**TONI BIELIĆ**, Ph.D.
E-mail: tbielic@unizd.hr
University of Zadar, Maritime Department
Mihovila Pavlinovića bb 23000 Zadar, Croatia
**SADKO MANDŽUKA**, Ph.D.
E-mail: mandzukas@fpz.hr
University of Zagreb,
Faculty of Traffic and Transport Sciences
Vukelićeva 4, 10000, Zagreb, Croatia
**VINKO TOMAS** Ph.D.
E-mail: tomas@pfri.hr
University of Rijeka, Faculty of Maritime Studies
Studentska 2, 51000, Rijeka, Croatia

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# MODEL OF SHIP MANAGEMENT IN EMERGENCIES

***ABSTRACT***

*The paper investigates conditions and circumstances of the occurrence of emergencies during ship exploitation. The concept and different forms of emergencies are defined while conditions of their occurrence are simulated, as well as possible modes of prevention of their occurrence or development. On the basis of the results of the investigation covering 240 professional seamen an appropriate organisational algorithm of participative ship management is defined as foundation for the application of the management algorithm in emergencies. On this basis the method of Risk and Hazard Assessment is applied. Also, the algorithm of Decision Making Process is derived from the related investigations. The proposed algorithm is not based only on the organisational presuppositions of participative management but also on complex human relationships as well as acting in stressful circumstances through all the phases of emergencies. The appropriate decision support system to help decision-makers during the emergencies is described.*

***KEY WORDS***

*emergencies, algorithm, team work, participative management, hierarchical acting, scenario, communication*

## 1. INTRODUCTION

Generally, emergency management rests on three pillars: knowledge about past emergencies, an understanding of human nature expressed in the social sciences, and specialized expertise in response mechanisms [1]. In this sense, ship management in emergencies is mostly based on previously trained and organized crew. In emergencies a combination of knowledge, skills and training of crewmembers as well as the organisation of management are fully expressed. For some types of emergencies we can be prepared in advance, such as, for example, the urgency in case of fire, man overboard and abandon ship because for these circumstances there are previously prescribed operational procedures and regular drills. Standard operational procedures for such emergencies, besides training, make an appropriate reaction possible. Taking into consideration the preparedness we can quickly respond to emergencies of this kind. On the contrary, there are emergencies for which there is no previously prepared plan, in other terms, emergencies for which the crew has not been trained as for the kinds mentioned above. Such emergencies occur with an explosion or a collision. In the same category there are also the emergencies which cannot be foreseen and which result from a breakdown of a piece of equipment or automation system. These are the cases of a high degree of urgency to which it is very difficult to respond with a reasoned, appropriate and quick reaction. These are precisely the emergencies for which the crew had not been previously prepared and which cannot be foreseen, that demand specific knowledge from the standpoint of management. Such knowledge is necessary to make reactions even in these circumstances reasoned, appropriate and quick as much as possible.

The paper investigates various influential elements in the occurrence of emergencies through a scenario which is based on maritime accidents that actually happened. On the basis of the previous investigation [2], an appropriate organisational model of management of the ship herself and the emergencies is defined as a contribution to the safety of navigation in all conditions. Based on the proposed model different algorithms in the field of emergency management onboard can be tested. In addition, it is possible to build advanced decision support systems for management in emergencies. These are now "mature technologies" that enable better decision making [3, 4].

Emergency management consists of two phases: Pre-incident and Post-incident phases. Pre-incident tasks include predicting and analyzing of potential dangers and developing necessary action plans for mitigation. Post-incident response starts while the emergency is still in progress. At this stage the challenge is locating, allocating, coordinating, and managing available resources. An effective emergency response plan should integrate both of these phases within its objective. Separating the Pre-incident and Post- incident objectives may lead to suboptimal solutions to the overall problem [4].

In Section 2 general principle of participative management of ship organisation is described. The method of "short-term strategy" consisting of five elements is also presented.

The emergency conditions on board are defined by the occurrence of a serious event which can result, or has already resulted, in an accident involving a threat to human lives, ship or cargo as well as the environment. The recognition of these emergencies is presented in Section 3.

The investigation based on the proposed scenario was carried out at the Faculty of Maritime Studies of the University of Split using navigation subsystem simulator North Control – class A1. The results are presented in Section 4.

In order to unify effectively the potential knowledge and the experience during *short-term* strategy it is necessary to previously develop cooperation as an effective work style which should replace competition and individual efforts in reaching the goal. The proposed model of management in emergency in conditions of participative management is described in Section 5. Gathering information, assessment and the aim of planning, decision making, issuing orders and checking the implementation are specifically described.

