Decision-Making in a Context of Uncertainty

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Abstract The decision process is considered as the key element for the smooth behavior of systems. For non-complex or linear systems, this process usually follows clear rules or requirements, so that the decision will be easy to make without any difficulty. In the case of complex (non-linear) systems, the decision-making process is repeatedly challenged problems because of the interactions of several factors at the same time and because of the hazards characterizing these factors. This situation will worsen further if the system goes out of its normal operating range to fall into uncertainty. In this paper, we will try to make our contribution, to arrive at simplifying the decision-making process, while playing on human factors (ability, anticipation, risk-taking, etc.). As this process can be improved by the development of intelligent decision support tools.

Keywords Decision process · Complex systems · Intelligent decision support tools · Rules and prescriptions · Decision making

1 Introduction

The decision-making process is the cornerstone in the operation of any system. This process can be very simple for linear systems that obey an uncomplicated logic, where the effects of a crisis can be elucidated in the manner of falling dominoes [1]. In complex systems, this process could become more complicated, especially when the system goes out of its normal operating range and into a state of uncertainty or even a crisis whose consequences can not be predicted or controlled. Currently, the majority of the systems dominating the domains of the daily life, are complex systems, characterized by the interaction of several factors, the distribution of the information on several decision centers, which makes the coordination of the actions and the decision making difficult [2]. In this communication, we will offer some

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suggestions, to simplify the decision process. This can be done by improving both aspects: human and technical. As far as the human side is concerned, the operators must be chosen according to criteria corresponding to the job profile, namely: the capacity for synthesis and analysis, good reasoning, intuition capacity, anticipatory capacity, recovery capacity, etc. From a technical point of view, systems must use experience feedback to improve their performance by correcting defects encountered during operation. As they must be designed in a way that allows for multiple decision alternatives. The systems must be error tolerant and allow the recovery of anomalies (feedback loops).

(1) **Complex systems**:

Complex systems currently represent a large part of the vital installations of our daily life: industrial processes, transport networks, urban management, etc. Unlike linear systems where the evolution of events, obeys a logical and simple sequence, complex systems consist of several interacting subsystems, forming an often complex architecture. This makes their evolution unpredictable and does not follow a classical linear relationship cause-effect, but it is circular characterized by feedbacks of collective behaviors and emergent (macroscopic) properties on the behavior of (microscopic) elements (Fig. 1). These systems are characterized by dynamic environments, in opposition to the static environments that characterize linear systems, the physical or structural properties of these dynamic environments, are likely to change with or without human intervention [3]. The components of these systems will collectively modify their environment, which in turn will force them to modify their states or possible behaviors. In a complex system, knowing the properties and behavior of isolated elements is not enough to predict the overall behavior of the system [4]. Despite the degree of their organization, these systems are still vulnerable

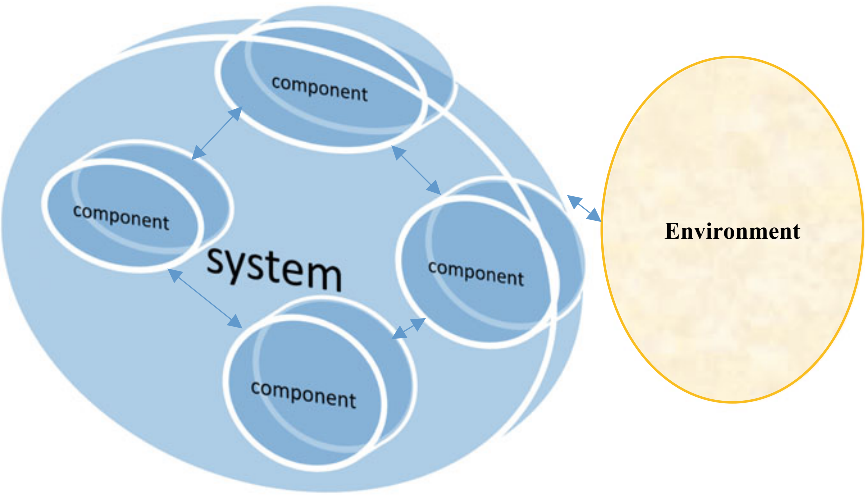

Fig. 1 Complex system

to the hazards, constraints and challenges imposed by the environment. In complex systems, the operation is always governed by formal requirements defined by the designers, leaving only small margins for the initiatives of human operators. But, when the system goes out of its normal operating range to switch into abnormal situations that can evolve into uncertain situations, the problem of decision making is acute. Faced with these uncertainties, maintaining the stability, performance and availability of the system in a changing and unstable environment is a challenge that forces the proponents of these systems to constantly reconfigure their means and methods of work, to adapt to changing situations. This constant reconfiguration of resources will require a great deal of dynamic capacity to adapt with these uncertain environments [5].

