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Proposition of a conceptual and a methodological modeling framework for resilience engineering

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Abstract. The realization of a resilience based research action project requires the elaboration of different models dedicated to the description of the organization studied, to the ideal functioning whishes, to the logic of evolution that have to be create. The objective of this paper is to present a modeling framework dedicated to the study of social organization and it's application to the resilience engineering context.

1 INTRODUCTION

The property of resilience, in the context of industrial safety, is related to the ability of a system to identify disturbances that can affect it, to know how to detect the occurrence of disturbances and to know how to act in order to minimize the negative consequences of the disturbance (Hollnagel and all, 2005). Defining an efficient research activity dedicated to the improvement of industrial safety based on the idea of resilience require to formalize a couple "Project-Context" related to the design of rich representations of the studying context, models on which we can reason to elaborate and argue propositions for human action (Le Moigne 2002).

The resilience based industrial safety project can be define as a conception process which result can be an artifact or a model of human action which once deploy in a specific context improve it's resilience properties. Such a project can be apply on different types of context such as work situations, organizations or territories.

Action research theory (Hatchuel and Mollet 1986) provides a theoretical framework in order to conduct such a project. Five steps are distinguished: the feeling of discomfort, building a rational myth, intervention and interaction, portraying a set of logic and the change process analysis. The feeling of discomfort step aims to describe the organization studied and to express the problematic. Then a model of an organization describing the desired ideal functioning mode have to be enounce. The third step objective is to interact with the organization in order to elaborate the foundation of the evolving process. Then the process requires the definition of a set of logic of actions authorizing the evolution of the organization from the problematic expressed to the rational myth. The last step consists in observing the real consequence of the deployment of the logic of actions on the organization.

The accomplishment of a resilience based research action improvement project raises both designing and engineering challenges. For each context (work situations, organizations, territories, etc.), a resilient rational myth and a resilience performance measurement scale must be defined so as to formalize the context studied problematic and the resilience improvement logic of actions.

Objectives of this paper is to present a proposition of a conceptual framework which will serve as a foundation for the design of a rational myth and a performance measurement scale in the context of the improvement of resilience in the context of an organization. Firstly, the theoretical foundations of the work are presented, then the conceptual framework is presented. In the second part of the article the framework is use one the one hand for the definition of a resilience organization rational myth and on the other hand for the definition of a resilience performance measurement scale.

2 THEORETICAL FOUNDATIONS

The conceptual framework aims to allow the representation of the structure and the dynamic of an organization in order to structure a resilience based research action project. For this reason, the model proposed is based on conceptual result of organizational and complex theories. This section is dedicated to the presentation of these two contexts.

2.1 Theories of organization

Organizational theories group together a set of theories and methods which aims are to study and understand mechanisms that govern the dynamic of social organization. Their origin are thought about the rationalization of industrial activities led at the beginning of XXe century. First models, issues of the work of Taylor, Fayol or Weber, were dedicated to the definition strict rules for order enabling in organization. Few years later, the human relationship movement, takes in consideration individual and relationship aspects with in particularly, works about impacts of work condition on workers motivation achieved by Mayo or fundamentals needs hierarchy achieved by Maslow. In the year 60 works focus on the structure of organization and more particularly of their interaction with the economical environment studied, among others, by the contingency theory of Woodward and Perrow. At the same time, an action theory emerged on the impetus of Barnard, Simon, Crozier or Friedberg on the idea that organization is the result of the activity of their actors. Recently the notion of culture has been introduce inside organization allowing the distinction between informal and human role against rules and structure.

2.2 Complexity thinking

Complexity thinking or systemic of second order it’s an evolution of the systemic way of modeling, founded on the idea that systemic modeling approaches are inadequate to

describe the complexity of phenomena (Morin 1977). Then, a new paradigm which is an extension of the first order systemic paradigm, constituted of concepts issue of the advanced of scientific area such as biology, cosmology or physics is proposed.