In Section 6 conclusions are given with some recommendations for the shipping companies.

## 2. MANAGEMENT OF TEAM WORK ORGANISATION

The team work of a modern ship organisation presupposes logical and natural relation and unification of the master and deck officers as well as that of chief engineer and his engineer officers on the basis of work coordination and collaboration aiming at optimum ship management in all conditions - participative leadership (*Figure 1*).

In team work operational procedures in emergencies imply measures and activities which are synchronised and optimised by cooperation and coordination [6]. The objective of such measures and activities is re-establishing normal circumstances in as short a period as possible by optimum use of means, equipment and human resources [7]

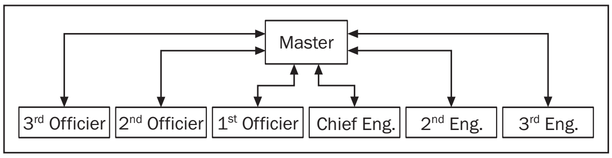


*Figure 1 - Principle of participative management of ship organisation*

*Source: [2] – according to [5]*

From the organisational aspect the operational procedures are optimised by application of certain methods which enable individual crewmembers to act effectively. If we take into consideration the measures and procedures which are in advance suitable for prevention of certain emergencies and are described in SOP (*Standard Operational Procedures* – SOP or *check lists*) the team acts on the basis of preparations and drills carried out in advance. However, in case of emergencies for which there is no in-advance determined operational procedure, a method characteristic for team work itself is applied. It is the method of "short-term strategy" consisting of five elements: 1. Define the nature of the problem, 2. Build up a plan of problem solving; 3. Check the plan; 4. Check if the plan is intelligible; 5. Control the operation and coordinate [8].

The first point or definition of the nature of the problem implies a mutual approach to establishing relevant facts which accurately describe the state and cause of the new situation. In this phase all the principles of coordination and cooperation of a mature team are applied which means maximum activity of all human resources.

The second point refers to establishing acceptable limits of the development through an appropriate plan which is built up on the basis of participation of all crewmembers who are relevant according to their responsibilities and the nature of the emergencies. This second point implies high motivation, i.e. a personal contribution to a positive development of the situation within which *brainstorming* takes place which means that of all ideas and suggestions those considered best are selected from the aspect of eliminating emergencies, i.e. returning to normal conditions. Setting priorities and selecting optimum is in the domain of the function and responsibility of the master, or team leader.

The third point implies checking the developed plan through application of the method of "questions and answers" in which each present team member makes it possible to ask questions, express reasonable doubt and propose possible alternatives. This is in fact the phase of checking possible effectiveness of action and limits set up by the plan.

The fourth point is directed towards checking the extent to which the plan accepted has been understood by individual team members. In this phase the "closed loop" of plan intelligibility is to be achieved, i.e. a clear cause-consequence acting of individuals who will cooperate in action and mutually coordinate their activities. This point also includes the concept of control of acting of individual groups that will be interrelated and dependant in their work.

The fifth point refers to managing the entire plan through prompt informing the master on the implementation of the plan defined, master's responses to possible questions during the realisation of the plan as well as correction of the plan and creation of alternative solutions which can become necessary while carrying out the activities planned. The role of the master or team leader in the fifth phase is important as an integrative element of the realisation of the plan defined and becomes apparent in his capability to direct support and possible corrections.

## 3. RECOGNITION OF EMERGENCIES

Emergency conditions on board are defined by the occurrence of a serious event which can result, or has already resulted, in an accident involving a threat to human lives, ship or cargo as well as the environment.

Therefore, the occurrence of emergencies can be analysed in two ways. Namely, from the context of the definition of emergency on board results; these emergency conditions occur when a serious event has happened which "can lead, or has already led to an accident involving a threat to human lives, environment, ship, or cargo". Double-natured analysis of emergencies results from the imperative of acting urgently with the objective to remove the consequences of the serious event by the action undertaken in order to avoid the accident; the action is undertaken even if the accident has already happened as a result of the serious event in order to diminish harmful consequences.

Identification of emergency conditions depends on the time passed from the occurrence of the serious event to its recognition as well as the effects of the event which is the basic element of the qualification of a serious event as an emergency in the narrower sense and emergency in the broader sense of the term.

