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Using Methods of System Analysis and Risk Management of Process Systems

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Abstract: The complexity of the process systems and the diversity of the kinds of methods in use of system analysis and risk management don’t permit to get perceptions and correct understandings of the internal working of process systems. To answer to this problem, it is necessary to adopt a structured methodology of development based on the combination of the two methods OOPP (Objective Oriented Project Planning) and FMECA (Failure Mode, Effects and Criticality Analysis) for the process systems analysis. In this article, we present a model of analysis and modelling of process system based on the methods OOPP and FMECA.

Keywords: process system, system analysis, risk management.

1. Introduction

The XXe century know an important change of method: the apparition of the systemic paradigm, coming to complete the causal paradigm. How the knowledge of the structure of a system proves to be more interesting than the detailed knowledge of its initial conditions in other terms, in the objective to foresee its behavior [1].

In the world of business, the tendency is to adapt global approaches of management, synthetic or systemic to replace the traditional analytic approach. This last consists in subdividing a complex problem in a certain number of small problems [2]. Each of these is then easily resolute and the global solution of the problem is considered, to harm, as being the sum of small problem solutions. The division of work is a demonstration of the analytic thought. In the case of simple situations, when the concerned parts are independent, the analytic approach is very applicable. However, it proves to be inefficient if parts have some complex relations between them or with other elements. The solution of a part can, in the case of the analytic approach, to take to an under optimization, that is to the optimization of a part at the expense of the all. Indeed, the understanding of mechanisms that governs systems is a common preoccupation to the analysis and the systemic approach.

The systemic analysis, also called system analysis, uses a model established on the basis of features and open system properties. It comes back, in a way, to make bring in the reality in a normalized mold, the one of the systemic model. This tool is especially adapted to understand and to optimize the working of a process of production of flux of matters, energy or information. Besides, it permits one fashion of apprehension and common understanding to the analysis and the decision. It serves as a reference to make some graphic modeling.

The systemic analysis belongs today a scientific research that analyzes the complex process elements as components of a whole where they are in reciprocal dependence relation. Its field of survey doesn't limit itself to the mechanization of the thought: the systemic analysis is a methodology that organizes knowledge to optimize an action.

The objective of the system approach is to schematize a complex system, to lead to a modeling that permits to act on it, after one understood its material configuration and its dynamic structure [3].

The systemic analysis encourages the acquirement of knowledge and permits to improve the efficiency of actions. Indeed, it brings to clear some intended general rules to understand these systems better and to act on them.

The systemic analysis of a process system has for role to define the general strategy of the modeling survey to achieve. This strategy must permit to fix a way specifies limits of the modeling, while defining borders of the system to model, and to specify among data that are really exchanged between the different components of the process system, and those that the survey of modeling is going to cover.

Under the appellation of system analysis, one finds a diversity of methods, languages and symbolism that all propose some representations of organizations and the problematic in game.

The systemic approach, as for it, is a global gait that answers to a demand of change, and no a systematic approach that analyzes of sequential manner all elements of a system, or a method of change or a tool of communication. It is a methodology that permits to gather and to organize knowledge in view of a bigger efficiency of the action. It leans on the notion of system and includes the totality of the elements of the studied system, as well as their interactions and their interdependences.

Contrary to the systemic analysis, the systemic approach takes a print of the reality to reveal all its specificity of it. Says otherwise, if the systemic analysis applies its own and unique model on all organization for in to translate the working better, the systemic approach rather endeavors to reveal the specific configuration of the system to consider in the goal to come with the change.

Thus, at all system to human components and all unit of transformation can be looked through the systemic model. As we already saw him, the organization of the system can be retailed in terms of subsystems until the elementary level that one considers like a black box. According to the objective of the observation, the black box can be situated to a superior level to the one of the element; it is a part of the system whose observer is unaware of the internal working voluntarily to only fear its entrances and its exits.

The systemic approach doesn't consist in looking of systematic manner at an organization through models, but well to make emerge the specific model of this organization following the logic of the system to which it belongs. It means that one interests itself by no means to the institutional systems but to the real exchanges. It is a global gait that answers to a demand and no a systematic approach that examines of sequential manner all elements of a system, or a method of communication or again a method of change. Difficulties of this systemic approach are rather attached to the process of requisite information collection to have a complete vision of a global and complex system.

