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A HYBRID DECISION MODEL TO ASSESS VARIOUS STRATEGIES OF MANUFACTURING IMPROVEMENT

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ABSTRACT
In the area of manufacturing, much has been written about the improvement approaches such as Business Process Reengineering (BPR), Six-Sigma and Total Quality Management (TQM). Each of these approaches is suitable for different situations and each approach may lead an increase in organizational efficiencies. The aim of this article is not to demonstrate that a particular approach is better than any other one. Rather, it will be argued that the organization should benefit from the advantages of all these approaches. So, it seems reasonable to try to integrate these different approaches in order to gather their best features. The integration of the BPR, Six-Sigma and TQM techniques is intended to maximize their efficiency sense because of their complimentary nature. This paper outlines the significant elements of each methodology and concludes with how BPR, Six-Sigma and TQM can be used as a powerful, integrated system to optimize the re-organization of the manufacturing systems. It also, presents an approach to the application of Quality Function Deployment (QFD) that brings together the concepts and models developed by Revelle et al. [1], Gien et al. [2], and Lazreg et al. [3]. These models are linked by the hybrid QFD matrix to facilitate knowledge transfer and information processing between different approaches. Thirteen QFD matrices are then used to generate the optimized action and implementation plan. In this way, the proposed model benefits from the advantages of every approach as well as the relationship between the different strategies from the various actions of the improvement process. The steps involved in the proposed approach are depicted and justified. Finally, an application and a discussion are provided to point out the benefits of the proposed approach.

1 INTRODUCTION
The design of a manufacturing system is a very complex activity. Their complexity and cost constitute a real difficulty as important as their real time implementation in the Small and Medium Enterprises (SMEs). As a response to environmental changes, new strategic paradigms have appeared, each offering a solution as to how a company should be managed and organized in order to be competitive [4]. All of these methods (Six-Sigma, BPR, TQM, TPM, etc.) talk about project planning and execution in phases. Furthermore, they tend to go from the re-engineering approach to the TQM risks to cause a disconnection between the improvement levels. Often, the problem is not so much that the proposed system is unworkable as the transition proves more difficult than people anticipated. Moreover, it is unclear which strategy to use in order to correct problems of the organization. No single approach should be favored or privileged in a company. Integrating these different approaches appears to be better than any one alone. Palady and Olyai, [5] did not recommend the choice of any single model, but perhaps two or three: "This process demands the synthesis of different disciplines, statistical techniques and other analytical tools to conquer each problem. Don't force the problem to the model you have; rather, let the problem select the right model(s)". The authors echo the previous assertion by recognizing that a process may demand, not one, but many problem-solving models. As the improvement project progresses through each phase, the aspects of the problem may change or new problems may be uncovered. The authors suggest that the integration of problem-solving techniques should be sought, rather than simply choosing one over the

other. Furthermore, continuous improvement principles associated with TQM can also be counterproductive - it may be that no single isolated change can improve a process, but a coordinated change can [6]. Incremental change can sometimes be more painful than radical change. However, if a strategy is to be effective, it must be supported with a decision-making process.

The main objective of the research described in this article is to develop a structured and integrative methodology for supporting different improvement strategies of the manufacturing systems. Based on this objective, our paper is organized as follows: Section 2 reviews the literature on improvement strategies and undertakes a short comparative analysis in relation to the three basic strategies for process management: BPR, Six-Sigma and TQM. Next, it introduces quality function deployment as a decision support tool for reorganizing manufacturing systems. Section 3 describes the research methodology. Section 4 proposes an application of our model in a maintenance service of a manufacturing company. Finally, our paper concludes with a summary of the important findings of the study.

2 LITERATURE REVIEW

2.1 Improvement approaches

2.1.1 Total Quality Management

TQM is concerned with improving work processes and methods in order to maximize the quality of goods and services. It intends to keep existing customers by meeting or exceeding their expectations concerning products and services. Often TQM is illustrated by a model of a quality award, such as the Malcolom Baldrige National Quality Award (MBNQA) [7] in the USA or the European Quality Award (EFQM) [8] established by the European Foundation for Quality Management. The quality diagnosis [9], [10] aims at identifying the various quality dysfunctions and their causes in the organization. Nonetheless, quality award models have also important limitations, as conceptual models but especially as measurement models. Both the MBNQA and the EFQM implicitly assume that there are causality links between TQM elements and results [11]. Yet, the real impact of changes in the inputs over results is often difficult to establish. Moreover, quality award-based frameworks were not developed using a scientific approach, based on the identification and validation of critical success factors, but rather result mainly from the assembling of *ad hoc* evidence and successful case stories. They are not based on systematic empirical evidence [12]. Additionally, from a measurement point of view, when weights are attached to each criterion, they are arbitrary and do not necessarily reflect the relative importance of each model construct. More else, TQM includes tools and techniques, which can enable anyone at any level to improve their daily work on a step-by-step basis. It aims to use the organization's own employees and managers as trainers rather than outside consultants, and to develop the feeling of involvement it will often allow managers and even employees freedom to set their own targets [13]. Thus, it sacrifices short-term financial gain for long-term attitude change.

Using an approach such as TQM, which aims at overall long-term involvement and attitude change might not be as sensible as using a more short-term-orientated approach. BPR is focused on values objectivity, control, consistency and hierarchy; whereas Six-Sigma is oriented to the customer. TQM is far less restrictive in change processes than BPR (radical, fundamental) and Six-Sigma (essential).