Therefore, it can be said that immediate conditions and circumstances of navigation are significant factors of a possible occurrence of serious event. Recognised conditions for the occurrence of a serious event point out to possible latent causes which should be foreseen as far as possible and appropriate safety precautions should be undertaken. The occurrence of emergencies through conditions and circumstances of navigation as well as crew readiness for possible events including the condition of the ship herself and her cargo can be analysed from several aspects [2], i.e.:

a) Circumstances and conditions of navigation, conditions of the crew, ship and cargo (passengers) are recognised in time as a possibility of the occurrence of a serious event which could lead to emergencies, so that raising the level of precautions and appropriate operating procedures the occurrence of the event or emergency can be avoided, and possible accident prevented – *safeguards against emergencies*.
b) Circumstances and conditions of navigation including conditions of the crew, ship and cargo (passengers) are not recognised in time as a possible cause of the occurrence of a serious event so that precautionary measures have not been undertaken; consequently the serious event has occurred and has led to the emergency so that at this stage urgent and organised measures are undertaken as well as operational procedures aiming at:
   b1) preventing further development of the event that occurred and its harmful effect on people, ship, environment and cargo, i.e. preventing the possibility that such an event or situation leads to even more harmful consequences - *emergency in the narrower sense*.
c) In case the previously mentioned measures have not been effective, and the event which has led to the occurrence of an emergency has become a threat to the persons on board or the ship's seaworthiness, i.e. has resulted in the need of abandoning ship, urgent and organised measures are undertaken:
   c1) abandoning ship and saving human lives as well as reducing the consequences of the accident – *emergency in the broader sense*.

## 4. INVESTIGATION OF OCCURRENCE AND PREVENTION OF EMERGENCIES

The investigation is based on the set of scenarios founded on the analysis of causes of maritime accidents. It simulates conditions which initially can lead to emergencies providing at the same time possibilities to avoid dangerous circumstances and emergencies. The set of scenarios [9] consists of five plus two independent scenarios (6, 7) which initiate action by the ship's crew which can either lead to an emergency or prevent it depending on the procedure chosen [2]. These scenarios are the following:

1) The master or officer of the watch initiates a possible action in relation to a certain situation. For example, the master or officer of the watch who is present in the navigating bridge speaks to the

other person on watch saying "What do you think will happen? What must we do?"

2) Another person on watch comes forward and crosses the borders of horizontal or vertical hierarchy, and directs the attention of the officer of the watch or the master to a possible circumstance or information.
3) The fear of a possible accident becomes stronger than the fear of the master's authority and possible repression, so someone comes forward from a typical hierarchical organisation structure.
4) Relationship based on equality between the master and the officer of the watch represents the basis of possible acting and change in the situation.
5) Among crewmembers on watch there are established relationships and it is exactly on the basis of these previously established relationships that prerequisites for acting and changes in the new situation are possible.
6) The crewmembers on watch do not take any initiative with regard to the dangerous situation since the master has taken over the ship management, so he is expected to provide further instructions and orders.
7) Fear of the master's authority (sometimes unfounded requirements of the company realised through the master's authority) and possible repressions due to not carrying out the previously given orders is stronger than the fear of an accident which can occur due to the requirements set and the orders, so the officer on watch without asking for assistance independently tries to find a solution for the new situation which has occurred under way or has resulted from the master's previous instructions.

The above mentioned scenarios can be put into function of the case recorded in the Danish Maritime Institute (DMI). A case which occurred during work on the simulator is described in [10].

In the simulated version of navigation the master has taken over ship management and set the ship onto the course which very soon should have resulted in grounding. All of his officers in the navigating bridge (who usually serve with the master) were aware of the fact, but nobody said or did anything. After the master was told to leave the bridge (simulator) on the excuse that he was not feeling well, all the officers took initiative to prevent the accident. Analysing the above mentioned event from the aspect of effectiveness of decision-making and their implementation the following conclusions can be made: Nobody opposed the master's decision. It was not taken into consideration that the person with the highest authority can be wrong [11]. Scenarios 6 and 7 of the set can be applied to this situation which negates the effectiveness of the organisation from the aspect of reaching the goal, i.e. a safe conclusion of the maritime venture.

