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**Modelling of fire managers' decision making method**

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# ADVANCES IN FOREST FIRE RESEARCH

DOMINGOS XAVIER VIEGAS

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# Modelling of fire managers' decision making method

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## Abstract

During fighting against forest fires the situation can change quickly, thus, managers must also be ready to change the strategy and tactic. Firefighting managers have a typical profession, during which – depending on the time – making both analytical and naturalistic decision. Trainings usually focus on traditional – analytical based – decision making, which takes time, however, in many cases there is not enough time to do that. Therefore managers make many times recognition-primed decisions as a symbol of naturalistic decision-making. The first part of this article gives a thorough review of the topic. The second shows a simple and a complex model, created by the author. Method: the author used different tools and methods to achieve his goals; one of them was the study of the relevant literature, the other one was his own experience as a firefighting manager. Other results come from two surveys that are referred to; one of them was an essay analysis, the second one was a word association test, specially created for this research. Results and discussion: the author created a simple and a complex model for firefighting managers making decisions, taking into account time pressure, the limited capability of processing information and also a mechanism complementing the recognition-primed decision.

**Keywords:** *decision making, fire managers, recognition primed decision, model for making decisions in emergencies*

## 1. Introduction

The background of recognition of a special decision-making mechanism in the focus of this paper was given that, in some cases, no sufficient time is available, necessary for classic decision-making. Therefore, strategists sought to design and plan the details of military operations in advance, just as today, however, their proper implementation, the application of different decision support instruments in live situations, designed for optimal decisions, failed many times in spite of these. Decisions made in reality, e.g. fighting against forest fire are often not harmonized, could not be harmonized, considering the circumstances, with the pre-formulated strategies, mostly because there was not enough time needed to achieve them.

In the paper, author illustrates the limits of the possibilities of analytical decision-making, presents the general operating mechanism of recognition-primed decision-making, elaborates on its special model relevant to firefighting managers, as well as explores and systemizes the factors that facilitate (catalyze) the processes.

## 2. Characteristic circumstances of emergency interventions

An important element of the activities of emergency responders is that they cannot or only to a very limited extent can modify the terms of the task, improve them as desired. Despite the differences of environment, indications of the *complexity* of the situation, the possibility of the *radical change* in the given situation, *uncertainty* and *ambiguity* of the information available can be recognized and well identified. During fighting against forest fire the weather condition can change radically – for this, a typical example is the change of wind direction –, the accessible resources, because of the intensive plum convection can be new hot spots also behind the existing fire fronts, firefighters can be injured seriously or can fallen in trap requiring help immediately.

The peculiarities of each specialized branch can be illustrated through the examples of several authors: Klein dealt with the analysis of the decision circumstances of the military also using the examples of firefighters (Klein, 1989), Killion took examples from the navy (Killion, 2000), Bruce shows his own medical case (Bruce, 2011), Johansen simplifies difficult circumstances (Johansen, 2007).

Most of above factors are present; occasionally all of them may be present at a certain level of emergency decisions: including the strategic, operational and tactical levels, but certainly with a different focus or at different times. On strategic and operational level, in general, not only more time is available, but also human and technical resources are at hand more broadly, and decision support instruments as well to reduce uncertainties occurring.

The extinction of fire in a smaller grass land requires the implementation of a completely different, simpler scope of tasks than to control forest fire in an extra dry weather period and high articulated area. The different scopes of tasks exist in different environments and structures, so the solution of similar basic problem also exists in other dimensions. Based on author's own experience, the more extensive case we are dealing with in time, space and from the aspect of involvement in the incident, the more the above factors cumulatively prevail, but because of the protracted implementation, it is, however, easier to solve them.

The most limiting factor from the above is *time*, proven also in author's own studies. This provides a framework impossible to burst and a forced drift, a *pressurized channel* for the decision-maker, entangled in which one can no longer break free.