2.1.2 Six-Sigma

Six-Sigma was created in the mid-1980s by Motorola to improve the performance of the key processes [14]. It is a disciplined method of using extremely rigorous data gathering and statistical analysis to pinpoint sources of errors and ways of eliminating them. Its focus is on using quality-engineering methods within a defined problem-solving structure to identify and eliminate process defects and solve problems as well as to improve yield, productivity, operating effectiveness, customer satisfaction, etc. [13].

The Six Sigma methodologies are DMAIC and DFSS. The first one is an acronym covering five phases of the implementation process: Define, Measure, Analyze, Improve and Control. It is used for improving a current process or improving existing product/service performance, which does not meet customer expectation. These steps are part of the Six-Sigma problem-solving method. Specific improvement tools and techniques are linked to each of these phases. This careful integration of tools with the methods is unique to Six-Sigma [15], [16], [17]. In this, it is much more specific than TQM. Six-sigma is viewed as a process performance improvement approach and a measure of process capability. The focus is on creating financial gains to the bottom-line of the organization. This is one of the facets of Six-Sigma that is not accentuated in TQM [18]. On the other hand, DFSS stands for Design for Six Sigma and is used to design/develop a new product/service and/or new processes for existing products [19]. In this, Revere [20] employs the IDOV (identify, design, optimize and verify) methodology; in the research presented by Wiele et al.[13] the process becomes Measure, Analyze, Design and Verify.

Many of the objectives of Six-Sigma are similar to TQM (e.g. customer orientation and focus, team-based activity and problem-solving methodology); many authors suggest that Six Sigma can be integrated into the existing TQM program of the company [20], [21], [22]. Revere and Black [23] suggest a framework to integrate Six Sigma into the existing TQM program in healthcare to improve the success of the TQM program. Similarly, Elliott [24] presents the initiative program of the company to combine TQM and Six Sigma to improve the production process and product quality. Yang [25] proposes the integration of TQM and GE-Six Sigma using customer loyalty and business performance as a strategic goal of the model. While others suggest integrating Six Sigma with a single quality program, Kubiak [26] proposes an integrated approach of a multiple quality system, such as ISO 9000, Baldridge, Lean and Six Sigma for improving quality and business performance.

2.1.3 Business Process Reengineering

Parker defines BPR as “the use of evolutionary tools/techniques combined with enabling technologies to provide an explosive mix to make dramatic change in the organization and to deliver what the customer requires" [27]. It is concerned with rethinking current systems and processes and tries to redefine existing work methods and processes to improve efficiency. Both Hammer [28] and Mayer [29] indicate that BPR is management-driven activity, where the performance objectives are first defined and processes are then developed to meet the objectives. Many of its principles, infrastructure and project phasing have direct counterparts within TQM. Its project requires four phases: preparation, innovation and design, implementation and assessment. Born [30] regarded BPR as a successor to TQM. Macdonald [31] believes that TQM and BPR are complementary and integral approaches and there are other researchers [32],[33] who believe that it will fall out of favor with industrialists, mainly because of the way it has been applied and its association with downsizing and job losses. In addition, the specific infrastructure and phases share certain characteristics with Six-Sigma;

While BPR is driven by competitive pressures and intense need to cut costs; TQM is motivated by the increasingly competitive market and the need to compete for specific customer demands. It may also be driven by specific problems such as high costs or poor quality. On the other side, Six-Sigma is preoccupied with the variation of the process needs to eliminate defects in business process and create financial gains; BPR and Six-Sigma lay little change stress and lay more emphasis on what an organization must do to achieve the desired end state whereas TQM is richer and much more elastic in the change stress and tends to brand the desired end state;

As total quality management owes much to tools like statistical process control and the “House of Quality”, BPR and Six-Sigma can benefit from tools to supplement and focus managerial intuition;

2.2 Deployment of the QFD in the improvement strategies

The deployment of the quality functions contributes to the improvement of the process and facilitates the planning of the system design in agreement with the positioning of the company in its competing environment. The crucial importance of the QFD [34] tool is considered in the process of communication that it generates as well as in the decision-making. Several literature abounds with what show the importance of deployment of the QFD in the reorganization of the manufacturing systems. We retain, in the following, the studies which seems to be the most coherent with our development:

In the BPR context, Brynjolfsson [6] introduced “the matrix of change” that allows managers to coordinate change in processes. After determining which business practices are most important, managers can highlight the interactions among the practices on the matrix to see where they will have the most difficulty in making a transition from one practice to another. The matrix uses stakeholders' opinions about proposed changes to emphasize areas of difficulty. It can also, guide the pace, sequence, feasibility, and location of change. The matrix of change, which includes three matrices, offers managers a chance to revisit a process to gauge progress and anticipate unexpected barriers due to current environmental factors. It also helps companies reshape and shift their workers' mental models to develop more coherent systems.

