A SYSTEMATICS TO DEFINE THE INDUSTRIAL MAINTENANCE MANAGEMENT

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Abstract. *The importance of maintenance in the strategical structure of the companies for to increase the operational availability, is being stimulated for the productivity requirements, quality increase, competitiveness, markets opening, among others factors. It is asked, then: why the companies have had difficulties to improve its operational availability despite the investments in qualification and modernization? The raised hypotheses to answer this question indicate restrictions in methodologies in the field of the asset management, appropriate physical resources, computational resources, integrated qualification the culture of the "soil of plant" and adjusted scientific research. Based on these hypotheses, it is considered in this work to present a methodology that allows analyzing the different alternatives for maintenance managements with its more appropriate tools and techniques for the requirement of the company, in the industrial field that operates. The methodology presents a knowledge structure that holds the basics information techniques on maintenance and the bases to analyze its enterprise context: physical and human assets. The analysis model for the managerial structure of maintenance is based on relational modules, that this has the advantage to proceed the analysis in specific points, more at the same time, include the vision of all.*

Key-Word*: Maintenance management, Maturity, Modeling.*

1. Introduction

To implement maintenance conceptions for to define the maintenance management model, brings itself a series of changes in the habitual way to make the maintenance actions. Organizational or transformations changes have helped some company to adapt to the changes of conditions in its environments, to get increment in the competitiveness and to locate the company for a better future.

However, in diverse situations, the improvements have been disappointing, with results very below of the waited one, resulting in resources wastefulness, in loss reliable in the change agents, in frustration in involved people and, perhaps the worse one of everything, in fear to face new changes (Rentes, 2000). These failures occur because the administrators have great difficulty in identifying, appropriately prioritizing and to line up its resources to make front to the many factors that produce sustainable organizational transformations.

Diverse aspects come to the mind during any process of organizational or functional change, which must be dealt with the maximum of care at the moment for implementing an innovation project. Between the most important aspects they detach: the reason for the change must be clearly understood by the people of maintenance and the production team and, to be accepted as a good reason for the change for the principal people of the company. If the reason is already understood and accepted and have clarity on which it's the area of production or maintenance procedure that must be changed, to have a structured methodology to define the most suitable form to make the management, will increase the probability of obtaining good results.

Other questions or aspects are equally important, but they are related with the personal aspects of the person in charge to take ahead the change process. It have special relevance individual characteristic as to have leadership, knowledge of techniques and tools, capacity to work in team, easiness to manage the changes and the conflicts that it derive from the innovation process and to get good relationship with the superior levels.

2. The management of the maintenance function

The intention of an organization for the maintenance can be defined as a set of basic elements that characterize what the organization would like to be in the future, which its will, its desire of being and acting. At last, the intention

synthesizes its proper will, its auto-image and its basic beliefs, exceeding the circumstances, if not limiting neither for the external environment nor for the current qualification (Arantes, 2002).

Komonen (2002) and Verma (2002) detach the fact that the maintenance is a combination of techniques, administrative and management action during the machine life cycle in the intention to keep or to return it to a state where it can fulfill its function. They give special emphasis to the management condition, and indicate that the high efficiency is gotten by means of three attributes: high trustworthiness, high maintainability and efficient supportability.

The maintenance function must have a vision, a mission and a well defined reach, that is, what the maintenance function wants to be in the future in the inside of the organization, which is the basic necessity that the function intends to supply and, finally, which are the real or auto-imposed limitations for the performance of the function.

It has an ample agreement between diverse authors that the engineering and the maintenance management are receiving each time more attention, especially due to necessity for to get of the high cost equipment a high productivity, as also by means of an effective maintenance to influence strongly in the competitive differential of its product. But, the attention that receives the maintenance function is, frequently, product of an isolated action without an adjusted integration between the varied employed techniques (Coetzee, 1999).