A similar investigation was carried out with 240 testees at the Faculty of Maritime Studies of the University of Split using navigation subsystem simulator North Control – class A1. The scenario of the investigation consisted in the master's decision to set the ship on a shorter, but meteorologically unfavourable course with the risk of entering an area of heavy seas which could be a threat to a ship of the size. The investigation was carried out in groups consisting of three seamen each of whom used the above mentioned simulator to carry out their officer duties within the limits of the scenario. The investigations were organised in parallel with the programme of training for professional seamen "Bridge Resource Management" (SAS) and "Ship Simulator and Bridge Team Work". The results of the investigation (*Figure 2*) indicate that out of 240 testees in simulated conditions, 67 testees resigned to the decision of the master who was instructed to deliberately make wrong decisions and order their implementation - possibility "c1" (emergency in the broader sense). Even 98 testees opposed the master's decision in the early phase of danger – possibility "a" (measures of protection against emergency), while 75 testees decided the same in the already dangerous situation – possibility "b1" (emergency in the narrower sense). The majority of the above mentioned 75, or 67 testees had their navigating experience mainly as second and third officers. The rest of 98 testees had their navigating experience as first officers. The basis for the reaction of 67 testees can be brought down to Scenarios 6 and 7 and it fits with the results gained at DMI, while the reaction of the rest of 75, or 98 testees can be interpreted by Scenarios 2 and 3 of the set.

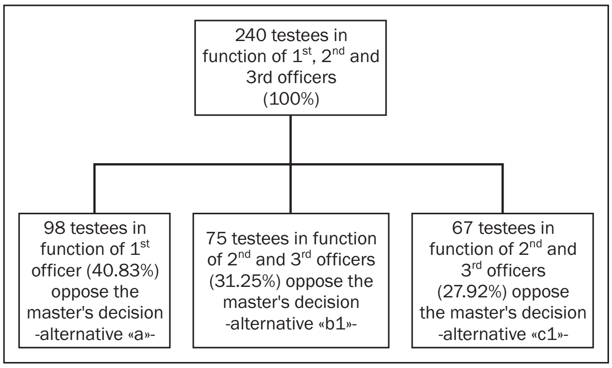


*Figure 2 - Results of the investigation of the occurrence and prevention of emergency*

The seamen involved in the above mentioned investigation had not previously had any major experience with organised team work, but their experiences were based on the traditional hierarchical form of ship organisation. The results gained by the investigation on the basis of the model described above point to the possibility of the occurrence of emergency in the narrower sense – "b1" of 31.25% (*Near Miss* circumstances). The occurrence of accident and emergency in the broader sense – "c1" is possible in 27.9% which means that the emergency of the levels "b1" and "c1" with regard to the scenario set occurred with 59.2% of the testees. Such a high percentage of the emergencies occurred confirms the unreadiness of ship's organisation to collaborate in coordinated solving of the actual problems occurring during ship exploitation.

The investigation carried out can be supported by the analysis of the actual maritime accidents [12] with highly emphasised vertical or hierarchical management structure described in [13]. One of the conspicuous examples is the grounding of the tanker *Torrey Canyon* in 1967 or more recently of the tanker *Erica* in 1999 wherein the masters by their decisions based on the profit interests of the company, and not on the safety aspects, supported by the lack of the crews' initiative due to the conventional fear of repression, led their ships into danger and eventually into distress – Scenarios 6 and 7 of the set. The more recent examples refer to the Ro-Ro passenger ship *Herald of Free Enterprise* (1987) which experienced an accident due to bad work organisation and inappropriate safety measures resulting from omissions and neglect by the company management as well as from the lack of initiative by the managing personnel on board to correct the obvious organisational and technical drawbacks – Scenarios 6 and 7 of the set. The next among the more recent examples is the Ro-Ro passenger ship *Estonia* (1994) onboard which the second officer acted untimely and inefficiently delegating an incompetent person (helmsman) to check the bow ramp for correctness in already heavy seas instead of asking for the master's assistance – Scenario 7 of the set. Herewith fall the latest accidents which continuously confirm the unreadiness of hierarchical ship's organisation to act promptly and effectively, i.e. to prevent emergency. One of the examples is the collision of the bulk carrier *Alam Pintar* with the fishing vessel *Etoile des Mondes* (2009). The basic reason reported is the unreadiness of the officers of the watch to call the master in time in the complex conditions in which they were caught – Scenario 7 of the set. A similar example has been reported in the collision of the tankers *Saetta* and *Conger* (2010) where there was obvious unreadiness for acting in emergency in the narrower sense (lack of cooperation among officers and engineers) as well as lack of communication – Scenario 6 of the set.