Barad [35], Gien [2] and Seklouli [36] have developed a supporting methodology for determining the improvement priorities of SMEs through a process similar to the manufacturing strategy formulation. The

methodology uses QFD to apply a contingency-oriented approach to improvement priorities. The manufacturing system improvement-needs should stem from strategic manufacturing priorities and from concerns that express unsatisfied needs. To propagate the improvement needs from the strategic level to the action level, two QFD oriented matrices were developed. The first matrix was used to define the operating improvement needs of an enterprise while the second was used to determine its improvement priorities. The proposed model is limited to the operational solutions. By introducing the maintenance study in the functional level [3], we showed the interest of the model in practice.
Revelle et al. [1] has showed that the QFD can be used on a design effort for the quality system itself. In place of the customer or market –driven requirements a set of TQM outputs are compared to the ISO 9000 elements. A subsequent matrix deploys the ISO requirements to the functional areas, such as manufacturing, maintenance and so on. This matrix which is customized to reflect the organization, details the interrelationships and dependencies among the organization's functional area deploying the TQM or ISO elements. From this, a third matrix can be developed linking the functional areas to specific activities. Further quality system development arising from either the functional area or activities matrix is pursued through another matrix showing the operating practices, policies and procedures that support those activities. Using the output of the fourth matrix, a subsequent matrix deploys procedures to the specific and detailed work instructions.

3 METHODOLOGY

The process of our methodology is divided into two interacting sub-processes: *formulation stage* and *implementation stage*. The first one involves concepts and strategies. Implementation stage refers mostly to the strategic plan, which forms the passage from the formulation phase to the implementation phase. Moreover, using QFD-based approach, an organization can define, clarify and exploit the synergies available between Six-Sigma, BPR and TQM. By merging these models into one, it can be envisaged that the manager will benefit from all of them. In the following sections, different strategies are presented and/or developed so as to introduce the Hybrid Strategy.

3.1 Quality strategy

In our approach (Figure 1-a) it is best to start by mapping the TQM outputs to the major paragraphs and items in one Quality System (QS) requirements such as Maintenance Excellence [3], EFQM, MBNQA, ISO 9000 and QS 9000. The relevant TQM outputs given from American Society for Quality (ASQ), for example, include [1]: quality orientation, continuous improvement, satisfy customer requirement, long term mission, management-led improvement, defect prevention, people as assets, teamwork, quality partner supplier, cross-functional team efforts, employee empowerment, current engineering, data-driven decision and management by planning. Once this matrix (Q1) has been accomplished, the similarities and synergies can be examined among the various requirements. Using the outputs of the (Q1) matrix which linking TQM outputs and the QS standards, a subsequent matrix (Operational_functions matrix: Q2) deploys and describes the purpose of each function. This clarifies that there are specific organizational activities for each QS requirement. The third matrix (Q3), captures the functions described as 'the Voice of the Customer' in matrix rows and aligns these to the organizational structure in matrix columns. The subsequent matrix assigns procedures to organizational units and workers. From this, the work_instruction matrix (Q5) is developed linking the regulations to specific actions. At this stage, the continuous improvement is associated to the sub-systems. This type of improvement characterizes the degree of the change at the low level. An action of improvement is a reply to one or a set of expressed needs. At this level the solution satisfying all the requirements of the QS is expressed by all the work instructions. The relationships between these different matrices can be augmented by prioritizing them based on organization need priorities determined in the redesign focus QFD and then cascading these priorities from matrix to matrix.

3.2 BPR strategy

The strategic level defines the internal and external strategic features at the high level of the manufacturing system. They are expressed by strategic objectives. These objectives describe the specific enterprise goals, rather than generic expressions of the future of the organization. A rigorous definition of these objectives requires a good strategic analysis. We group these objectives according to the following criteria of performance: cost, quality, flexibility, time and human aspects.

In this stage (Figure 1-b), we identify the needs of internal functioning by all, that is necessary and indispensable to reach these strategic objectives of the organization. The identification of the voice of the organization began with focused group interviews of the various profiles of employees from delivery management. These discussions involved their likes and dislikes about the current organization, their needs and expectations with priority ratings. Statistical measures like mean, standard deviation and co-efficient of variation were used to interpret the responses of the customers. These needs are defined by the desirable organizational evolutions in the mean term. They are essentially expressed by the different responsible of the company. Using the outputs of this BPR-strategic matrix (B1) linking strategic objectives and required internal functioning, the BPR-operational matrix (B2) defines the organizational changes in the mean term. These changes are expressed by internal needs of functioning. In a general list of needs, obtained from industrial cases, the organization identifies its needs of internal functioning. It can happen that the organization produces new needs. In that case, they are added to the general list to complete it. The BPR-technical matrix (B3) describes in detail "How" the organization implements the strategic plan and, it answers the question *"How will the organization implement what it wants to do"*. A certain strategic plan may be implemented in many alternative ways and the strategic action refers to these ways. The inclusion of this entity makes explicit the real enterprise action implementation.