In this direction, Coetzee (1999), Waeyenbergh and Pintelon (2002) detach that the correct form to direct the necessities for an effective maintenance function inside the organization is having the holistic vision of the function, completely integrated in the system business-oriented of the company (Gits, 1992), to use information technologies and to formulate a maintenance conception with theoretical bases proven (Sherwin, 2000; Vatn *et al*., 1996, Pun *et a*l, 2002; Zhu *et al*., 2002). Moreover, if the varied employed methodologies, philosophies and techniques are properly coordinated and planned the effect in this way it is a successful improvement of the maintenance function.

The more concurred approach for to develop the maintenance function efficiency is to implement some philosophy or maintenance management more recommended. This includes RCM (Reliability Centered Maintenance), TPM (Total Productive Maintenance), CMMS (Computerized Maintenance Management Systems), among others. All these techniques had contributed of some form for the success of the maintenance organization, but, the accidental or improvised form where they are introduced is a probable way for to sub-optimize its application (Coetzee 1999).

3. Maintenance conception for an industrial system

The conception of the maintenance it relates, in essence, to have criteria, administrative delineations and procedures for to face and to manage the maintenance tasks that they indicate, as to obtain the best income of the equipment and resources defined for the maintenance (Gits, 1992). The central subject is related with the volume, amount, production type, complexities and equipment relations for that must be taken care of.

The maintenance function contributes (Fig. 1), now more than never, to reach the objectives of the enterprise for the total integration with the production process. Thus, the maintenance acts positively in the reduction of the total cost, in the equipment improvement, the people and the environment security, in the project of new products, among others aspects and all of this imposes higher demands for the maintenance team that also must increases its efficiency and capacity. It is a problem of competitiveness in all level.

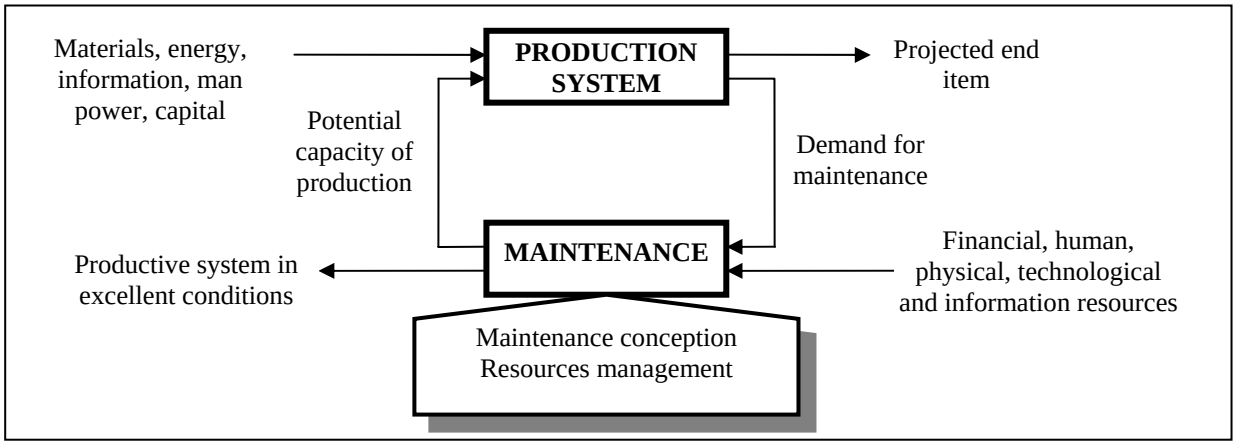

Fig. 1: Maintenance integration in the productive context

The most difficult case it is relates to the strategy that an industrial organization must adopt to keep its entire patrimonial asset in good conditions and with an adequate depreciation process. The variables to take care are: definition of the maintenance types, in agreement attendance with the critic level of each equipment, calendar of the equipment stopped, definition of the man power's quality and its attainment, evaluation of the external services, introduction of new technologies, decision on the equipment elimination and its substitution, definition of logistic canals, definition of the administration and information system, etc. However, the more relevant aspect than must be taken care of is to know the maturity of the maintenance team and the maturity of the organization that coexists with the maintenance function.

To define the conception, firstly, all of the operational system requirements must be analyze and this must include the minimum times of functioning for period, maximum time for repairing, the more critical equipment, its technological level, required personnel, associated risk with its operation and considered costs for the repairing and loss of production.