The main part of this paper gives an overview of the methods of system analysis and risk management for analyzing and modeling process systems. The paper is organized as follows. In Section 2 we will give a presentation of the general context of analysis and modeling of process systems followed by a presentation of the two methods OOPP and FMECA in Section 3, a combination of these methods in order to analysis a process system in Section 4, and Section 5 concludes.

2. General Context

An enterprise is an economic and social structure that regroups the human means, materials and financiers. Indeed, the enterprise combines and remunerates some necessary production factors to the creation of possessions or services. The enterprise searches for the productive efficiency that is the most efficient productive combination [4].

This efficiency of the productive combination is measured thanks to the fruitfulness. The objective of the enterprise is to improve its fruitfulness to increase its profitability.

According to Bennour, the enterprise modeling is the interaction of the different modeling languages and the enterprise methodologies [5] (Figure 1).

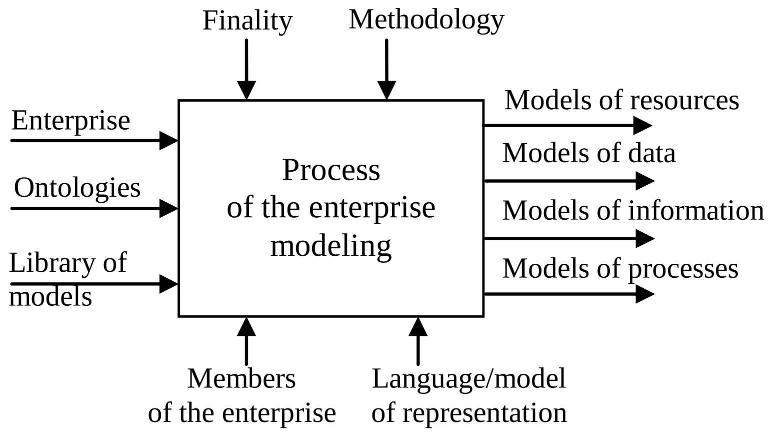

Figure 1. Process of the enterprise modeling.

The process system is a key element to increase the fruitfulness and the competitiveness of the industrial enterprises. Indeed, a process system is all transformation of a whole of raw materials or components semi-finished in finished products while answering to the customer and satisfactory of the various constraints (delay, cost, competitiveness, customer service, presentation, communication...) [6].

The process system puts the accent on the notion of the production that is one of the economic activities the more old and traditional in the evolution of the humanity. Several researchers define the production as being a transformation of resources belonging to a productive system and driving to the creation of possessions and services. Resources can be facilities, men, matters (raw materials and components), the technical information (ranges, nomenclatures, operative cards...) [7].

The process system can be modeled under three subsystems:

- The conception system that conceives some new products, modify and improve products already made and conceives manufacture tools.
- The management system that permits the production management, the organization and the stocks management.
- The manufacture system that manufactures the product from the well stocked data by the subsystem of conception (manufacture documents).

In order to model a process system, it is important to have a good management of the production that is destined to apply methods and techniques in the goal to accomplish the transformation of matters in finished product. It is the material means combination, human and of raw materials to assure the manufacture of products in quality and in quantity.

The process of production makes part of a coherent chain permitting to assure the satisfaction of the customer and a profit in the enterprise. This process can be described through the following stages:

- Survey of the external environmental: choices, existing products and demands.
- Definition of customer needs in relation to the existing product.
- Survey of the product in scientist its cost, the quality and the quantity asked to assure needs of customers.
- Realization of the product by the identification of production means, the determination of raw materials and the implantation of means.
- Manufacture with its production phase and its control phase.
- Insurance of the service after the sale.

The fast evolution of the process system in enterprises is, of the fact, that the system of production or lines of production have been automated entirely. This evolution has been advanced to the year 2000, by the existence of the harmonization of the human operators and the automatic machines what should be a human process system [8].

Indeed, an automated process system is a means to assure the objective primordial of an enterprise and the competitiveness of its products. It permits to add a value to the incoming products.

The notion of the automated system can apply to a freestanding machine as well as to a unit of production, or even to a factory or a group of factories. It is therefore indispensable, before all analysis, to define the border permitting to isolate the automated system studied of its outside.