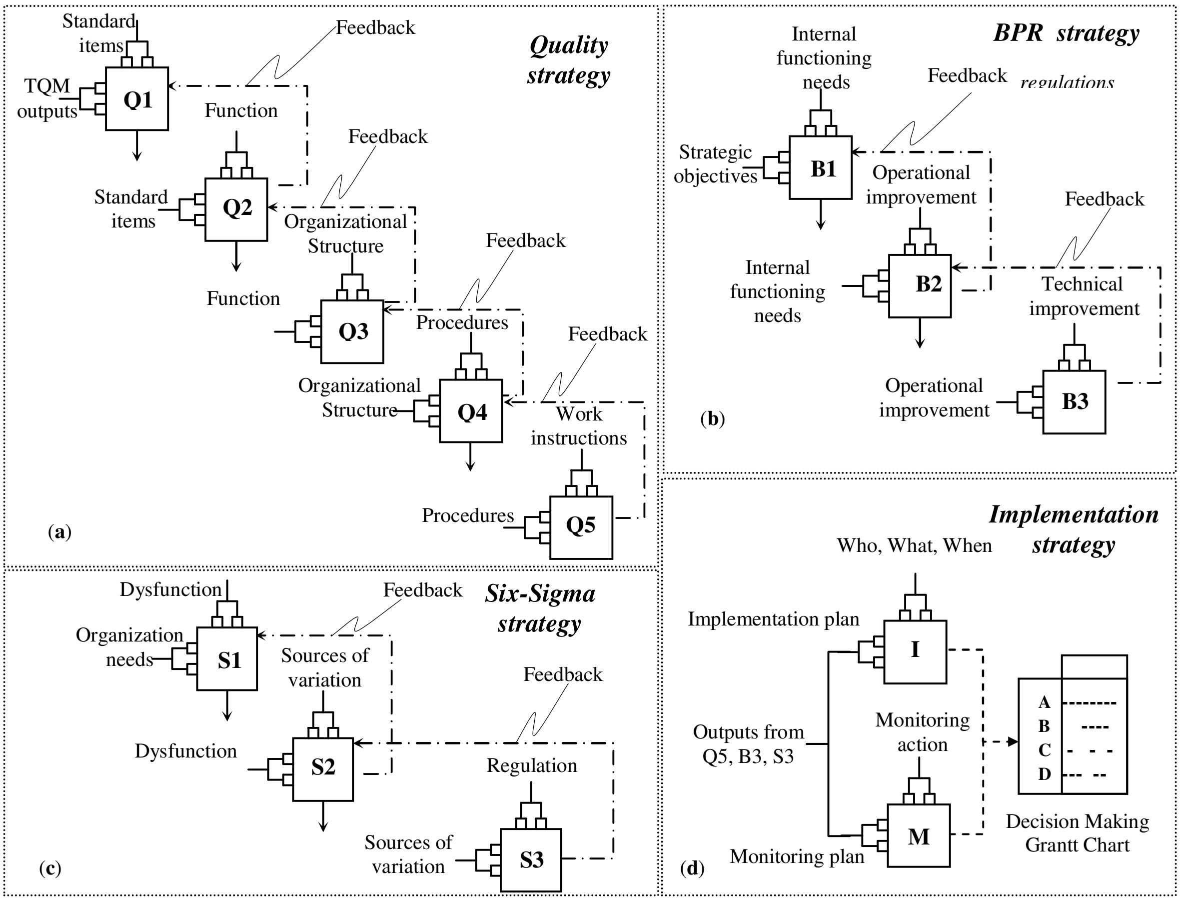

Figure 1: The improvement and implementation strategies

3.3 Six-Sigma strategy

The basis of the Six-Sigma philosophy lies in its problem-solving methodology, known as DMAIC. This stands for Define, Measure, Analyze, Improve, and Control. Therefore, and referring to these previous items, our approach is not only to correct the existing process, but to redesign the organization. In other words, we are proposing to design a QFD-based approach for Six-Sigma success. The goal is to have disciplined control of the process such that the potential defects are avoided and when they do occur, the cause is immediately addressed and eradicated.

Managing change is seen as a matter of moving from one state to another, specifically, from the problem state to the solved state [37]. The analysis of the system state is used to turn the attention on the possibilities for improvement, which bring back the most significant profit. To propagate the organization needs, from the "Define" level to the "Improve" level, three QFD-oriented matrices are developed (Figure 1-c). The first matrix (S1) is used to deploy the organization needs to the factors that are affecting organization performance. The second matrix (S2) is used to "Analyze" and determine the sources of variation for each factor. When analyzing a process, it is important to keep in mind the 4 elements that may cause variation: Processes, Tools, People and Environment. With the subsequent matrix (S3), the consultant makes a conscious effort to focus on technical solutions that align with the organization's broad business goals and needs, and that should, therefore, be actually deliverable.
By analyzing our Six-Sigma strategy, it can be seen that information flows from the previous phase to the next one in a systematic way: the output of the previous matrix becomes input in the next one. A main characteristic of this model of QFD is that decision regarding target values for the output of the (S3) and (M) matrices. Many complementary techniques such as Taguchi robust design and FMEA can be employed along this phase.