The mentioned requirements are complemented with the administrative aspects as the definition of the responsible ones for the tasks, if they will be made by proper staff, with external resources or combination of the two forms, definition of efficiency parameters and equipment useful life for each ones.

The methodology of the Reliability Centered Maintenance (RCM), Total Productive Maintenance (TPM), Business Based Maintenance (BBM) or others can be adopted. Each one of these methodologies can be applied with greater or lower emphasis in some aspects inside of a technique, economic and an availability of the human resources viability target.

4. Systematic modeling

The modeling of a process allows to the different integrant involved in the project to understand the behavior of the system and adopting and handle a common language without mistakes in the interpretation. Al-Ahmari *et al*. (1999) indicate that the analysts and designers need to elaborate models for to describe the industrial operations, the relevant decisions and the flows of information, but the model must be simple and capable to support different levels of abstraction. Hangos *et al*. (1997) add the project conditions, control and optimization.

A model is composed for two phases: a qualitative and another quantitative. The qualitative modeling is the one that to provide the resources to effect a mapping of the system, including the participants of the problematic situation, such that can facilitate its understanding and give bases to consider changes. The quantitative modeling or dynamic industrial modeling if focuses in solving problems of behavior of a composed system of machines, staff and organization of the company and is used in the planning, in the implementation and in the control (Towill, 1996; Corben *et al*. 1995).

The considered model to describe the methodology is formed by two phases: the first one is a conceptual type modeling where it will be presented a global vision of the function maintenance in its surrounding and the objective equipment that will be reason of analysis. The second model is used to evaluate the current state of the maintenance function and the possibility to implement the changes in base to the necessary requirements for implementing a new maintenance conception.

4.1 Conceptual Model

The main objective of this model will be to show the relationships between the centers of activities, which can be disclosed as decisions, information and materials flows. In Fig. 2 is presents graphically the factors that are important for the methodology development that will lead to the election of the more adjusted conception with the reality of the company.

The level 1 (superior level of the pyramid) in Fig. 2 represents all the set of production lines or groups of equipment that is taken care by the maintenance function. For this set of equipment must exist a criterion that will allow to classify them as critical or to give the analysis reasons for which will be applied the methodology to change the maintenance conception. A guide to define the critical level of an equipment is described for Murthy *et al*. (2002) that they indicate that no business can be operate if its equipment won't be in excellent operational state. The controlling of superior management level need to understand the implications of the risks associates with the equipment without reliability and of the external jobs in the execution of the maintenance.

In the second level (level 2: selected lines of production) it is found the lines or equipment considered for the study. For all these equipment it must be collect all the necessary information to evaluate the possible success when applying one definitive maintenance conception. The information will be concerning, mainly, with the data availability, of enabled staff, current maintenance system, budgets and commitments with the change. This study it is the most important phase of the process, and will be to make with the biggest rigor, since it compromises time, money and effort and if in the long of the application time will not have success, the credibility in the changes will be lost. In Fig. 3 it is shows the detailing of the study for this level.

The last level (level 3: individual equipment) represents all the individual equipment with its respective technical and of their using information, which will be the information entrances for the study of the equipment at level 2. All these data will be very important at the moment to define the maintenance plan, in special if the decision is to implement RCM, since in this conception exists involved much of operators experience.

4.2 Evaluation model for the conceptions implementation

A complete evaluation will have to consider varied aspects that are related with the maintenance, and each one of them, considered as important, must be positive in the direction to direct correctly for a new form of maintenance management. It is more productive to eliminate the weaknesses detected in the process of the system evaluation before following for the next step in the conception implementation, of that to come back backwards when the process it is already directed in order to solve these problems that had been hanging.