The investigation has shown that the circumstances for the occurrence of emergency arise from ineffective (hierarchical) ship organisation and inappropriate communication which disables undertaking of any collaborative or coordinated action [14]. Consequently, the basic prerequisite for an effective management of ship's crew aiming at avoiding emergency is the introduction of participative management of ship organisation or professionally set team work. Such an organisation of work and management on board implies the Scenarios 1, 2, 4 and 5 of the set which can keep the possible occurrence of emergency at the level "a" to "b1" at worst. In case of the occurrence of emergency an efficient way of a fast return to ordinary conditions is possible through Scenarios 1, 2, 4 and 5 of the set and is represented by the model described in the next section.

## 5. MODEL OF MANAGEMENT IN EMERGENCY IN CONDITIONS OF PARTICIPATIVE MANAGEMENT

The occurrence of emergency requires an urgent response to the altered conditions through mutual and synchronised acting of the crewmembers. The stressful conditions emerging in the first phase of the occurrence of emergency can lead to a spontaneous blocking of rational thinking and resigning to fear. In this phase the symptoms of stress are recognised. The development of the circumstances and the level of stress reached are reflected in the actions and work capability in two ways: increase in the energy level of the body / increase in the work capability and fall of the energy level of the body / reduced work capability (*Figure 3*).

It is precisely the application of *short-term strategy* explained in Scenario 2 which allows the implementation of Scenario 1 of the set. This makes it possible to control the level of stress and essential balance between decision-making and acting. By such an approach negative expressions of stress can be suppressed so as to enable the re-establishment of ordinary conditions.

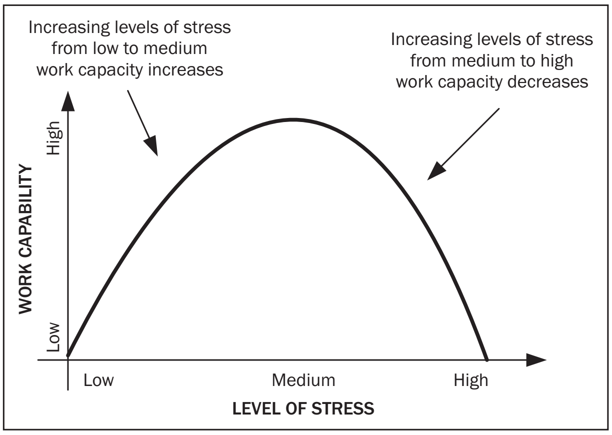


*Figure 3 - Level of stress in relation to work capability*

*Source: [15]*

Short-term strategy can be effectively carried out only in a well-trained team since it is based on open communication, well-developed initiative and acceptance of master's authority. The application of *short-term strategy* is based on merging of individual knowledge and experience into the common, aiming at acting effectively and reducing the risk of the action planned in emergency (*Figure 4*).

In order to unify effectively potential knowledge and experience during *short-term strategy* it is necessary to previously develop cooperation as an effective work style which should replace competition and individual efforts in reaching the goal.

## 5.1 Gathering information

Gathering information after the occurrence of emergency implies previously trained activities of reacting in emergency and preparing the *emergency squad* [16]. It is of particular importance during information gathering to use effectively the time at disposal as well as potential knowledge and skills of all those who can take part in coping with the unexpected circumstances considering the nature of emergency.

Creative use of the time at disposal will reduce the risk for the emergency squad to fall under the influence of stress which in the initial phase of disorientation and uncertainty can lead to lack of information exchange among the members of the team, too much trust that the master will solve the problem as well as to a wrong reaction fuelled by fear.

The master's support to the team work through the participative management style in the phase of gathering information (Scenarios 1 and 4 of the set) is extremely important for the feeling of leadership and taking responsibility which make the other members feel safe and create the climate for overcoming fear. Pieces of information on the conditions must be described and, without pretensions to the future development of the events, definite and not general, timely and objective.

On the basis of the information gathered the nature of the problem and its actual state are determined. This is also the first phase of *short-term strategy* which enables a creative approach to solving of new conditions.

## 5.2 Assessment and the aim of planning

Assessment and the aim of planning represent the second phase of *short-term strategy* during which a plan of problem solving is developed. The second phase by its nature represents a logistic management process, or in other words it ensures a later development of logistic processes according to assessment and the aim planned. In this part of short-term strategy a creative use of the team members' potential is very important (Scenario 2 of the set). The success in achieving the aim planned is in direct relation with the team members' reaction to the actual problem identified and potential chances of its solution. In that sense, in dependence of the degree of team development three kinds of reactions of the team members can be expected: a positive reaction, a passive reaction or a negative reaction.