3.4 Implementation strategy

The success of each improvement strategy is a function of many variables (both controllable and uncontrollable), and many of them are specific to the company situation. Additionally, when attempting to implement new organization, in different companies, it is necessary to comprehend the value and attitudinal framework of the cultures in question. Therefore, each company should adapt its approach in order to exploit its unique strengths and overcome its particular weaknesses. On the other hand, the implementation requires a "technical plan" including a series of actions necessary to the attainment of the desired outcome. Actions taken by or within an organization, those are uncoupled from goals or objectives, are unlikely to make a value-adding contribution for the medium to long-term period.
Once the "technical plan" is established, attention is then directed towards the planning of the actions, cost's re-examination, the definition of the plan timetable and the deployed resources. All these items are undertaken in the implementation matrix (I) (Figure 1-d) in order to ensure the execution of the project reorganization, which includes the tasks' assignment [3]. Furthermore, the development of an implementation plan is an important part of any goal setting or problem-solving. Process, activity and task are the sub-categories used to describe in detail the content of the implementation plan. The economic report is a sub-category of the implementation plan outcome referring to its quantitative economic evaluation. It can be considered to introduce the economic view in the framework of enterprise architectures. Implementation plan is the mean by which the future is planned. It converts a goal or a solution into a step-by-step statement of who is to do what by when. More over, overloads and conflicts as well as groups or persons with no responsibilities become apparent. One benefit of this analysis would be to reveal where additional resources may be needed and to point out where the additional resources may be available.
In the monitoring matrix (M), we can deploy techniques, control methods, and monitor procedures in the realization process. This matrix indicates precisely, the necessary actions in each phase of the process to make sure that all the outputs of the process will be under control. In operation, it provides the piloting means and the control methods used to control characteristics, which are likely to cause non-quality. Once established and updated, this matrix constitutes the base of the strategy of the control process. The monitoring matrix identifies which individuals or groups "own" particular operating procedures and policies and have the responsibility for keeping them current and consistent [1]. This is basic to understanding which areas are responsible for what information and provides the basis for development of an effective Document Monitoring Plan.
In addition, when the consultant defines indicators, the manager can adjust the strategic initiatives concerning quality, creativity and the re-engineering program so as to carry out the_progression. The value of the indicator has importance only if it is brought closer with a reference. Variations and not absolute values are thus analyzed. To remedy that, it is ordered to bring closer certain differences between them, in particular, those which normally evolve together. The logical progression in the analysis of the implementation plans is to: (i) investigate how and where the implementation plans have an impact on the operation of the organization, (ii) examine the contribution of the implementation initiatives to desired outcomes of implementation process and, (iii) examine the sequencing of the implementation activity in the perspectives of points (i) and (ii) above.

3.5 Hybrid strategy

One of the most frequent reasons cited for failure of all types of change programs is the lack of communication and understanding between (a) the person who will be impacted by the changes and (b) the group involved in creating the new organization. The Hybrid strategy that we propose here provides a comprehensive and effective approach that will strategically and simultaneously address TQM, BPR and Six-Sigma and to show with clarity the relationships between the elements that allow those requirements to be met. Such an approach also avoids turmoil and waste of time, people and resources. It selects those practices that are most likely to contribute to business goals. It detects complementary and interfering practices, and presents an overview of an interlocking organizational system. By this, the risks of failure are reduced because there is a greater and continuing focus on the needs of the organization of the process being re-engineered. What is more, failure of organizations to benefit from implementing a TQM model frequently arises from their perspective that the ISO elements are independent activities; whereas they are actually interdependent.

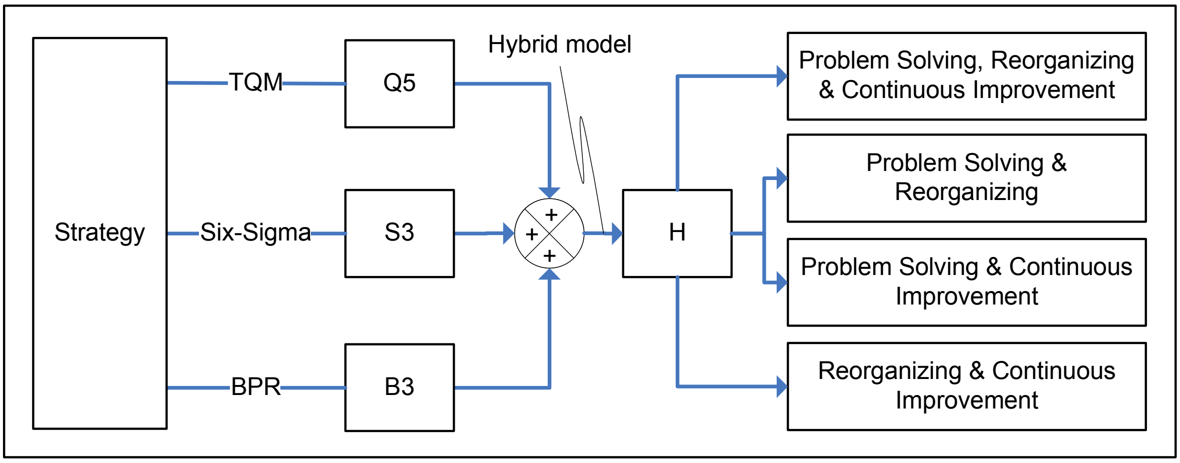

Figure 2: The structure of the hybrid model

By introducing the Hybrid matrix, our strategy highlights interactions between Six-Sigma, BPR and TQM. Four cases can be presented (Figure 2). These interactions play a critical role in affecting outcomes; a role that leads to an operational action plan. This output takes into account and coordinates the interactions among all the components of a business system. The strategy chosen here consists in mixing these approaches and proposing a new decision by completing the lacked information in the six sub-matrices inside the Hybrid matrix. As a result, it can be said that the Hybrid matrix works by seeking to identify relationships of the different strategies. In this way, the consultant can have a broad understanding of how strategies act on each other and hence reach a better trade-off between them. Moreover, the Hybrid matrix is used to compare procedures, operational improvement and sources of variation on one axis (requirements) to work instruction, technical improvement and regulation on the other axis (actions).