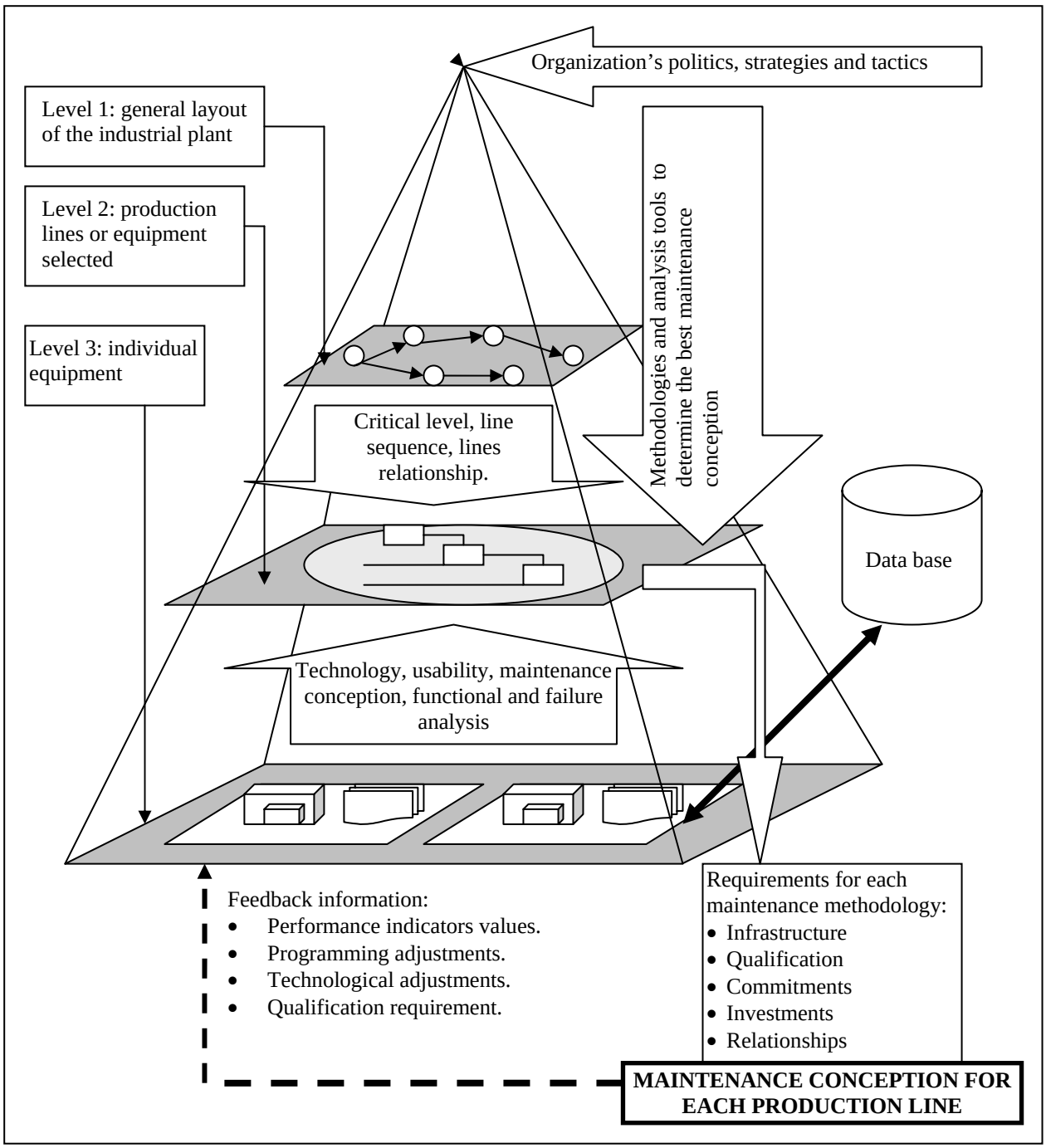

Fig. 2: Conceptual model for the maintenance function analysis.

The process is described in Fig. 3, in global form, and, in Fig. 4 in detailed form. The study it will be started with the definition of the maintenance mission, according to the company's strategies and tactics defined to reach its business objectives. This will be the first information that it must have for to determine the goal proportions that it must be impose to the maintenance function, which must be compatible with of the company. Of here will get the first set of indicators such as minimum equipment availability.