3. Presentation of OOPP and FMECA

There are many methods that have been used for system analysis and risk management of the process systems. We review two of these methods here because we think them to be fairly representative of the general kinds of methods in use. The methods include OOPP and FMECA.

3.1 OOPP Method

The OOPP method which is also referred to Logical Framework Approach (LFA) is a structured meeting process. This approach is based on four essential steps: Problem Analysis, Objectives Analysis, Alternatives Analysis and Activities Planning. It seeks to identify the major current problems using cause-effect analysis and search for the best strategy to alleviate these identified problems [9-11].

The first step of “Problem Analysis” seeks to get consensus on the detailed aspects of the problem. The first procedure in problem analysis is brainstorming. All participants are invited to write their problem ideas on small cards. The participants may write as many cards as they wish. The participants group the cards or look for cause-effect relationship between the themes on the cards by arranging the cards to form a problem tree (Figure 2).

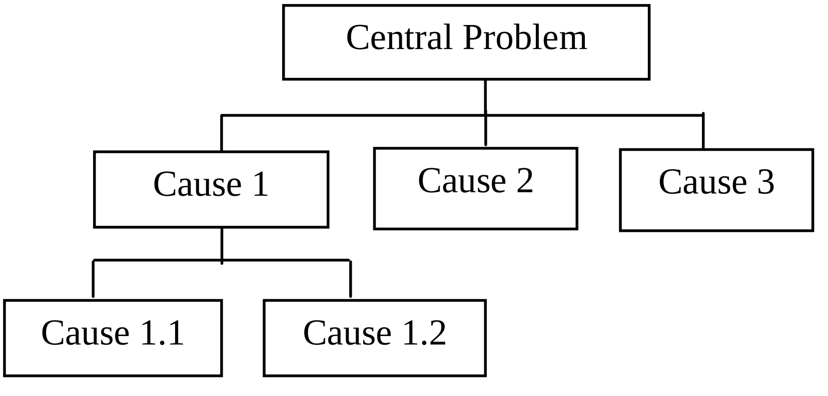

Figure 2. Problem tree of the OOPP method.

In the step of “Objectives Analysis” the problem statements are converted into objective statements and if possible into an objective tree (Figure 3). Just as the problem tree shows cause-effect relationships, the objective tree shows means-end relationships. The means-end relationships show the means by which the project can achieve the desired ends or future desirable conditions.

The objective tree usually shows the large number of possible strategies or means-end links that could contribute to a solution to the problem. Since there will be a limit to the resources that can be applied to the project, it is necessary for the participants to examine these alternatives and select the most promising strategy. This step is called “Alternatives Analysis”.

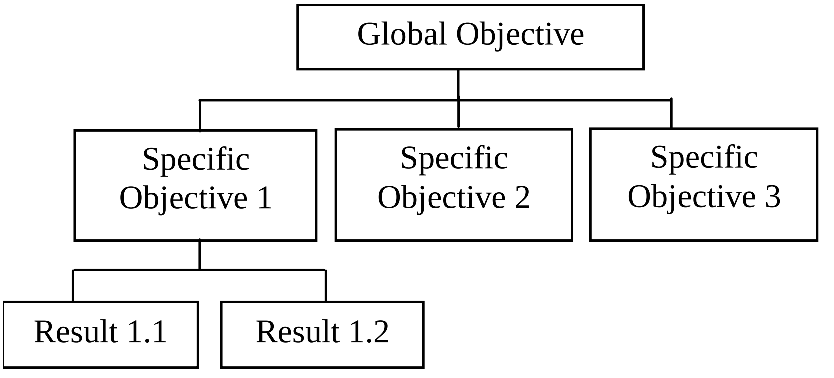

Figure 3. Objective tree of the OOPP method.

After selection of the decision criteria, these are applied in order to select one or more means-end chains to become the set of objectives that will form the project strategy.

After defining the objectives and specifying how they will be measured (Objectively Verifiable Indicators: OVIs) and where and how that information will be found (Means of Verification: MOVs) we get to the detailed planning phase: "Activities Planning". We determine what activities are required to achieve each objective. It is tempting to say; always start at the situation analysis stage, and from there determine who are the stakeholders.