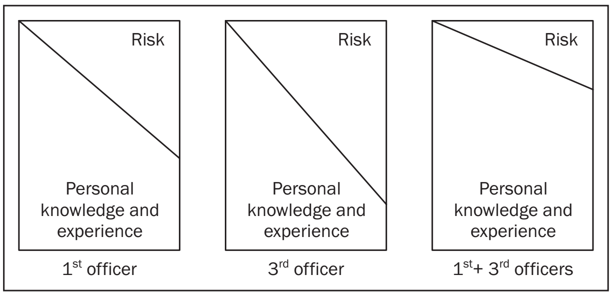


*Figure 4 - Merging of knowledge and experience*

*Source: [8]*

The positive reaction is characteristic of well-tuned and mature teams. The passive reaction is possible in the circumstances in which new, previously unknown members have joined the team so that the social aspects of mutual acceptance are still not pronounced, and the lately joined members refer with caution to the others [17]. The negative reaction of individuals depends on the level of stress that they can take. The persons who have reached a high level of stress show symptoms of emotional resistance to events – "storming" and reduced work capability. Due to a loss of self-control such persons must be left out of team work in order not to lose control of the situation and the direction in which the team works.

During team work it is particularly important that the members think of themselves as the most important part of the team not losing sight of the fact that the success depends on their interaction with other team members. Moreover, they have to recognise the interdependence of all team members. This means that each team member must realise that for successful assessment and planning mutual trust is essential. This is supported by Zand's model of trust (*Figure 5*).

Zand's model of trust explains how trust increases in teams acting in conditions of dynamic changes (Scenarios 4 and 5 of the set). The model shows the interaction of trust with regard to three variables: information, influence and control. Vulnerability as an essential element of trust is expressed through accepting responsibility even for other persons' mistakes, mutual exchange of essential information, encouraging individuals in their personal importance, contribution and self-control. In reply to such trust expressed the team members effectively share useful information referring to evaluation and planning. This consolidates the efforts of crewmembers that have united in the acceptance of responsibility so as to reach the goal set and in this way have realised the cooperative relations. These factors applied and combined with self-control, and not with formal control, strengthen the circle of trust. On the contrary, lack of trust prevails if the mas-

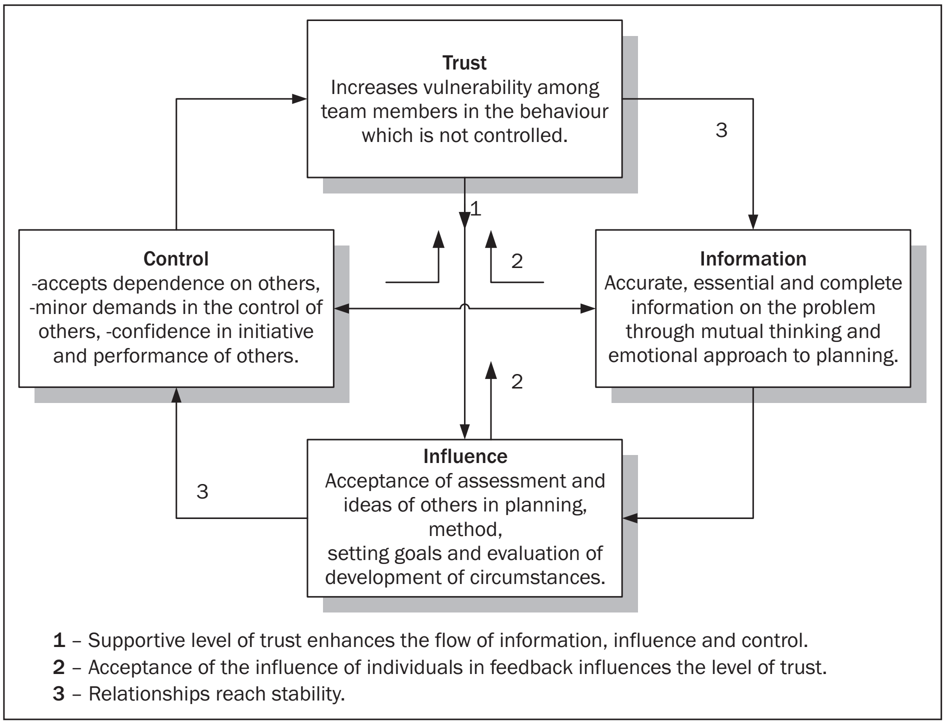


*Figure 5 - Zand's model of trust*

*Source: [18]*

ter tries to be invulnerable, does not share essential information, limits the influences and replaces self-control by formal control.