In the second analysis will be evaluated the equipment technical condition, its life cycle in reason to the product life cycle, its condition of modernization viability, or either, everything what it concerns the technological capacities of the company. The exit of this analysis is an evaluation on the efficiency of the technician system to fulfill with the requirements of the business.

In the following step the maturity of the organization will be evaluated in the maintenance aspect to face the new challenges considered in each conception of maintenance. The maturity has relationship with the commitment of the involved people with the maintenance and, mainly in superior administrative levels of the company. It has that to have in accounted other aspects as the organization culture and capacity to face the change, knowledge and use of administrative methods, communications and transmission of important information to interior and exterior of the

organization and interactions handling (conflicts) product of the change process (Clarke *et al*. 1997). The maturity level supplies a high level of indications for future actions that must be undertaken in special forming team spirit.

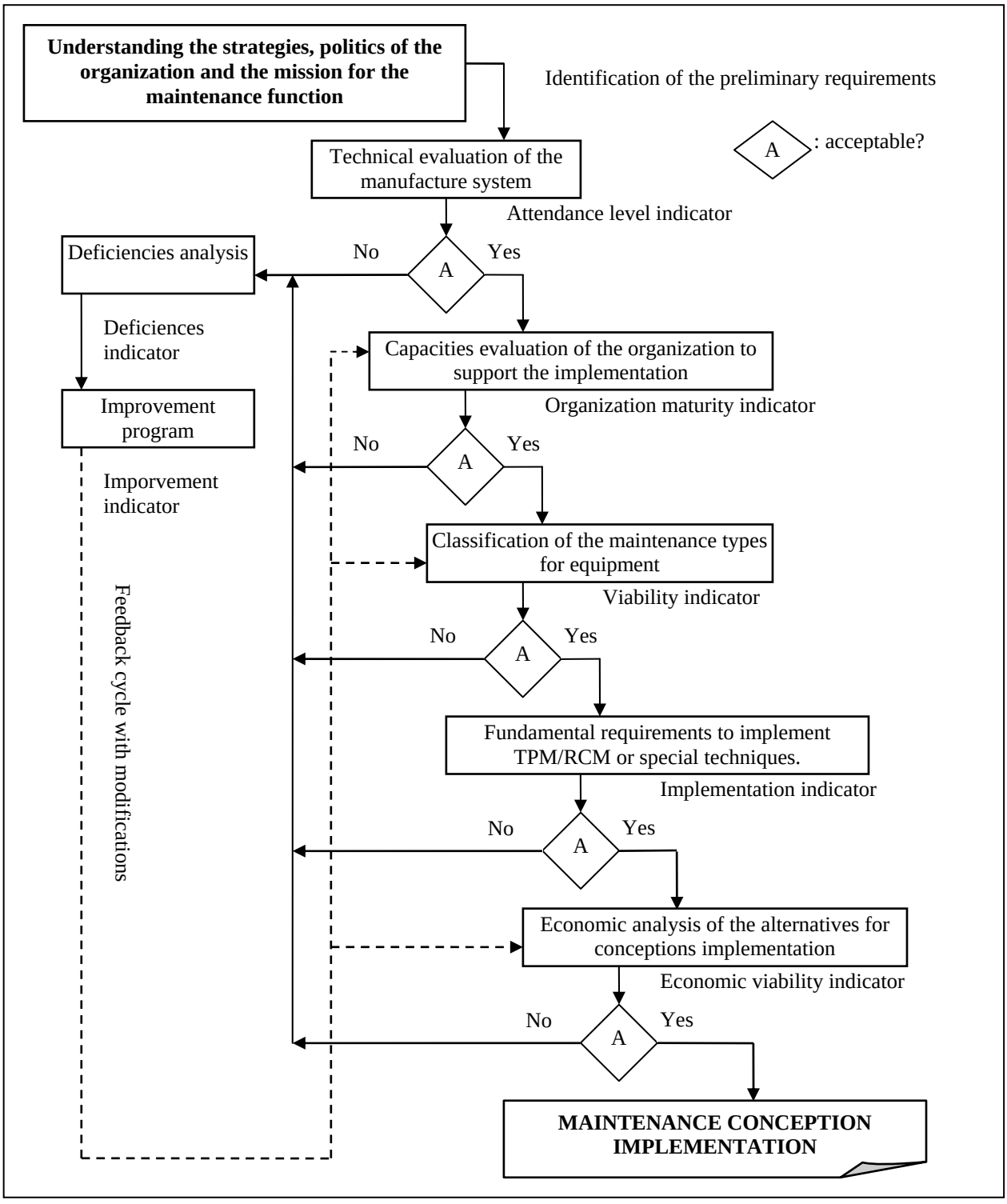

Fig. 3: Global deployment for the implementation of maintenance conceptions.

Having adjusted equipment to fulfill with the company's mission, an engaged maintenance team and with total support of the high management this is the moment to make the corresponding analyses to define which it is the more convenient maintenance conception for the organization.

Each enclosed conception in the study has proper characteristics which must be compared with a set of necessary requirements so that its implantation will be a success. The indicators make reference to the aspects related with the availability of equipment information, functionality knowledge of the distinct systems that compose each machine and of each system that they integrate the production line, the level of technical preparation of the operators and the maintenance staff, resources administration system, etc.