### 3. General model of recognition-primed decisions

The above proves that, in certain situations, the multi-criteria, analyzing, evaluating decision-making simply cannot be used or in a limited manner. However, it can be seen that managers, directors or commanders are many times in situations that they simply *cannot elude from their decisions*; they should make them in a short time. The functional background of decisions made in a short time, their mechanism different from the conventional was first studied in depth by Klein, who gave the name *recognition-primed decision* to this special decision procedure (Klein, 1989).

Author refers, at the general model of recognition-primed decisions, mostly to Klein's work (Klein, 1989; Klein, 1999), which is analyzed by Cohen with others from the direction of critical thinking (Cohen *et al.*, 1996). Killion supplements and combines with his multi-aspect decision-making model, (Killion, 2000). Based on Klein's work, the essence of recognition-primed decisions is that the decision-maker, through his previous experience, has several different solution schemes in his mind, which he is capable of recalling in a new situation from memory. The decision-maker immediately applies the first pattern that matches the typical features of the given problem of, that is to say, makes decisions fast as a result of previous experience.

Supplementing the general model with the assessment of action versions, we receive the model of *analysis of possibilities* (Killion, 2000). In this case, if the action version is not satisfactory, a new action version will be modified or assessed. If the decision-maker has a significantly longer time to assess his concepts, naturally within the framework offered by a recognition-primed decision, there is the possibility to assess on the level of critical analysis (Cohen *et al.* 1996), or according to options characterizing analogical thinking (Killion, 2000).

Recognition-primed decisions do not exclude the possibility to amalgamate conventional, analyzing decision-making (Killion, 2000; Radnóti & Faragó, 2005). At complex tasks, where a given situation is examined from several aspects – and choose from the options with analogical thinking – recognition-primed decision-making can be automatically applied by experienced decision-makers while solving some partial tasks to reduce the time of the decision process.

The above issues harmonize with the observation that decision-makers simplify complex problems, i.e. create partial problems, until the elements broken down become manageable and resolvable (Simon, 1960; Paprika-Zoltay, 2002). By enlarging its interpretation range, of course, we can reach

the point where the decision-maker may say the problem does not exist until he sees its solution (Duggan, 2002), or the problem does not exist at all if it does not have a solution (Ribárszki, 1999). Many times we can see that forest fire managers come face to face with fire and without any time of thinking they are able to give instructions immediately. We say, routine works but it means they use schemes rather than making ad-hoc decision.

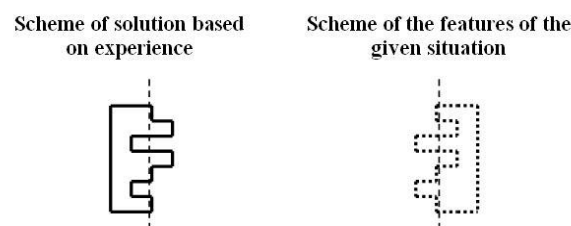
It springs forth from the above that the relative position of multi-aspect decision-making and recognition-primed decision-making is not constant. Recognition-primed decision can be the partial process and decision unit of analogical thinking. In this case, the main decision-making mechanism is analogical thinking; recognition-primed decision is the additional element.

#### 4. Decision-making mechanism of a firefighting manager

Limited time frame allows the elaboration and management of limited amount of information. We know from Miller's researches that the *short-term memory* of the vast majority of people can only process simultaneously  $7 \pm 2$  units of information (Miller, 1956). This information, of course, can be quite different, e.g. a characteristics of fire, the capacity of the response unit, a number, or even the absence of information searched. Our memory handles the combinations, "operations" between the information units as information units (Ribárszki, 1999), from which clearly springs forth that the capacity of the short-term memory of a firefighting manager is exhausted very quickly.

Author has proven by essay analysis how complex the tasks of emergency responders are (Restas, 2013); this shows that in several cases, simultaneously, there is or would be a need to process many more units of information than the capacity of our short-term memory would allow. *The maintenance of our decision-making capability, i.e. our short-term memory, based on the above, clearly requires that we should omit analyzing and evaluating decision-making processes protracted and use the recognition-primed decision-making procedure, based on previous experience.*

Author wishes to create a model element to demonstrate the decision-making mechanism of firefighting managers, which takes into account the limits of the simultaneous processing of information, that is, it also illustrates *Miller's decision-making capacity*. Since the information units may be qualitatively independent of each other, author choses the simplest *graphical representation of the unit-based discrete difference* to separate them from each other. A model element must be such, which can graphically demonstrate the schemes based on earlier experience, the characteristics of different fires, and the interlocking of the former as the application of the scheme, which represents the technically correct solution of the task, i.e. effective decision. The model refers, at the general model of recognition-primed decisions, mostly to Klein's work (Klein, 1989; Klein, 1999).