The technical difficulty is introduced as a factor to correct the relative priorities of actions based on technical difficulty a company will experience to attain a demanded quality. It can be used to give more importance to those characteristics which implies less technical difficulty. Following, the consultant could evaluate some details of the layout and features during the development of the action plan. By using the correlation matrix, which is more often referred to as the Roof, of the Hybrid matrix, it is possible to re-examine the correlation among actions. This correlation matrix helps identify the interactions among these actions and provide early recognition of positively and negatively correlated features with action plan. Besides, it is used to identify where these components must work together lest they will be in the reorganization conflict. Any cell identified with a high correlation is a strong signal to the consultant; showing that the significant communication and the coordination will take place, if any changes will be realized. If there is a negative or strongly negative impact between actions, then the action plan should be compromised; unless the negative impact can be designed out. Some conflicts can't be resolved because they represent constraints. As a result, improving one of them may probably cause a negative impact to the other.

3.6 Reactive approach

It should be noted that the relationship between the different matrices of each improvement strategy is bi-directional, depicting the dynamic nature of our strategy process. We do not only meet the information feedback on the level of the planning of the tasks, but also in the monitoring system. Any difficulty encountered during the research of the monitoring techniques, is immediately retransmitted to the former matrices to be tried another way. This process of experience feedback feeds the following process during which the target values of the indicators are examined, brought up to date and readjusted according to the most recent measurements vision of the performance results.

Financial resources are a major constraint, since they can change the decision of acquisition into accessibility. To face this economic constraint, the consultant should turn more attention on the driver cost of his plan. The designing and the management of the reorganization system at objective cost are a management strategy and a support methodology to obtain a practical plan. The target cost of each action can be given by distributing the objective-cost of the plan to each solution. In addition, when the calculated cost of an action is higher than its target profit, it becomes a bottleneck. We should, then, study again the solution and the plan items to solve this problem.

4 APPLICATION

The “Sotim” is a medium-sized enterprise of the production of mechanical parts. The workshop is composed of a manufacturing unit, a thermal treatment unit and a laboratory of metrology. For our application, it is necessary to initially choose one sub-project, which leads to obtain tangible results in the very short-term. This sub-project is selected in part of the organization, to be used as catalyst for the whole of the organization. The objectives and the results to realize should be carefully determined, and the way in which they will be measured and/or evaluated. Testing our model in the maintenance service allows us to try out our approach. From the practical point of view, meetings of work were organized for this purpose. The person in charge of the maintenance service were critical and constructive. All participants, in the execution meetings of the QFD-design and the diagnostic process, show at the same time critical, constructive and objective spirit. Current maintenance in this company is reactive, i.e., breakdown. It is a practice that is inherently wasteful and ineffective with disadvantages such as: possibility of secondary damage, no warning of failure with possible safety risks, production loss or delay, and the need for standby machinery. The time wasted while trying to find parts for maintenance technicians makes up one of the largest portions of the lost productive time. Individuals who do not understand how maintenance inventory is different from operations or production inventory make order policies and storage policies. This lack of understanding creates stock outs and overstocks, both of which are unnecessary expenses that weaken the "Sotim" competitive position.

To meet the needs of restructuring the company, we developed the hybrid matrix (Figure 3) on the basis of the previous models. We conserved the same data of the diagonal matrices (S3, Q5 and B3) used in the TQM, BPR and Six Sigma strategies. The relationships between SQ, SB, QB, QS, BS and BQ sub-matrices, were completed with the staff of the maintenance service. In our Hybrid matrix, we can notice certain similarities between the requirements described by the various approaches. The 6th need coming from the Six-Sigma approach "High percentage defective of the equipment" and the 22nd need belonging to the BPR approach "Reduce breakdowns" seem to have the same weight. Also, we noticed another similarity between "Procedure of the purchasing process" and "Reduce the frequency of inventory" which were included into TQM and BPR needs. This demonstrates the existence of a common domain between the needs of the various approaches. The deployment of the "Procedure of the product identification, Procedure of the store inventory, Develop a maintenance program and Train the staff" have solutions only with TQM and BPR.

In addition, applying Six-Sigma philosophy to the ISO Standards (Matrix SQ) is the best way to achieve the optimal results in quality progress and therefore in customers satisfaction. In fact, Six-Sigma uses an array of statistical and analytical tools to apply a data-driven, root-cause analysis to the existing processes to minimize variation and aim for zero defects.

Finally, TQM (ISO 9000), Six-Sigma, and BPR may overlap in some areas; they are not mutually exclusive. Each of these strategies programs builds a foundation for continuous improvement, along with differences in scope and coverage. The aim is to help the manager determine which methods to use in which scenario and to predict the effectiveness of these methods.