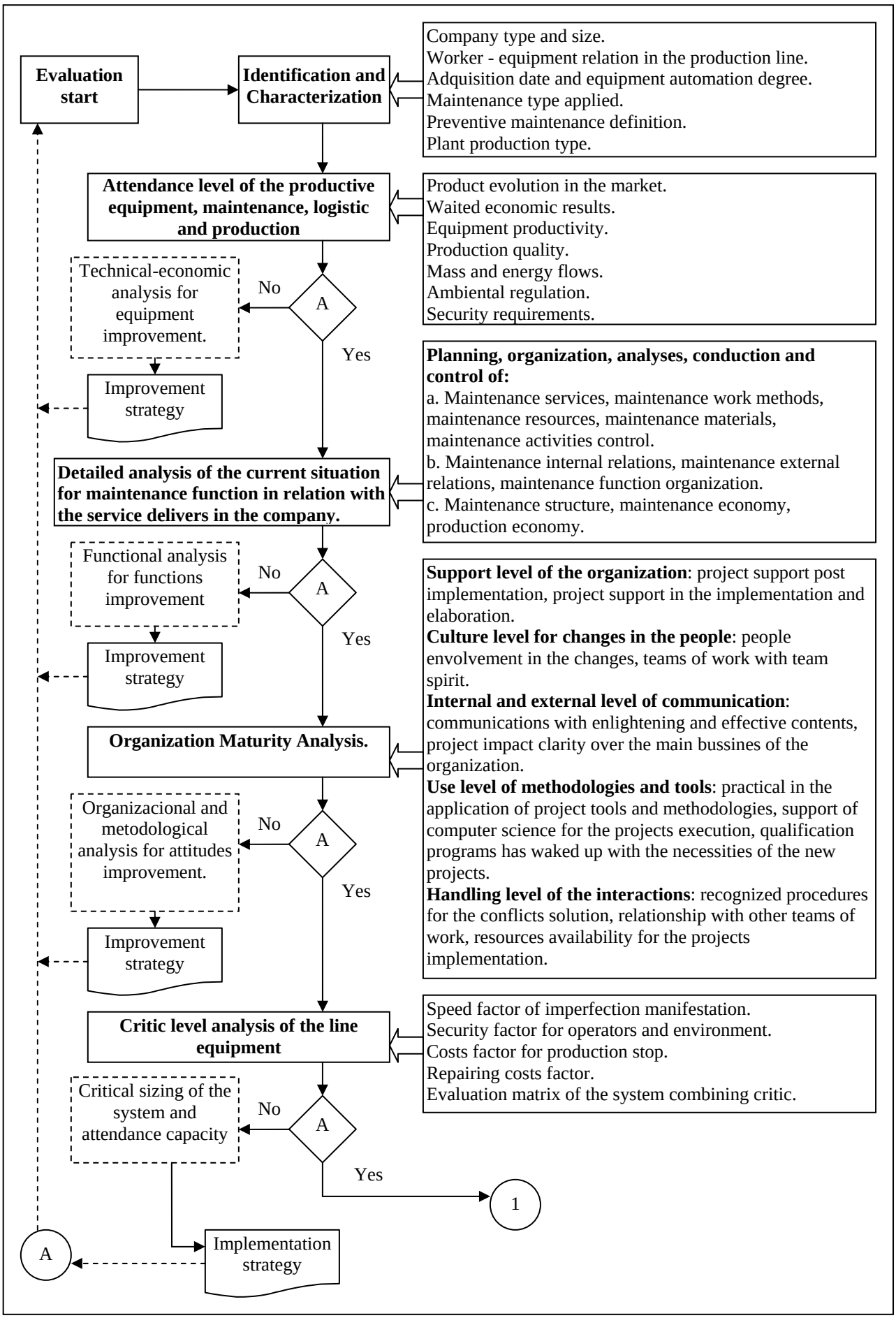

Fig. 4: Detailed deployment to implementation of the maintenance conception.