*Figure 1. Graphic representation of the empiric scheme of recognition-primed decisions matching a given situation*

The schemes in figure 1 represent 7 graphical discrete values each, which are marked by positive or negative protrusions and their "center line"; these values indicate the amount of simultaneous decision-making capacity. Thus, the "negatives" of the schemes can be matched as a given situation and the solution necessary therefor. As an integration of above processes, decision mechanism functions as

follows: an experienced firefighter has performed the elimination of a large number of and forest fires. Despite the fact that as far as the parameters each forest fire is different from another, some characterizing features can be well conceived (figure 2).

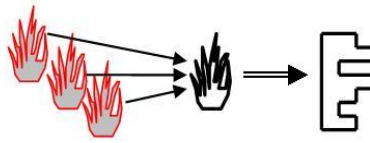


Figure 2. Evolvement of the scheme on forest fire

The characterizing features of identical types of fires are crystallized by experience, and are fixed in our *long-term memory*. Similarly, to the characteristics of a forest fire, the characteristics of successful extinguishing, the facilitating decisions are also fixed (figure 3); just as the mistakes desired to be avoided and the unsuccessful procedures and failures. Experience gained through many years, based on the features of forest fires, formulate the system of schemes, behind which we can find actions (decisions) efficiently applicable to eliminate them.

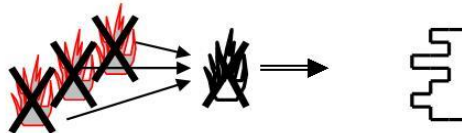


Figure 3. Evolvement of the scheme on the lessons learnt from extinguishing a forest fire

If another incident has almost the same circumstances as one already many times successfully eliminated by a firefighting manager previously (model of positive confirmation), he will attempt to use the same ones in the procedures. Therefore, another fire, quasi bearing the typified properties of previous similar fires, a decision-maker involuntarily immediately recalls the typified decisions in his conscience. The properties of a fire and of previous successful extinguishing operations, based on the above, are closely interlinked; they are each other's "reflections" (figure 4). Author proved with the results of association studies that the above, i.e. the characteristics of a fire and the thoughts directed towards its extinguishing, the schemes of response, in the case of firefighters, are very closely connected in a complex way (Restas, 2013).

When a firefighting manager identifies a fire, he imagines what would happen if he applies the usual tactics to fight it. If the scheme of solution matches, he accepts it, if not, he rejects it and thinks of the next most typical action. Thus, it is a recognition-primed, model-matching process, which can be followed by a quick and almost automatic decision. The above process is naturally not limited only to forest fire managers; it can be used more broadly to firefighting managers.