Main conceptual tools of complexity thinking are the concepts of system, organization, interactions, order and disorder and the properties of emergence and constraints and the hologramatic principle.

The idea of system is inherited of the first order systemic and denote the global organized unit of interrelations between elements, actions or individuals. Organization points out the arrangement of relations between components or individuals which produce a complex unit or system, equipped with properties unknown at the level of components or individual. Interactions are reciprocal actions altering the behavior or the nature of elements, phenomena in presence or in influence. Order figures the set of laws, constraints, repetitions or constants that constitute the framework of a system. Disorder points out disturbances (impacts, events, accidents, noises, mistakes, etc.) which appears in a process disrupting and transforming it. The properties of emergence and constraints are related to the principle that "the all is as more and less than the sum of the parts" which express that the creation of an organization father the creation of new properties unknown at the level of the components of the organization but also the disappearance of some properties due to opposition effects. The hologramatic principle enounce that "the all is in the part which is in the all", which express that the behavior of an element depends of it's objectives and of the organization and reciprocally the behavior of the organization depends of it's objective and of the objectives of it's elements.

The complexity thinking modeling conceptual tool will be the framework allowing the integration of organization theories ideas.

3 THE PROTOTYPE OF CONCEPTUAL FRAMEWORK

The framework is constituted of six interconnected systems (social structure, technology, physical structure, culture, organization environment, general environment) with a dynamic founded on the ideas of disturbances and crisis (cf. Figure 1.). This section aims to describes this framework.

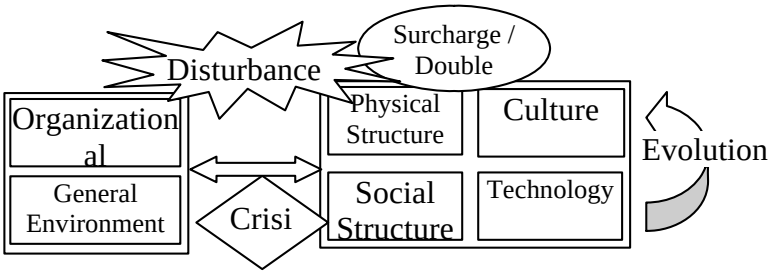

Figure 1. Organization description conceptual framework model

3.1 Structure of the framework

Six interconnected systems compose the framework. Four are dedicated to the description of internal mechanisms of an organization: social structure, technology structure, physical structure and culture. Two are dedicated to the description of it's environment: organizational environment and general environment.

The social structure of an organization is the total sum of mean used for dividing work in distinct tasks and to allow the coordination of their execution. Five components can be distinguished (Mintzberg 89). The operational center points out the actors whose produce means and services or directly allow the production. The strategic top comprise all the managers whose objectives is to make certain that the organization activities fulfil all the objectives off all of it's stakeholders. The hierarchical line figures the link between the operational center and the logistic line. The technostructure involves annalists which take part in the planning and the supervision of the organization activities. The logistic support points out services which directly support the organization.

The technology structure points out means use in the organization in order to achieve a result. It can be an objective, a product or a service. This structure includes physical objects or artifacts used (products, tools, production means, etc.), obtaining process and knowledge necessary for the development and the use of equipment, tools and methods. The notion of organizational culture figures a set of meaning publicly accept and collectively valid for a specific group at a given moment. Organization culture includes believes, hypothesis, values, norms and artifacts that structure decisions and actions in the organization. The physical structure points out relations between the physical elements of the organization. It includes the spatial distribution and the links of the work situations of the organization, the spatial organization of the objects that compose work situations and the architectural style of the different plant of the organization.

The social structure, the technology, the organizational culture ant the physical structure allow the description of the internal elements of an organization, the description of the relation of an organization and it's environment can be done by the mean of the notions of organizational and general environment. The organizational environment figures the entity which are in direct interaction with the organization. Three category of interactions are distinguished: economical environment, institutional environment, territorial

environment. The economical environment points out the relation between the organization and the economical actors which are clients, suppliers, subcontractors, competitors, trades union, banks, etc. The institutional environment figures interactions with actors whose objectives is to control that the activity of the organization respects the legislation. The territorial environment points out entity which are located in the same territory of the organization. It can be natural things (forest, river, sea, etc.) or industrial plants.