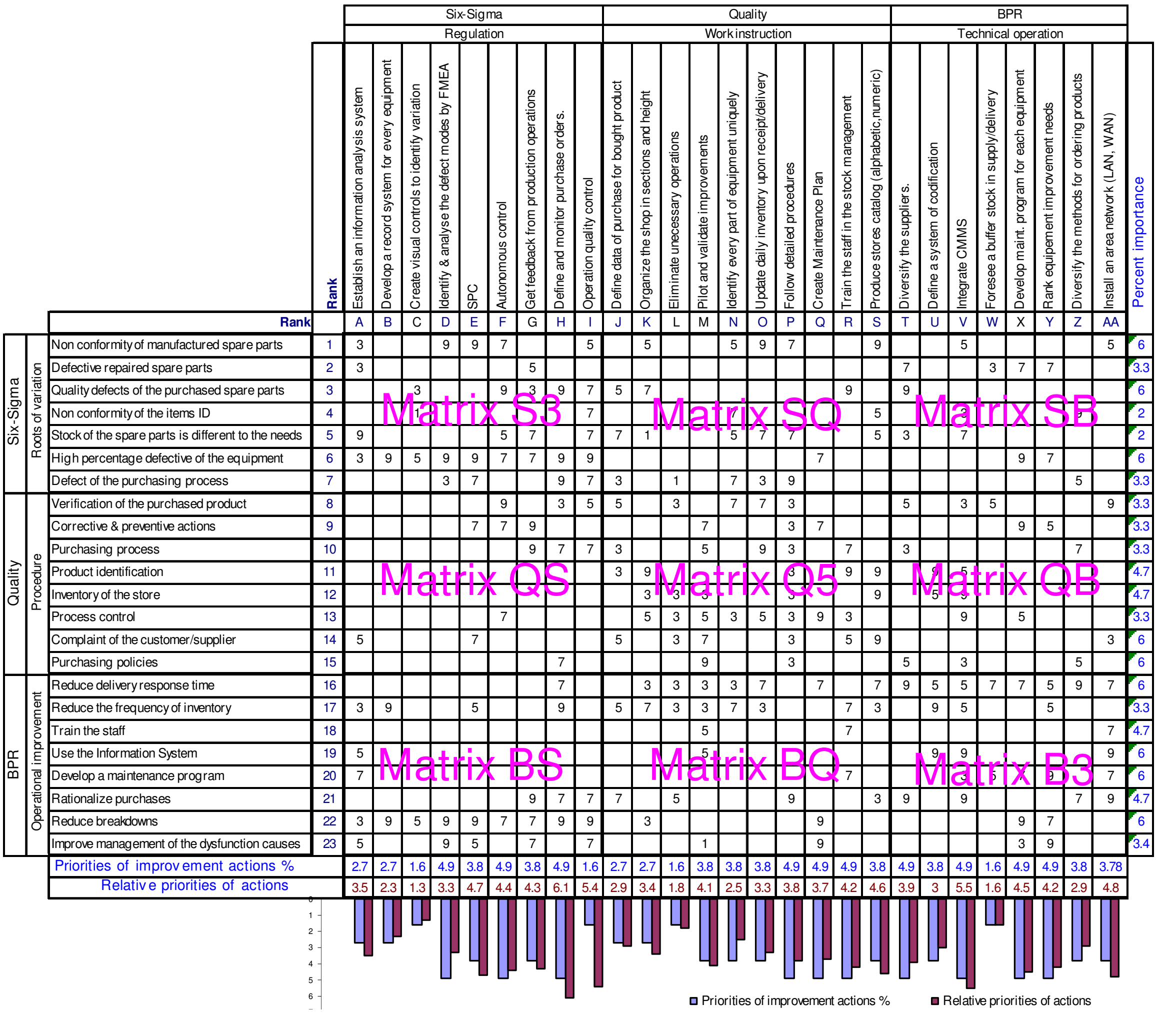

Figure 3: The hybrid matrix

5 CONCLUSION

In this paper, a literature review of Six-Sigma, BPR and TQM was presented with the objective of identifying appropriate modeling technique. Modeling not only helps to plan reengineering, but also makes implementation of necessary changes to the organization and other related resources easier. There are many advantages of our overall QFD-based model. For example, it provides some structure, discipline and a format for identifying, analyzing and operating regulations in the organization. It also provides a means to tackle the task with roles and responsibilities. QFD has been applied in an innovative way to develop a structured model connecting the continuous improvement of a company with its problem-solving and business reengineering.

The Hybrid strategy proposed in our methodology works by merging four models in a defined way. As pointed out in the preceding paragraphs this proposal is driven by the understanding that these different models are complementary to each other. Hence, it is believed that integrating these strategies can further contribute to the final goal of satisfying demanding company needs. However, it may be argued that this approach will possibly lead to make tactical and strategic decisions much more rapid and robust. The greatest benefit from our Hybrid model may be that it helps the consultant to decide which strategy would be most suitable for any specific organization. It shows which practices are the greatest sources of value to stakeholders. Also, it forces management to make explicit the practices and interactions that are implicit in the old, new, and transition systems. When the change process is probably going to exceed the period of time, the components of the strategy can be revisited to gauge progress. New relationships can be captured as the consultant develops a deeper understanding of the situation. The new value of each matrix/sub-matrix is to optimize results not just in isolation but also as part of an integrated system with a more cohesive fit.

REFERENCES

[1] Revelle, B.J., Moran, J.W., Cox, A.C. , *The QFD Handbook*, 1996, (John Wiley & Sons, Inc.) p.403.

[2] Gien, D, S. Jacqmart, A. Seklouli and Barad M., *An approach based on fuzzy sets for manufacturing system design*, 2003, Int. J. Prod. Res., vol. 41(2), pp. 315-335.

[3] Lazreg, M. and Gien, D., *Maintenance excellence model for diagnosis and preparing the implementation of a new organization in SME,* 2006, 18th National Computer Conference "Information technology and sustainable development". Riyadh, Saudi Arabia, 26-29 March, pp. 313-321.

[4] Gertsen F., Acur N., Sun H., Frick J., *Formal manufacturing strategy – Does it matter?*, 2003, Center for Industrial Production, Aalborg University. pp20.