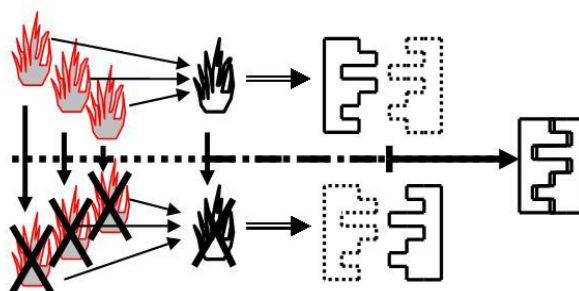
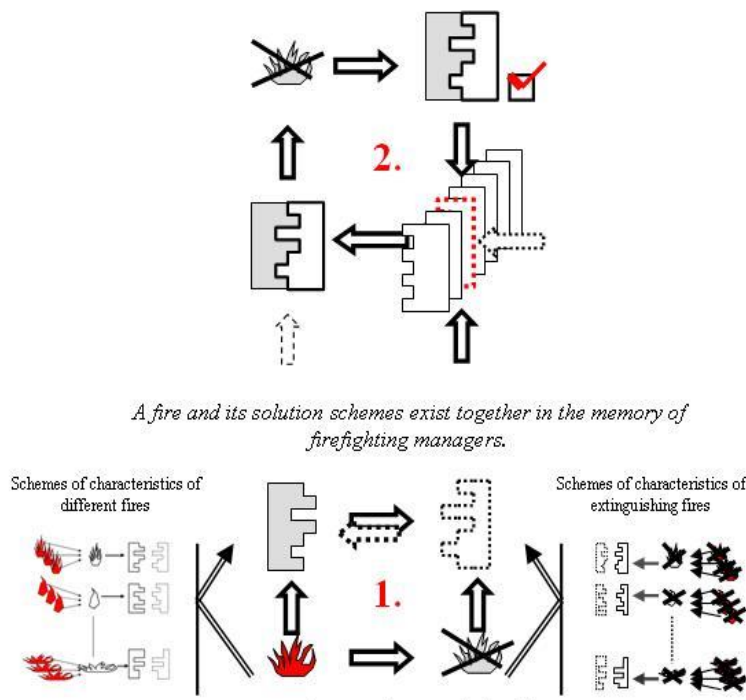


Figure 4. Aggregated scheme on fire and the evolvement of the lessons learnt from extinguishing it

The amalgamation of previous schemes into a given incident is shown in figure 5. The long-term memory of a firefighting manager, through practical experience, has the schemes of both different fires and their extinguishing characteristics. During another alert, information available and collected on a fire automatically generates the recollection of the scheme necessary to solve it, based on which a firefighting manager defines the firefighting tactics necessary. However, the results of association studies clearly point in the direction that at a given fire (problem) managers do not focus on the fire as a problem but rather on its immediate solution (Restas, 2014). From this, author makes the conclusion that a decision-maker will not follow the change of the characteristics of a fire, but the validity of solution scheme, that is, the dynamics of the implementation of the extinguishing process. This does not mean a contradiction with the previous, but rather a difference in views, the shift of emphasis of the focus of attention.

*Recollection and matching of solutions (fighting tactics) according to the type of fire, and confirmation in case of successful extinction*



**Figure 5. Decision-making mechanism of a firefighting manager**

The difference in views, that is, the shift of emphasis means that a firefighting manager does not focus on the change of characteristics of a fire, but rather on the expected evolvement and dynamics of the scheme selected, i.e. extinguishing tactics. Based on the previous, these are, of course, inseparable from each other; however, author finds the dominance of the interventions trend in the results of association studies in the case of firefighters so strong that, based on it, author judges his above conclusion to be justified.

The above do not contradict Klein's model, they rather complement it. Klein, in his model, evaluates (imagines what will happen) the results of matching schemes by the decision-maker prior to performing action version, which, based on author's own experience, is so without doubt, however the aftermath of the decision, in author's opinion, is much more significant in case of firefighting managers. Since the problem immediately and automatically generates both the direction of the solution and start of the action version, rather the process itself is important in terms of efficiency, which is caused by the decision. The schemes based on experience certainly contain the information on the dynamics of the process of fire, so if it meets the expectations, we do not have to modify the original firefighting tactics. However, if the dynamics of the process does not suit the expected, the

change is inevitable in the performance of efficiency. Based on the above, the recognition-primed decision is not just an individual act before extinguishing the fire, but it is also the continuous accompaniment as needed. By doing this, author shares the view that the experienced decision-maker perceives the problem together with its solution, furthermore, author extends the continuous co-existence of the problem and of the whole process of solution of an emergency (firefighting and technical rescue).

## 5. Mechanisms complementing a recognition-primed decision

### 5.1. Triggers

Different triggers, internal resources ensure the operation of recognition-primed decisions. Klein, in his work, assumes 5 markedly distinct abilities, these are *intuition*, *imagination*, *perception of the invisible*, the *ability to formulate*, *metaphors* and *analogies* (Klein, 1999). In the joint work of Cohen, Freeman and Thomson (Cohen *et al.*, 1996), draws the attention to the importance and benefits of critical thinking as criticism of actions planned by ourselves.