The general environment figures the general forces that can have an impact on the organization. Different sector are distinguished: the social sector related to the mechanisms that structure the social behavior (demography, mobility model, style of life, etc.), the cultural sector related to history, culture, traditions, values which structure decisions and actions of the society, the legal sector is dedicated to constitutions and laws which structure territories where the organization act. The political sector points out the degree of repartition and concentration of the power and the nature of the political system in the countries where the organization evolved. The economic sector figures the work, the financial and the good and services markets. The technological sector points out knowledge and information descended from scientific progress. The physical sector includes nature and natural resources (cool, oil, pollution level, climatic conditions, etc.).

This six interconnected systems compose the structure of the framework, in order to build organization change works a model of dynamic of the organization must be defined.

3.2 Dynamic of the framework

The dynamic model of the framework is founded on an approach centered on the concept of crisis take in this Greek etymological meaning of decision (Morin, 1984). It represents the diagnosis moment in the dynamic of an uncertain phenomenon. The utilization of this approach will allow the elaboration of a generic model which will be independent of the nature and the intensity of the perturbation.

The dynamic model start with the occurrence of a disturbance which origin can be endogenous or exogenous of the organization. In the first case, it's events, incidents or accidents issue of the environment of the organization. In the other case, it's a not disruptive process upsetting such as the impossibility of the process to solve problems that it solves on this side of some threshold or a double-binding phenomenon where the system, stuck between two contrary requirements, is paralyze, disrupt, put out of order.

When the disturbance is detected by the organization, the crisis state begins. This state is characterized by a situation of decisions facing the disturbance and it's effect and also in a situation of indecision due to the uncertainty of the occurrence of the disturbance which is invisible in a normal situation. Actions which are result of decisions take by the organization in order to get out the crisis situation may have different types of consequences. The aggravation of disturbances by the mean of positive retroaction loops which maintain, emphasize and amplify them. The rapid mutation of the relation between the different actors, group or classes by the development of different strategies. The multiplication of the conflict and blocking in the group involve in the crisis man-

agement process. The release of research process dedicated to resolve with an innovative solution the crisis situation. The research of responsibilities which father antagonist behavior of looking for on the one side the origin and the consequences of disturbances and on the other hand of the real or imaginary guilty people.

4. APPLICATION OF THE FRAMEWORK FOR RESILIENCE ENGINEERING

The conceptual framework can be used as a foundation for the different steps of a resilience engineering based research action project. In order to achieve such an objective the properties of resilience must be interpret with the concept of the framework in order to build a resilient organization rational myth. This sections aims to present this interpretation and a reflection about the use of this framework as a foundation of resilience properties measurement.

4.1 A resilient organization rational myth

The idea of rational myth is related to the ideal model of the phenomenon studied which is the target of the research action process.

A resilient organization possesses three main mechanisms devoted to anticipation, attention and response behaviors. Anticipation mechanisms aim to acquire knowledge about disturbances that can occur and affect the organization. Attention mechanisms are related to the ability of detecting as fast as possible the weak signal of a disturbance. Response mechanisms objectives are to produce an efficient answers in order to minimize the negative effects of the disturbance (Hollnagel et al, 2006). The rational myth of a resilient organization is founded on a resilient culture sub system and a dynamic process dedicated to the elaboration of this sub system.

The resilient properties organizational culture sub-system is dedicated to the description of disturbances in order to insure the anticipation, attention and response mechanisms. This knowledge is related to the description of the source of the disturbance, of the potential direct and indirect consequences on the organization, of the detection pattern for the attention behavior, of the different strategies for the prevention and the mitigation of disturbances. Due to the dynamic of the organization and of it's environment this subsystem must be connected to a perpetual process of construction. This process is on the one hand an organization reflexive approach and on the other hand an environment observation approach both dedicated to the identification of each disturbance associated of all elements and their interactions.