In accordance with the model proposed with assessment and planning the goal, each of the members present expose their plan in interaction with the others. This strengthens the synergic relations within the team when personal motivation and the entire knowledge with which the team disposes are manifested. The result of the motivation and joined knowledge result in the agreement achieved and the plan for future action. It is the interactivity achieved through joining knowledge and experience that enables maintaining stress within the limits of medium level since mutual concentration on circumstances and possible solutions reduces emotional resistance to events. The unity realised helps control the stress and increases the level of body energy which is reflected in the increase of work capability. Such a team ready for work during this phase can set priorities in the process of problem solving.

The basic priority of the team prepared is the assessment of hazards which can appear during the implementation of the plan accepted. Successfully integrated knowledge and experience of the team members become the condition the area of risk in the operation planned is to be reduced. Thus integrated knowledge can be applied by the *Hazard and Operability Method* – HAZOP[1]. The method contains general rules and directs its prerequisites to an organised team approach to the analysis of possible hazards and risks. Consequently, applied to the assessment of hazard to the operation planned it enables involvement of all team members (master, chief engineer, as well as deck and engineer officers). The team members headed by the master must carry out a study of the emergency operation planned and check the following prerequisites of safe operation: 1. Assess if the operation planned will initiate further hazards that will affect the solution of the problem; 2. If such circumstances are recognised, determine the degree of risk which results from the hazards recognised; 3. In accordance with the risk recognised assess the possibility of carrying out the operation planned; 4. In case it is impossible to carry out the operation due to unacceptable or high risk, foresee deviations from the plan and lower risk alternative solutions; 5. Define those phases of the operation in which it will not be possible to make instantaneous decisions and, accordingly, foresee information which can be necessary in such circumstances as well as appropriate actions; 6. Ensure that the operation is carried out according to the above mentioned regulations.

The prerequisites of safe acting within the limits of the action planned and alternative solutions can be shown by the algorithm in *Figure 6*:

Algorithmic presentation of HAZOP method points to two possibilities:

1. Acceptance of the plan and the schedule of its implementation with regard to acceptable risk and hazards;
2. Deviation from the original plan and acceptance of an alternative plan and the schedule of implementation so as to reduce risk and hazards.

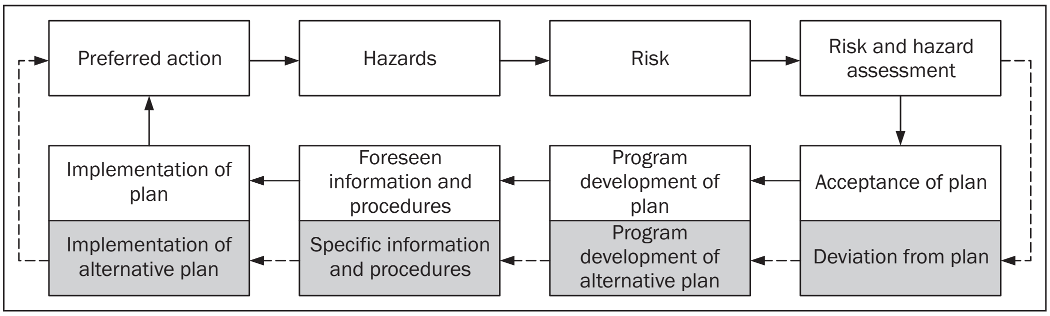


*Figure 6 - The algorithm of safe operation*

*Source: [2] according to HAZOP prerequisites*

Special information and procedures in the implementation of the alternative plan result from phase 5 of HAZOP method. Risk evaluation putting the alternative plan into function has four basic grades, i.e.: high, conditionally acceptable risk; medium, conditionally acceptable risk; low acceptable risk; existing but minor risk.

*High, conditionally acceptable risk* implies circumstances in which the application of the basic plan would mean direct hazard to human lives and/or environment, ship and cargo. In that sense the alternative plan must contain measures and procedures of reducing the existing risk through possibilities of additional activation of human and technical resources either external or internal (shipboard) [19]. Therefore, the application of the alternative plan should result in the reduction of the existing risk to an acceptable level in relation to the circumstances and achieve the aim, i.e. the effect wanted, and return to ordinary state.