Despite the fact that one could assume, based on the previous issues, that recognition-primed decision-making enjoys exclusivity on a tactical level, it is absolutely not true. We can compare it with several fires or incidents, still, one of the essential features is that it protracts in time. It allows the decision-maker to think through the situation, collect information, develop action versions and consider. Not just forest fires but peat fires, or in many cases, fires of storage facilities or other hall-type buildings, burning for several hours or days and covering a large area are categorized specifically into the above types. During protracted decision-making, the recognition-primed processes, based on author's experience, proved to be irreplaceable assistance rather in solving partial tasks.

### 5.2. Analytical thinking

Killion sees the combination of recognition-primed decision-making with the analyzing and evaluating procedure in two ways (Killion, 2000). In both cases, the conditions are that adequate time should be available for analyzing the options. In the first case, prior to recognition-primed decisions, focusing on the given circumstances, we set up options and analyze them. In the second case, a more detailed analysis of the action version of our recognition-primed decision may take place. In the latter case, the spectrum of the task is obviously significantly narrower than in the first case. The two mechanisms, depending on the situation, can be harmonized or one of them may become predominant.

The observation of the elemental parts of multi-aspect decision-making shows that decision-makers divide complex problems to smaller and smaller partial problems until they become such a basic level problem that a decision-maker is able to solve even with little effort (Simon, 1960). This latter process can also be a recognition-primed decision-making, but logically we can find Duggan's view (2002), previously referred, at the end of thought list, according to which successful decision-makers not perceive a problem until they can solve it.

### 5.3. Critical thinking on tactical level

Cohen, Freeman and Wolf studied the possible decision support role of critical thinking on a tactical decision-making level (Cohen *et al.*, 1996). In their work, active naval officers and case reports were studied based on which they state that experienced emergency decision-makers, in new situations, using their previous experience, make decisions with help of recognition-primed mechanisms.

Cohen's model explains in detail the critical analytical strategies that contribute to the operation of recognition-primed thinking. Systematic situation models often based on informal narratives as schemes organize our information in cause and effect relationship in individual cases and underpin the development of recognition-primed thinking.

One of the most important elements of Cohen's model is the quick test. A quick test is a higher-level control mechanism for critical analysis and its accuracy. Its recognition strategies are formed, similarly



to other decision-making processes, by the success or failure experience of past events. The complex recognition mechanism comes to the fore when the demand on time and resources for critical analysis is outweighed. It is possible in three well-definable cases (Cohen *et al.*, 1996). *A quick test considers the conditions in the light of the above factors, and if they appropriate, prevents recognition-primed decision, and focuses on critical thinking. When circumstances are not adequate, a quick test will allow for an instant reply.* (Cohen, 1996).

#### 5.4. Satisfactory procedure mechanism

We have seen previously that a firefighting manager's time, just as the time of other decision-makers in an emergency to make a decision is limited. Since this time limit precludes the possibility to carry out the necessary analyses of the classic model, objectively the choice of an optimum option is not achievable for a decision-maker<sup>1</sup>. In response to the difficulties of the collection of information and the reduction of the costs in relation, a decision-maker does not strive for optimum results, but, depending on the circumstances, settles for satisfactory solutions.

The above process, unlike analytical thinking, is enforced by several factors. Some of these factors are the impossibility of obtaining all information necessary to select the best solution, or the shortage of time; the latter induces a compulsion of decision-making. The limited nature of the processing information available is also of significant influence. Filtering of information and by this the selection of response to the tasks is necessary because the capacity of our short-term memory is quite limited. According to Miller's studies, it allows the parallel processing of only  $7 \pm 2$  bits of information at one time (Miller, 1956). If a firefighting manager made all the basic decisions, his decision-making capacity would be immediately exhausted at a complex firefighting task.