This knowledge is the core of the disturbance life cycle of a resilient organization. In this life cycle the distance between the occurrence of the disturbance and it's detection by the organization is nearby zero because of the attention process which perpetually try to detect the presence of weak signals of a disturbance of the resilient culture subsystem. In the crisis step the decision are founded on the prevention and mitigation in-

formation associated to the disturbance detected. Once the consequences of the disturbances solves, the disturbance database is update with new information about the cause and the consequences of the disturbance and the efficiency of the management rules associated.

This rational myth is the foundation of the target of research action processes, the conduct of such an approach requires a performance model authorizing the measurement between the actual state of an organization and the rational myth.

4.2 A resilience performance measurement approach

The resilience performance measurement model objectives is to allow the evaluation of the resilient properties at one moment and the deduction of logic of actions dedicated to the improvement of the resilient capabilities of the organization.

The improvement of resilient capabilities of an organization is related on the one hand to the efficiency of the resilient behavior (anticipation, attention, response) and on the other hand to the complexity of the representation of the resilient culture. The strategy of the measurement of the performance of resilience proposed is founded on the idea of level of complexity of the model of culture which structure decisions and actions of the different mechanisms of resilience.

The different levels of complexity are deduced from the organizational model presented in the precedent sections. A level is associated to each subsystem, two other levels are associated to the interactions between the four internal subsystems of the organization and to the interactions between the two environment subsystems.

The first performance measurement framework is related to the evaluation of the efficiency of the culture of resilience. The performance evolution process consist in identifying, for each level of complexity, if disturbances relatives to the system connected to the level are known and sufficiently describe for the functioning of the resilience behaviors.

The second performance measurement framework is related to the evaluation of the efficiency of the three resilient behavior. The evaluation of the anticipation behavior performance consist in observing, for each level of complexity, if the system associated to the level of complexity is regularly observe in order to enhancing the resilient culture associated to the system. The evaluation of the attention behavior performance consist in checking, for each level of complexity, if a watch process is present and efficient on system associated to the level. The evaluation of the response behavior performance consist in an experience return process relative to each disturbances which objective is to check if decisions and actions of the crisis state produce positive results and to update the resilient culture system.

5. CONCLUSION

The improvement of industrial safety by the mean of a resilience founded action research requires a modeling framework dedicated to the different modeling and engineering actions related to the description of the problematic, enounce a rational myth, deduce and execute logic of actions and observe the result on the dynamic of the organization.

The objective of this paper was to present a modeling framework founded on theory of organization and the dynamic of crisis. This framework was used to present a first prototype of rational myth of resilient organization and a first approach of resilience performance evaluation approach.

Those model must be improve by on the one hand a more detailed analysis of the link between each level of complexity and each resilient behaviors and on the other hand their confrontation with concrete examples.

6. BIBLIOGRAPHY

Hatchuel. A. & Mollet. H. (1986). Rational modelling in understanding and aiding human decision-making : About two case studies. *European Journal of Operational Research 2) 178-186 North-Holland.*

Hollnagel E. & Woods D-D. (2005). Epilogue: Resilience Engineering Precepts. In E. Hollnagel, D.D. Woods and N. Leveson, (eds). *Resilience Engineering. Concepts and Precepts.* Aldershot, UK: Ashgate.

Le Moigne J-L. (2002). Légitimer les connaissances interdisciplinaires dans nos cultures, nos enseignements et nos pratiques. In Kourilsky Francois (Ed), *Ingénierie de l'interdisciplinarité, un nouvel esprit scientifique.*

Mintzberg H. (1989). *Le management, voyage au centre des organisations.* Editions d'Organisation.

Morin E. (1977). *La nature de la nature, La méthode Tome 1.* Edition du Seuil.

Morin E. (1984). *Sociologie.* Edition Points Essai.