We present some studies of the OOPP method in IS planning that have been presented in various researches:

Researchers, P. Gu et al. [12] have presented an object-oriented approach to the development of a generative process planning system. The system consists of three functional modules: object-oriented product model module, object-oriented manufacturing facility model module, and object-oriented process planner.

Researcher, Peter S. Hill [13] has question the appropriateness of highly structured strategic planning approaches in situations of complexity and change, using the Cambodian-German Health Project as a case study. He has demonstrated the limitations of these planning processes in complex situations of high uncertainty, with little reliable information and a rapidly changing environment.

Researchers, Peffers K. et al. [14] have used information theory to justify the use of a method to help managers better understand what new Information Technology applications and features will be most valued by users and why and apply this method in a case study involving the development of financial service applications for mobile devices.

Researchers, Killich S. et al. [15] have presented the experiences and results of the development and implementation of a software-tool for a SME-network in the German automotive supply chain industry. The tool called TeamUp enables the communication of experts as well as the coordination of discussion groups in order to make use of synergetic potentials.

A system analysis based on the OOPP method was used in order to analysis an automated system [16] and to analysis a supervisory system of thermal power plant [17].

Some works are presented in order to refine the OOPP method into a method of informational analysis by objectives [18] and into a method of representation of the information by objectives [19].

3.2 FMECA Method

The second method presented in this research is Failure mode, effects and criticality analysis (FMECA). In fact, this method is an extension of failure mode and effects analysis (FMEA). FMEA is a bottom-up, inductive analytical method which may be performed at either the functional or piece-part level. FMECA extends FMEA by including a criticality analysis, which is used to chart the probability of failure modes against the severity of their consequences [20]. The result highlights failure modes with relatively high probability and severity of consequences, allowing remedial effort to be directed where it will produce the greatest value.

The FMECA analysis procedure typically consists of the following logical steps [21]:

- Define the system;
- Define ground rules and assumptions in order to help drive the design;
- Construct system block diagrams;
- Identify failure modes (piece part level or functional);
- Analyze failure effects/causes;
- Feed results back into design process;
- Classify the failure effects by severity;
- Perform criticality calculations;
- Rank failure mode criticality;
- Determine critical items;
- Feed results back into design process;
- Identify the means of failure detection, isolation and compensation;
- Perform maintainability analysis;
- Document the analysis, summarize uncorrectable design areas, identify special controls necessary to reduce failure risk;
- Make recommendations;
- Follow up on corrective action implementation / effectiveness.

FMECA may be performed at the functional or piece part level. Functional FMECA considers the effects of failure at the functional block level, such as a power supply or an amplifier. Piece part FMECA considers the effects of individual component failures, such as resistors, transistors, microcircuits, or valves. A piece part FMECA requires far more effort, but is sometimes preferred because it relies more on quantitative data and less an engineering judgment than a functional FMECA [22].

The criticality analysis may be quantitative or qualitative, depending on the availability of supporting part failure data.

Strengths of FMECA include its comprehensiveness, the systematic establishment of relationships between failure causes and effects, and its ability to point out individual failure modes for corrective action in design.

Weaknesses include the extensive labor required, the large number of trivial cases considered, and inability to deal with multiple-failure scenarios or unplanned cross-system effects such as sneak circuits [23].

FMECA is an excellent hazard analysis and risk assessment tool, but it suffers from other limitations. This alternative does not consider combined failures or typically include software and human interaction considerations. It also usually provides an optimistic estimate of reliability. Therefore, FMECA should be used in conjunction with other analytical tools when developing reliability estimates [24].

The FMECA was presented in some woks in order to analysis a medical process or an enterprise in general [25-28].

According to Figure 4, one notes that exist three corrective action types: prevention actions, actions of preventive detection and actions of effect reductions.

4. Analysis Using the Methods OOPP and FMECA

The diagnosis and the analysis of a process system is a complex operation. It first requires knowledge of the global working of the system and then a more and more detailed knowledge of the various components of the system. It is appropriated therefore to use a systemic approach that adjusts to this global gait and permitting to establish ties brings in means and ends on the basis of a previous analysis of problems, objectives and activities. This gait is based on the use of the OOPP method.