Despite the small capacity, thanks to recognition-primed mechanisms, correct decision is made in most cases (acceptable, given the effectiveness of firefighting). A firefighting manager, using his experience, in situations not requiring decisions different from the previous solutions, implement automatic measures, protocol procedures, thus continuously maintains his decision-making capacity. In this case, using his own experience, a firefighting manager is not interested in by which series of best elementary decisions he can eliminate fires, but only in satisfying the conditions of professional firefighting through the decisions made as a whole.

#### 5.5. Decisions by exceptions

The aim of the application of the method is that the leadership responsibilities of managers should be drastically reducible; its essence is that we should only intervene into processes having permanent characteristics in majority, if they cross the pre-specified lower and upper limits. The method developed later (management by sensitive exception), so derived from the dynamics of the processes, the necessary interventions are now possible even before crossing the borders (Hoványi, 2002). The method of management (decision) by exceptions, based on author's experience, is the greatest help for a firefighting manager to continuously maintain his decision capacity. It can appear in different ways, like protocol procedures, individual way of speaking, silence approval, peripheral vision, information-processing in zones.

The experience and competence of the persons performing a given activity allows that every firefighter make his basic decisions in his own field of work. This shows the arrangement in zones of information processing (figure 6). Of course, not every incident or moment requires response. This zone does not require action that is practically ignored by a firefighter, because it is a natural consequence of extinguishing. A significant part of problems outside the zone, as a result of a firefighter's decision in

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<sup>1</sup> Except the single case when the random choice exactly coincides with the decision made with the method of analysis. Its magnitude can be identified through statistical methods.

that location, is solved by intervention (firefighting), this information now reaches the firefighting manager, but he usually does not require a decision yet. A firefighting manager manages the problems outside this zone that exceed the decision-making competence of subordinate firefighters. This originates in the fact that, on the one hand, based on the information from reconnaissance and radio traffic, he can create a comprehensive and dynamic picture of the entire process, the evolvement of fire or the efficiency of extinguishing, on the other hand, legislation entitles firefighting managers to take actions.

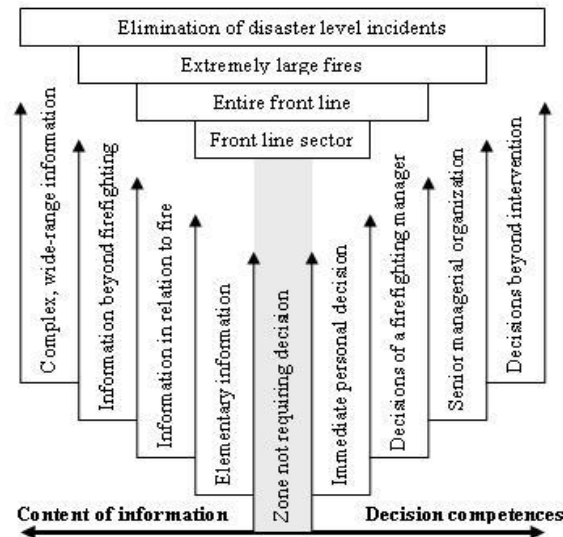


Figure 6. Decisions based on exceptions

### 5.6. Creativity

Creativity has many definitions. Munteanu, in one of his works, presents 35, which approach creativity in different ways, however, there is no single definition generally accepted or used, either (Munteanu, 1994). Analyses researching creativity show that there are three general directions of study (Csíkszentmihályi, 1996; Paprika-Zoltay, 2002). The first concerns the *nature* of creative thinking, the second one the *development* of creativity and the third one the *characterizing properties* of creative people. Amongst the properties, there is practically none, which would not be advantageous for efficient work in a VUCA environment describing the working conditions of a firefighting manager. Based on the above, author made the conclusion that the creative capabilities of a firefighting manager can be explicitly beneficial for facilitating the technically correct decisions relating to firefighting and technical rescue tasks.