(2) **uncertainty in complex systems**:

Generally, the uncertainty is due to the presence of certain hazards that disrupt the functioning of the systems, to which is added the complexity of the architecture of these systems combined with the disturbances of the environment. This uncertainty will worsen further with the unpredictable behavior of human operators [6]. Uncertainty can be exacerbated by pressures on the system as a result of requirements from different parties: regulatory requirements, safety requirements, user requirements, etc. [7]. Lack of resources could also affect some system functions, such as maintenance, renovations and upgrades, which complicates its operation (outages, disruptions, incidents, etc.) [8]. The poor control of the techniques by the human operators will have a negative impact on the functioning of the system by errors which can evolve towards uncertain or even catastrophic situations [9]. The traffic and information processing component, if not adequately addressed, can complicate communication between different stakeholders in the various spheres of the system and create confusion during unpredictable events. Rigidity in the requirements for operators to perform certain tasks requiring decision-making, will further affect their freedom of action, which drives the system into uncertainty [10]. Finally, the technical means such as: man-machine interfaces, communication media, decision-support software, if they are not adapted with the technological evolutions, can compromise the functioning of the system and make the realization very delicate tasks. This can lead operators to misinterpretations that sometimes lead to uncertainty [11].

(3) **improvement of the decision in the contexts of uncertainty**:

To create better enabling conditions that help decision-makers in an optimal and efficient way, we need to act on several factors: human, technical, organizational, and so on.

(3.1) **On the human level**:

Human operators who will be assigned to positions requiring a level of decision-making responsibility, must be selected according to profiles compatible with the required qualifications (ability to analyze and summarize, ability to intuit and deduce, ability anticipation, recovery capacity, etc.) [12], evoked the controlled attention skills in complex cognitive tasks, through which the operator tries to resist interference from the instantaneous surge of a large amount of information, by blocking access to unnecessary or irrelevant information. In addition, these operators must undergo periodic training focused on intervention in uncertain situations and must practice simulation exercises to test their ability to respond to unpredictable situations [13]. Operators must train on co-operation and mutual co-ordination and avoid hasty and risky behavior. To successfully coordinate actions in order to arrive at a timely decision, good communication between interveners on the one hand and between them and the hierarchy is necessary.

(3.2) **At the technical level**:

The decision process could be improved by the design of:

- Error-tolerant systems with multiple choices for intervention;
- Systems characterized by flexibility in procedures and allowing freedom of action for interveners;
- Systems with feedback loops to recover errors and anomalies;
- Systems with interfaces facilitating communication with the human operator.

Finally, we must point out the importance of modeling and simulation techniques in the calculation and verification of many low cost assumptions, compared to the actual development of equipment. Thus, many security defects are identified and corrected as early as this design phase [14].

(3.3) **use feedback to improve decision support systems**:

Feedback can be used from situations of incidents or accidents experienced in the past and creating situations of uncertainty. Information about these situations must be stored in a database. After processing this information selectively, it will be possible to configure devices offering several actions to facilitate decision-making [15]. These actions may concern the aspects inherent to the correction of certain system design defects (corrective actions), or may concern the development and implementation of intelligent tools in the form of decision support software (Fig. 2).

2 Conclusion

In conclusion, it can be said that the decision-making process in uncertain situations, especially when dealing with complex systems, requires the consideration of several factors. The human factor is the cornerstone of this process because human is the main actor in the design, operation and maintenance of the systems. Thus human operators must be selected according to criteria compatible with the functions to be assumed. Continuous training and simulation exercises are needed to test the capabilities of the responders to the disturbances that can evolve to uncertain situations. On the technical side, several solutions can be proposed, in the form of flexible decision support devices and allowing the recovery of errors due to bad decisions. Improved interfaces

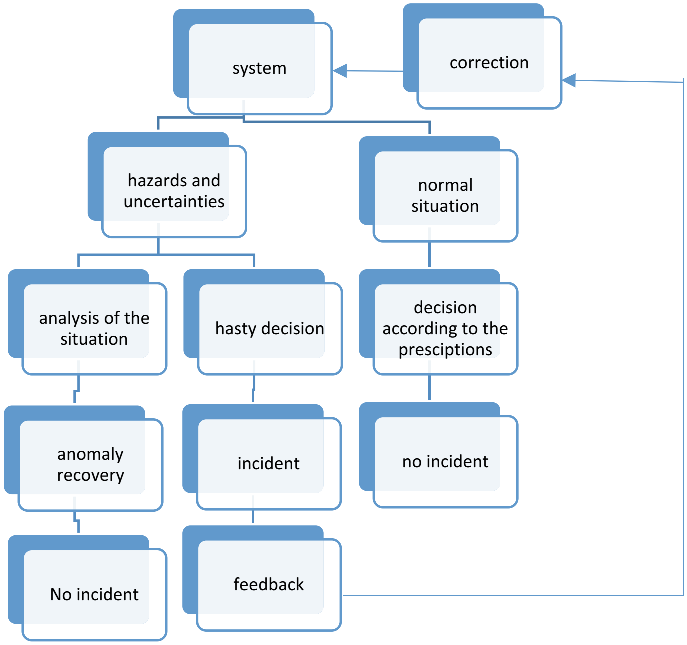

Fig. 2 Decision process

and modes of communication can facilitate a good interpretation of information which facilitates the decision process.

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