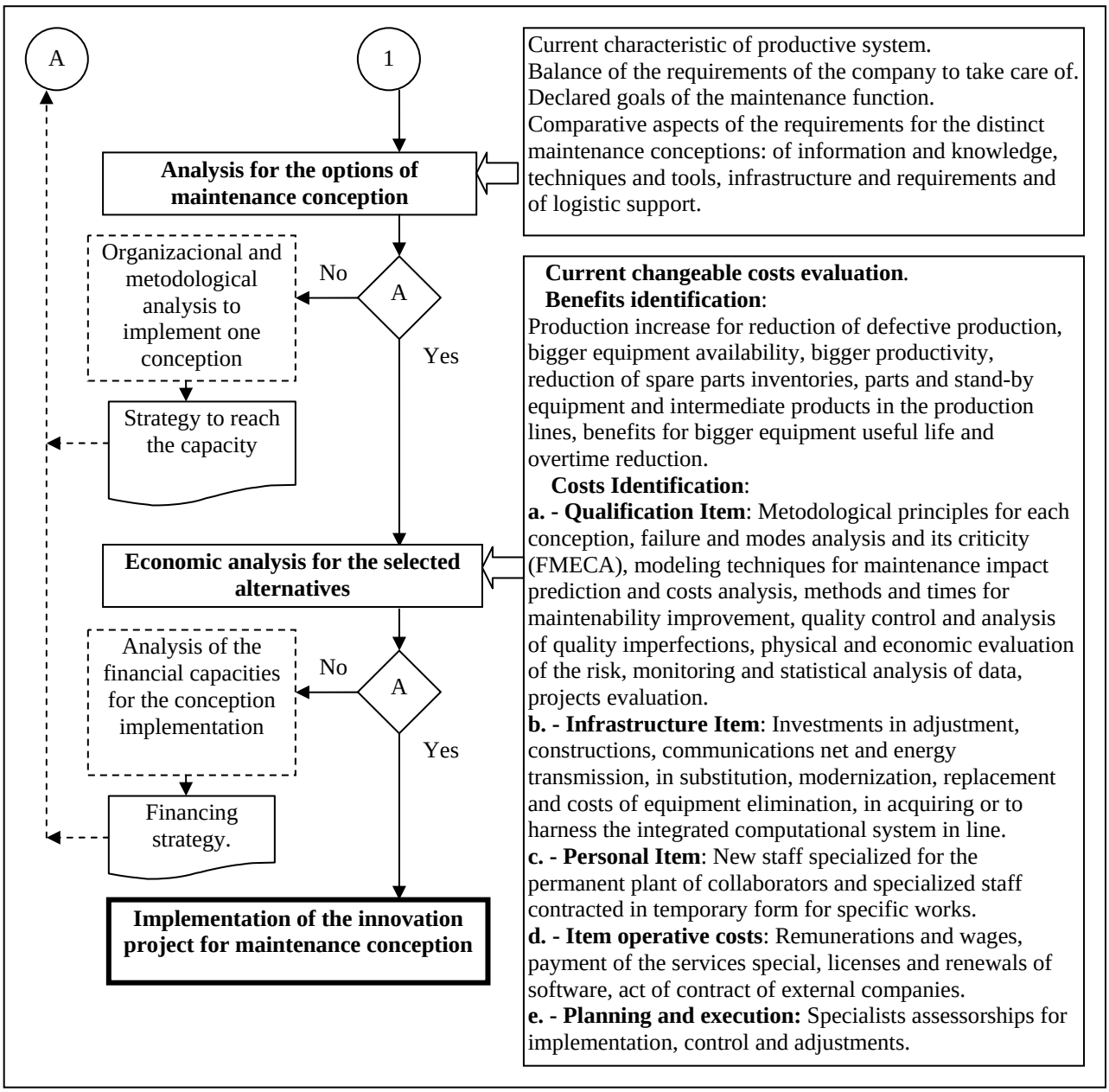

Fig. 4 (cont.): Detailed deployment of the study for the implementation of maintenance conceptions.

The study that always will have to be present, to legalize a decision over the most convenient conception for the organization it is the economic evaluation. Each structure of maintenance action that it is imposed, either TPM, RCM, or another conception, has an initial cost for the implementation and an annual cost of operation. In the resultant benefits it is had mainly, reduction of operational costs and the reduction of production losses. In this case, the indicator will be of financial type and will have to be in agreement with the levels demanded for the company's investment projects. The conception that to get the higher value of the waited utility would have to be selected as maintenance conception for the group of selected equipment, if will not exists politics restrictive conditions.

In each one of the stages, in the application of the evaluation model, it is generated a very important set of information for the weaknesses (also for the forces) and aspects that can be harnessed in the maintenance organization. This information would have to be dealt as a source data for an analysis of each deficiency, for to search improvements alternatives and to define an implementation plan of guided actions to optimize the efficiency of the maintenance function.

The process that it is considers must be made in agreement with the maintenance team, which it encloses since the main administrator or of the responsible management until the specialist for each branch of specialty that is present in the organization. It must also be included production personal because some points are owns in its function, in special when the subject is related with the viability analysis for to apply TPM for the maintenance organization.

It call attention that the proposal methodology, in its application, does not take no decision only supplies to the administrator and its study team diagnostic, profiles, diagrams or explanatory texts on the aspects that are evaluated. It corresponds to the maintenance team based on its experience and the knowledge of its environment (personal,

resources, supports, politics, etc.) to decide on the step to the next stage to the evaluation. The important one is to be rigorous and not to create false expectations of a possible application and improvement of its management.