[5] Palady P. and Olyai N., *The Status Quo's Failure In Problem Solving*, 2002, Quality. Progress, p 34-39, August

[6] Brynjolfsson, E., Renshaw, A.A., Van Alstyne, M., *The Matrix of Change*, 1997, Management of Technology and Innovation, Vol. 38, No. 2, pp. 37–54

[7] NIST, *Baldrige Index Beaten by S&P 500 For Second Year*, 2004, NIST Tech Beat. NIST. http://www.nist.gov/public_affairs/techbeat/tb2004_0423.htm#quicklinks

[8] Efqm, European Foundation for Quality Management, EFQM Excellence Model, 2003, EFQM, Brussels

[9] Flynn, B.B., and Salain, B., *Further evidence on the validity of the theoretical models underlying the Baldrige criteria*, 2001, Journal of Operations Management, 19 (6) pp. 617-652.

[10] Juran, J.M., and Godfrey, A.B., *Juran's Quality Handbook*, 2000, McGraw-Hill.

[11] Ghobadian, A. & Woo, H., *Characteristics, benefits and shortcomings of four major quality awards*, 1996, International Journal of Quality & Reliability Management, Vol. 13, No. 2, pp. 10-44.

[12] Black, S. & Porter, L., *Identification of the critical factors of TQM*, 1996, Decision Sciences, Vol. 27, No. 1, pp. 1-20

[13] Wiele V. D, T., Iwaarden, V. J., Dale, B.G. and Williams, R. *A comparison of five modern improvement approaches*, 2006, Int. J. Productivity and Quality Management, Vol. 1, No. 4, pp.363–378.

[14] Bhota, K.R. and Bhota, A.K., *World-Class Quality: Using Design of Experiments to Make it Happen*, 1991, 2nd edition, New York: America Management Association.

[15] Breyfogle, F.W. III, *Implementing Six Sigma*: Smarter Solutions Using Statistical Methods, 1999, Wiley, New York, NY.

[16] Ishikawa, K., *What is Total Quality Control? The Japanese Way*, 1985, Prentice-Hall, Englewood Cliffs, NJ.

[17] Hoerl, R.W. , *Six sigma and the future of the quality profession*, 1998, Quality Progress, pp. 35-42.

[18] Miltiadis M., Jiju A., Frenie A. and Maneesh K., *Statistical thinking and its role for industrial engineers and managers in the 21st century*, 2005, Managerial Auditing Journal, Vol. 20 No. 4, pp. 354-363

[19] Banuelas R., and Jiju A*., Six sigma or design for six sigma?*, 2004, The TQM Magazine, Vol.16, N4, 2004, pp. 250-263

[20] Revere, L., and Black, K*., Integrating Six Sigma with Total Quality Management: A Case Example for Measuring Medication Errors*, 2003, Journal of Healthcare Management, Vol.48, No.6, pp.377-391.

[21] Pfeifer, T., Reissiger, W., and Canales, C., *Integrating six sigma with quality management systems*, 2004, *The TQM Magazine*, Vol.16, No.4, pp.241-249.

[22] Yang, K., *Multivariate statistical methods and Six Sigma*, 2004, International Journal of Six Sigma and Competitive Advantage, Vol.1, No.1, pp.76-96.

[23] Revere, L., Black, K., and Huq, A. (2004), *Integrating Six Sigma and CQI for improving patient care*, *The TQM Magazine*, Vol.16, No.2, pp.105-113.

[24] Elliott, M., Opening up to efficiency, 2003, *Industrial Engineer: IE*, Vol.35, No.7, pp.28-33.

[25] Yang, C.-C., *An integrated model of TQM and GE-Six Sigma*, 2004, International Journal of Six Sigma and Competitive Advantage, Vol.1, No.1, pp.97-111.

[26] Kubiak, T., *An Integrated Approach System*, 2003, *Quality Progress*, Vol.36, No.7, pp.41-45.

[27] Parker, L., *An ABC Guide to Business Process*, 1993, Reengineering, Industrial Engineering, Vol. 25, 52-53.

[28] Hammer, M. and Stanton S. A., *The Reengineering Revolution*, 1995, Harper Business, New York.

[29] Mayer, R., *A framework and suite of methods for BPR, knowledge based System*, 1998, Inc, Texas A&M University, http://www.idef.com/.

[30] Born, G., *Process Management to Quality Improvement*, 1994, Chichester: John Wiley.

[31] Macdonald, J., *Together TQM and BPR are winners*, 1995, The TQM Magazine, Vol. 7, No. 3, pp.21–25.

[32] Harrington, H.J., *Performance improvement: the rise and fall of re-engineering*, 1998, The TQM Magazine, Vol. 10, No. 2, pp.69–71.

[33] Zairi, M. *Uninspired by re-engineering*, 1996, Strategic Insights into Quality, Vol. 4, No. 1, pp.19–20.

[34] Akao, Y., *Quality Function Deployment: Integrating Customer Requirements Into Product Design*, 1996, Cambridge, UK, Productivity Press.

[35] Barad, M., and Gien, D., *Linking Improvement Models to Manufacturing Strategies - A methodology for SMEs and other enterprises*, 2001, International Journal of Production Research, 39, 12, pp. 2675-2695.

[36] Seklouli, A., 2004, *Traitement d'informations floues pour l'amelioration progressive du fonctionnement global des systemes de production*, Thesis, Cleremont-Ferrant, France, N. 1456, p. 190.

[37] Lazreg, M. and Gien, D., *An approach to improve the quality of the diagnosis of the production systems in small and medium-sized companies*, 2006, 4th STCEX. Riyadh, KSA, 2-6 December, pp. 477-485.

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