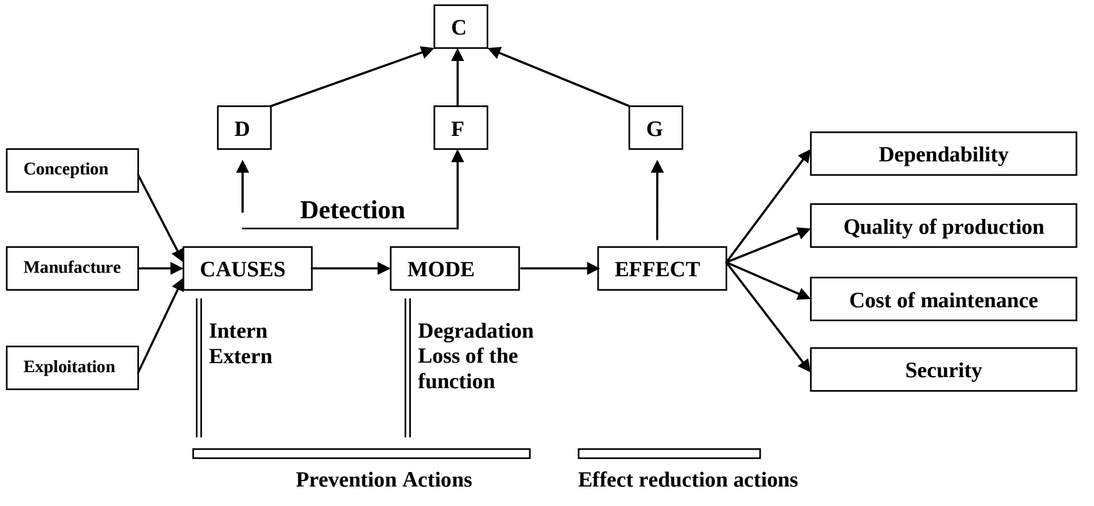

Figure 4. Corrective actions of the FMECA method.

This analysis is not sufficient, it is necessary to complete it by the utilization of a method of risk management. In fact, we propose to adopt the FMECA method which is an excellent hazard analysis and risk assessment tool, but it suffers from other limitations. This alternative does not consider combined failures or typically include software and human interaction.

It also usually provides an optimistic estimate of reliability. Therefore, FMECA should be used in conjunction with other analytical tools when developing reliability estimates.

Consequently, we chose to push our research on these two methods of modeling: OOPP and FMECA in order to propose a new combined modeling approach. The elaborated model was decomposed in three phases in order to assure the effective OOPP and FMECA analysis. These three phases are: OOPP analysis; FMECA analysis and improvement of the process system.

The first phase of the model is to identify the various problems and reverse them in order to determine the objectives using the OOPP method. This phase is an examination of the situation of the process system in order to better understand its operation.

This first phase of the model allows us to give a clear answer to the question “what?”

The result of this phase is a matrix of activities according to the formalism of the OOPP method.

Once the results and the activities have been identified, the next phase of the model is to analyze the failures, their effects and their criticality by the FMECA method. Therefore, we rely on the OOPP analysis to better identify failures and effects.

The result of this second phase is a set of FMECA grids representing the various machines of the process system.

After the analyzing the process system using both OOPP and FMECA methods, it is necessary to implement a strategy of production and maintenance models in order to develop a production plan. Therefore, the third phase is designed to improve the performance of the process system.

This phase allows identifying different possible strategies to achieve an overall goal and to choose the strategy to be adopted by future intervention in which we are interested. In fact, a production strategy is essential in order to better organize the various structures of the enterprise. In addition, the implementation of models of maintenance of the process system and the effectiveness of their operability is an essential operation for the improvement of the process system.

Figure 5 presents a model of combination of the two methods OOPP and FMECA represented by its various stages.