5. Conclusions

The objective of this work is to supply a tool that guide the project leader in the choice of a conception for maintenance management but, with a sufficient required knowledge of the maintenance current situation and the projection in the future with more probability of success. To select the most adequate conception and to get of its application the greater potential it must be consider all the aspects related with the technician factors, information flows and resources that describe the interrelations between the different systems of the organization that has relation with the maintenance. The aspects related to the company organizational structure and its strategical plans of development are also added.

The maintenance conception delivers the guidelines under which the function administrator will define the maintenance actions for each one of the organization assets, its regularity and necessary technology. All this information is now the base for to define the maintenance management process, as it will be sizing of the operation capacity, the amount and necessary resources availability, knowledge and technology, vertical and horizontal integration with other company organization deparment. Others elements are the fisical infrastructure, the administrative structure, the planning and control system, the staff conscription and training, the implementation of equipment modifications and the system for performance measurement and incentives. All which, stand out the importance of to select the best maintenance conception for the individual characteristics of each company.

The end product that the proposal methodology delivers for the analyst or maintenance administrator is a set of information that supports its decisions making. This set makes reference to the multiple aspects that are outstanding for the maintenance management and those they enclose aspects of the organization maturity until an economic evaluation for the selected alternatives. To define the best maintenance conception is not a trivial problem, since the variables to be considered vary in agreement with the companies, managemental vision, times and analysts. It is not possible to apply a standard systematic and to decide: this is the best, since a modeling that searchs an optimal one (in the direction that indicates the operational research) is excessively complex.

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