Creativity can significantly increase professional efficiency of decisions made by firefighting managers in unexpected situations. This can be seen when firefighters are able to turn local conditions, in a moment, exploitable advantages. However, author found that a significant part of properties characterizing innovativeness do not prefer everyday work, free of interventions, in structured organizations, in respect of firefighting managers. This is confirmed by research findings as well, according to which it is explicitly problematic to follow strict rules for people producing creative results (The Reader's Digest Association Ltd., 1992). Maybe this is why it is a typical example that chief fire officers can safely trust the professional firmness of subordinates at incidents, in everyday life, even though the working relationships of managers and subordinates are burdened with tension.

### 5.7. Heuristics

*Heuristics* means that certain distortions are not incidental and unarranged errors, but the results of simplifying mechanisms, with which decision-makers make the complicated tasks manageable for

themselves, which cut the Gordian knot (Paprika-Zoltay, 2002). Based on researches related to the names Tversky and Kahneman, we distinguish 5 basic groups of heuristics (Tversky & Kahneman, 1974). These are representativeness, availability, fixing (imprint) and adjustment heuristics, retrospective distortion, as well as overconfidence and calibration. Studying the activities of firefighting managers, there are many examples of practical heuristics.

Overconfidence, based on author's judgment, is one of the greatest risk factors to the efficiency of decisions of a firefighting manager. A firefighting manager, quite often, stops searching for the necessary information earlier than sufficient, based on his experience, he trusts his own judgment, many times, assuming unnecessary risks. The extent of rational risk assumed during interventions should be always chosen proportionate to the given task; a risk assumable at a fire in a grain storage facility is incomparable with a fight for the life of a human being.

Researches show (Lichtenstein & Fischhoff, 1977) that overconfidence means that the division between actual and putative knowledge is around 50%. We are best able to judge the certainty of our decisions around 80% of knowledge, over this value, we underestimate our abilities. The above have shown that our actual knowledge does not grow parallel with certainty, the increase of our knowledge does not automatically mean the growth of self-assurance (Paprika-Zoltay, 2002). During firefighting (technical rescue), the characteristic VUCA environment exactly expresses that the actual knowledge of a decision-maker can only be partial, he can only be sure temporarily of the reliability of his knowledge. Aggregating the above, we can see that the risk of overconfidence continuously prevails in the decisions of a firefighting manager.

## **6. The complex model of decision-making of firefighting managers**

In this article, author made efforts to examine and show the mechanisms promoting the more efficient decision-making of firefighting managers. Author demonstrated the linking opportunities of recognition-primed decision procedure and analogical thinking, pointing out the fact that the two do not exclude each other. If an intervention is protracted or longer time is available for the decision, many times, firefighting managers may achieve more efficient firefighting by using the latter.

If not enough time is available for analyzing and evaluating decision-making, recognition-primed procedures receive a greater role. Critical thinking uses recognition procedures, during which the decision-making process can be accelerated or analyzed with the help of a quick test and depending on the time available. The quick test, considering the circumstances, hinders recognition-primed decision and prefers critical thinking. However, when the circumstances are inappropriate for critical analyzing thinking, the quick test allows immediate reply.