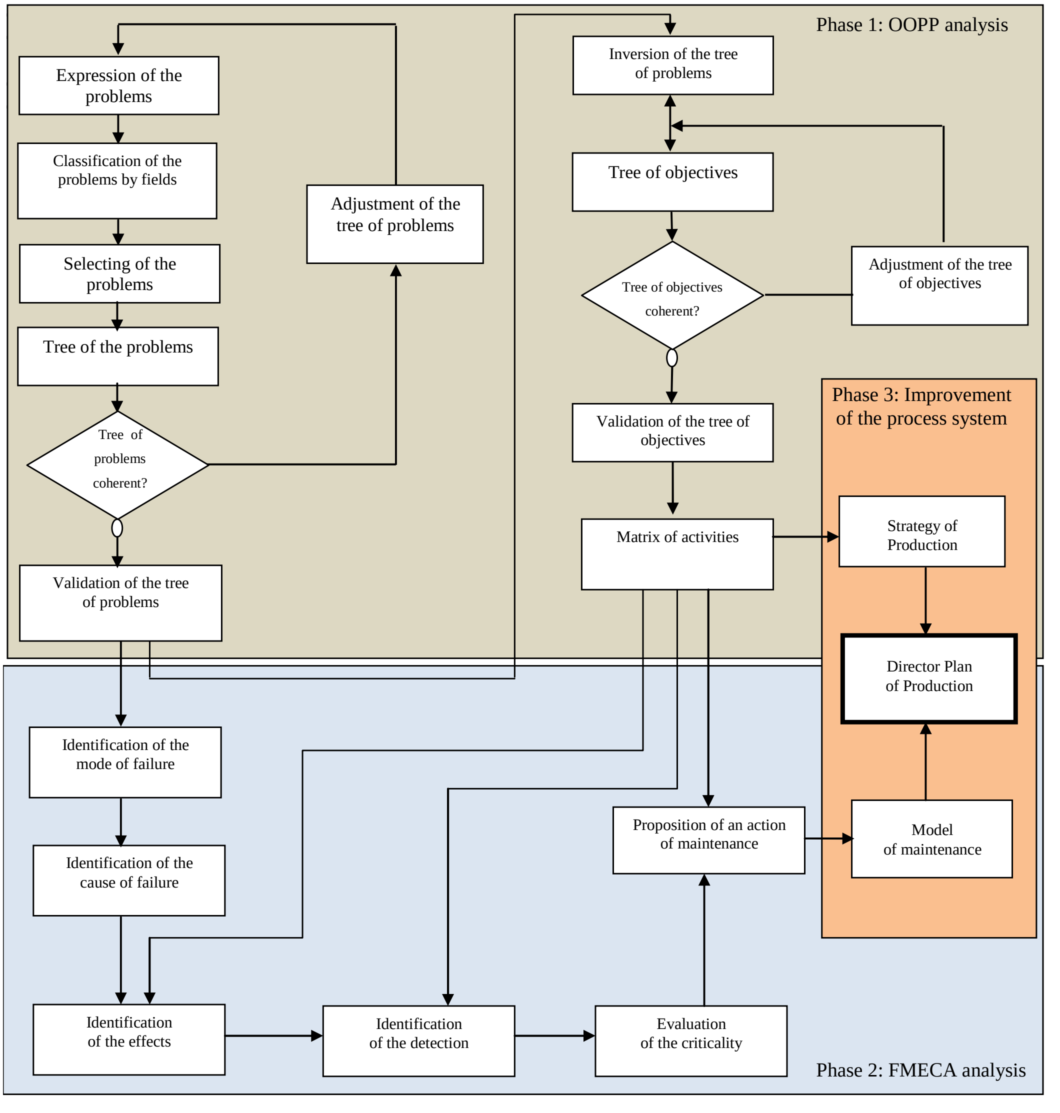

Figure 5. Model for the combination OOPP – FMECA.

5. Conclusion

In this paper, we presented the main methods of system analysis and risk management of process systems. In fact, the analysis and the modeling of process systems is a complex activity and require a structured methodology of development. This is why the proposed gait is based not only on a systemic method for the representation of process systems but also a risk management method in order to improve the process system. Then, it is necessary to adopt a method permitting to manage the risk of a process system. This method is as useful at the time of the re-conception of process systems that it was about a modernization or an optimization.

The elaborated systemic model based on the OOPP method was decomposed in hierarchic and structured manner and was permit to assure the effective communication between all the personnel of the process system.

The analysis of the different fashions of failures modes, their effects and their criticality according to the FMECA method represents a preliminary stage of a project of improvement of the process system.

Finally, it seems important to continue this study in order to make procedures of maintenance of the model proposed and to spread this analysis to all the parts and the facilities of the process system; this will give the evaluation and the improvement more easy and efficient.

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