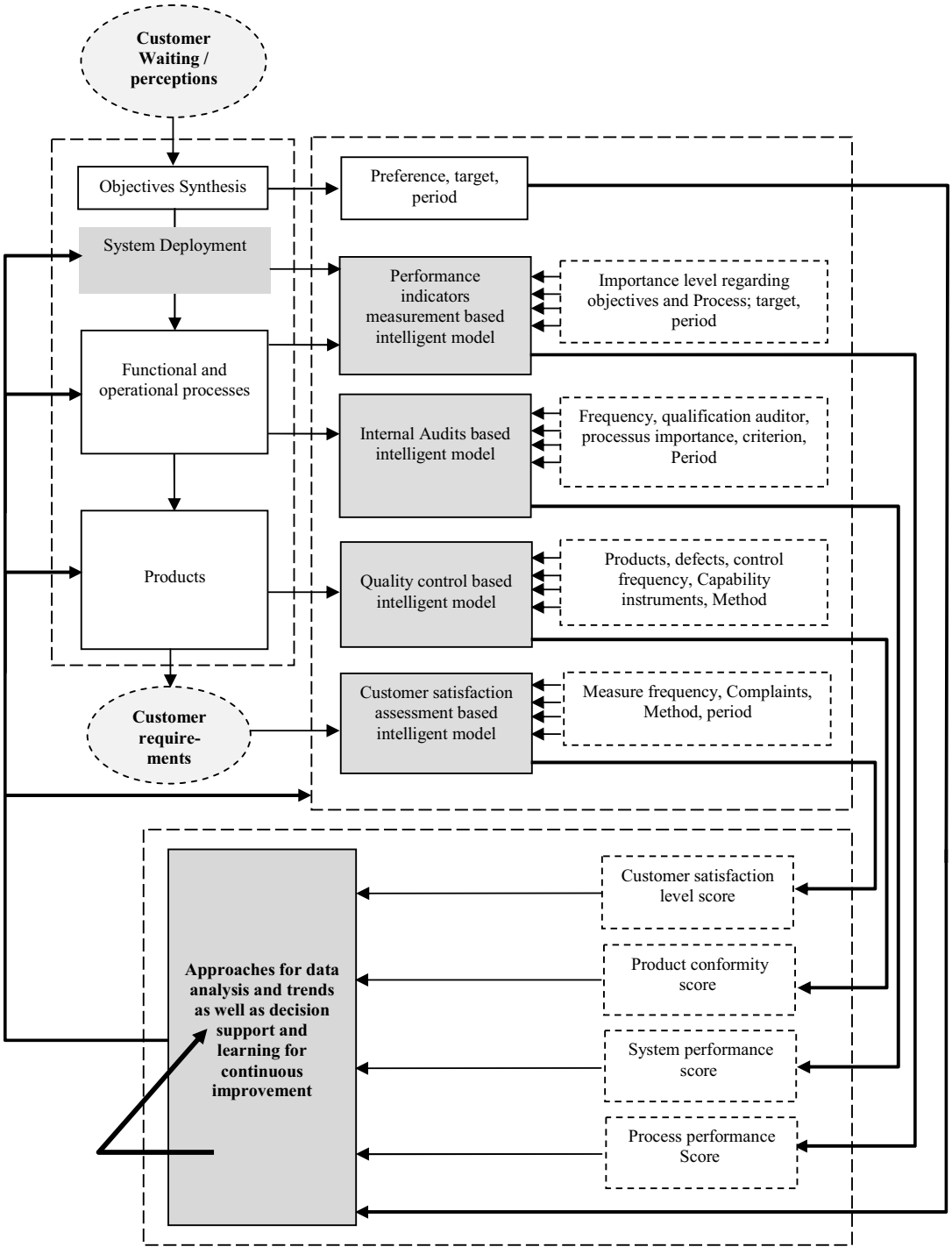

Figure 2. Structure of QMS assessment and improvement model.

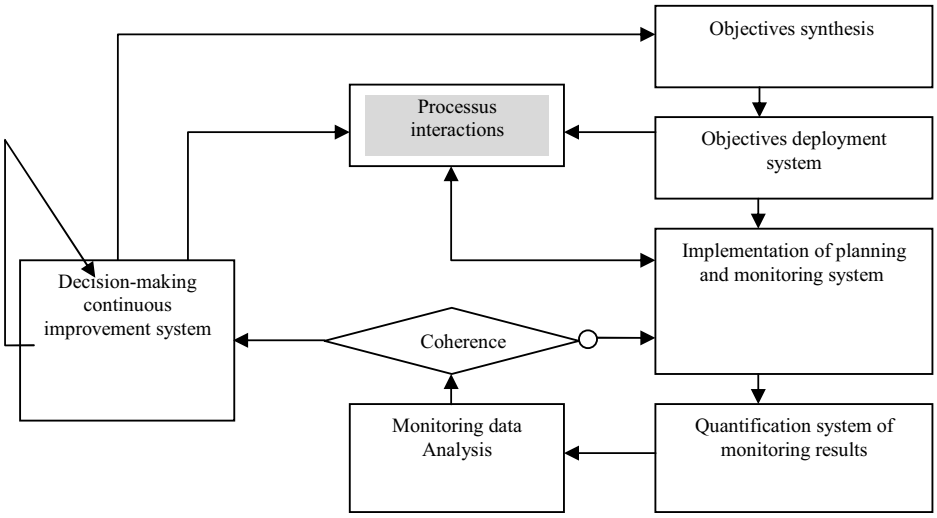

Figure 3. Structure of Data analysis and decision-making algorithm.

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