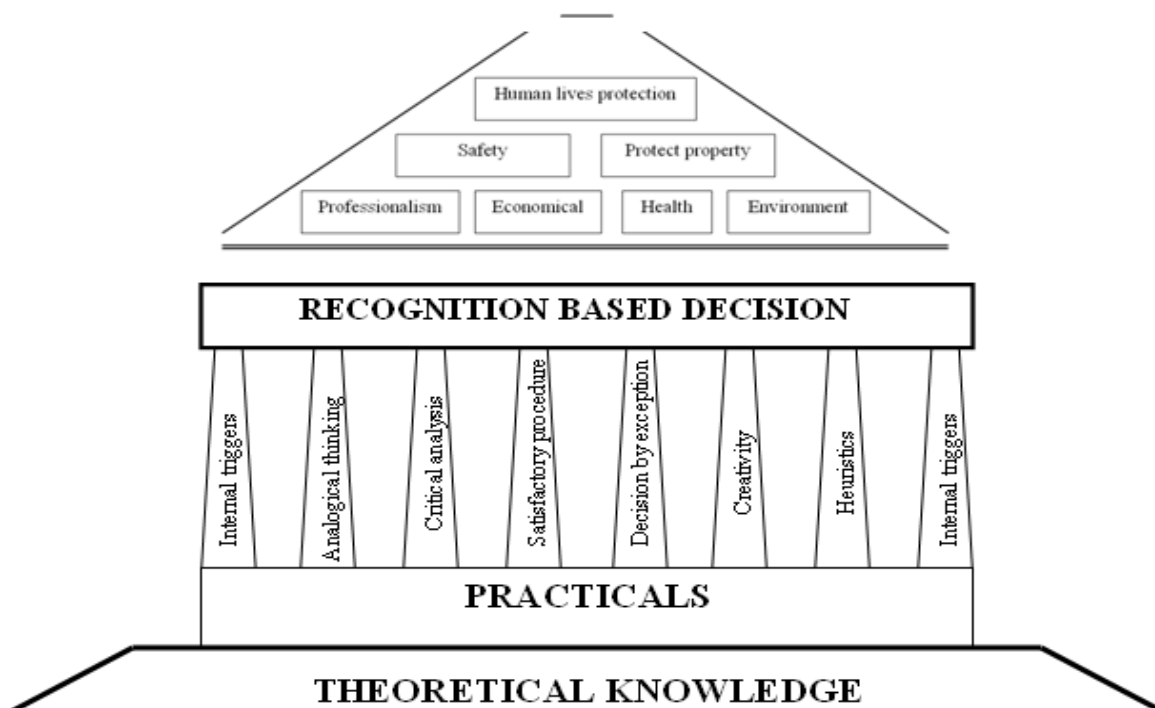
Despite the limited decision capacity, thanks to recognition-primed mechanisms, in most of the occasions, correct decision is made by firefighting managers. Time limit precludes the possibility for the firefighting manager to carry out analyses necessary for the classic model, therefore, the selection of the optimal possibility is objectively not attainable by the decision-maker. The decision-maker is not striving to achieve ideal results, as a response to the difficulties of collecting information and reducing costs in relation, but depending on the circumstances, he is satisfied with the its satisfactory solution.

By reducing the time available for decision-making and for maintaining decision-making capacity, a firefighting manager applies the management (decision-making) method based on exceptions in numerous situations. Its essence is that several moments of interventions proceed protocol-like, thus, they need not be controlled all the time; on the other hand, not all the phases of the processes require direct management decision.

During the study of creativity, author has concluded that there is no such a feature characteristic of the working circumstances of firefighting managers that would not be advantageous to perform efficient work in a VUCA environment. Therefore, it is sure that the creative capabilities of firefighting managers can be explicitly advantageous to facilitate the professionally correct decisions on

firefighting and rescue tasks even if a significant part of the characteristics of innovativity does not favor the performance of an everyday work free of interventions with respect to firefighting managers. Heuristics are not random-like errors or specific distortions facilitating our everyday activities. These are the results of simplifying mechanisms, through which decision-makers can make difficult tasks manageable for themselves. Besides the benefits of heuristics, the greatest challenge for a firefighting manager can mean the inherent erroneous distortions, which surely often help, but their uncritical acceptance, in certain cases, can end up in fatal dangers.

The declared objective and sense of the decisions of firefighting managers is the efficient implementation of emergency interventions. It is symbolized by the principles of firefighting with structured division, on the top of which we clearly find the saving of human lives.



*Figure 7. Complex model of decision-making of firefighting managers in emergencies*

Firefighting managers certainly have less time to make their decisions compared to the time interval of classic decisions, so, their decision mechanism is strongly based on recognition procedures due to the peculiar environment (VUCA), and the limited process possibility of simultaneous pieces of information. The competence of firefighters is based on the unity of theoretical knowledge and practical experience. Building on practical experience, the different mechanisms like analogical thinking, critical analysis, satisfactory procedure, decisions based on exceptions, creativity and heuristics, together with the internal triggers, hold as pillars and make recognition-primed decision procedure of firefighting managers operational. Author illustrates the above as a complex system of emergency decision-making of firefighting managers in figure 7.

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