*Medium, conditionally acceptable risk* of the basic plan is not a direct threat to human lives and/or environment but refers to the possibility of significant extension of damage to the ship and/or cargo. In that sense, the application of the alternative plan means that possible measures should be undertaken to prevent the existing risk from extending damage within given circumstances with a simultaneous realisation of the effect wanted.

*Low acceptable risk* which can be contained in the basic plan is also not a threat to human lives and/or environment, but can indirectly lead to a limited extension of damage to the ship and/or cargo. If the basic plan, as opposed to the alternative plan, enables a faster and more efficient solution of the new conditions which in dependence of the circumstances can worsen and turn into emergency in the broader sense, the basic plan can get the approval for implementation.

*Existing but minor risk* has no significance with regard to human lives and/or environment, while regarding the ship and/or cargo minor damages are possible. If the basic plan enables efficient and fast solution, in urgent circumstances it can be applied without reducing risk, i.e. the application of the alternative plan.

In dependence of the maturity of the team and meeting of the above mentioned prerequisites it is possible in emergency to get the effect of *brainstorming*[2]. Precisely the *Zand's model of trust* which must be previously implemented in everyday practice provides conditions for achieving the above mentioned effect in this phase of *short-term strategy*, and, consequently, the possibility of optimum application of HAZOP method.

Summarising the acting of the team during assessment and the aim of planning it may be concluded that by realising the integration of knowledge of the master, chief engineer and officers the risk area of the action planned will be greatly reduced by optimum assessment of hazard and the degree of risk.

## 5.3 Decision making

Decision making is based on previously made assessment and goals set. The decision on application of the basic or alternative plan means checking of the plans by all team members with regard to the existing circumstances (Scenarios 1 and 2 of the set). Algorithm of decision making in relation to circumstances is presented in *Figure 7*. Previously trained and in regular circumstances adopted method of "challenge and response" is the basis of checking of the plans mentioned as well as possible corrections with regard to the circumstances in which the ship is. This is also the phase for additional possible suggestions and spotting of possible omissions on the basis of HAZOP results, i.e. danger and usability of the action planned.

In the phase of evaluation of individual proposals the master has to be guided by a simple system of feedback relation in order to achieve the wanted quality of his final decision. For that purpose he can use anticipative management[3] or preventive control since in that way the team members accept the master's final decision most easily because they see it as help in their work, and not as a means of pressure. Such management style results from the "leader – participation" model [20]. The master shares the problem with subordinated crew members as a group. They mutually analyse and evaluate alternatives trying to reach the

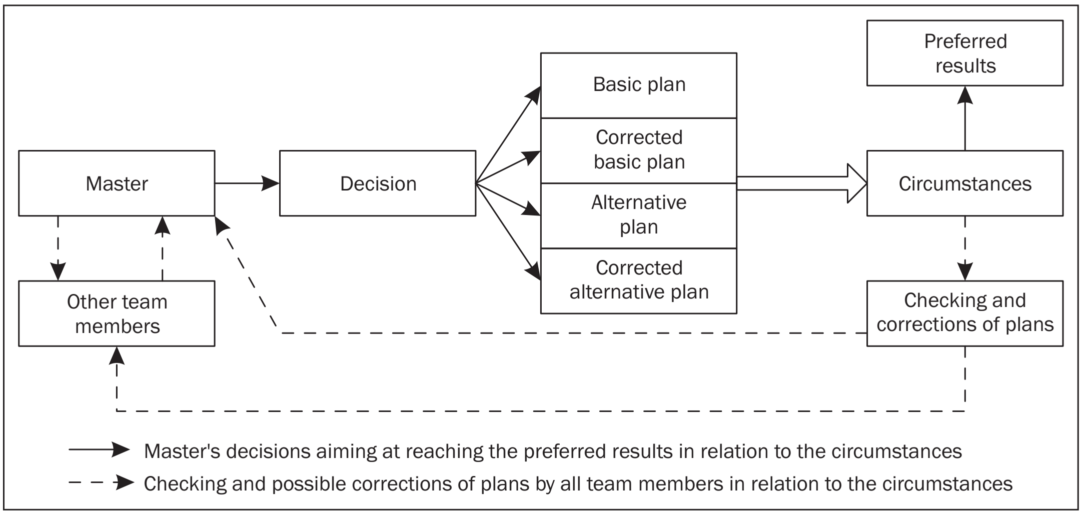


*Figure 7 - Algorithm of decision making in relation to circumstances*

*Source: [3]*

consensus about the decision. In this sense it should also be mentioned that, according to research made, group decisions are usually more accurate than individual ones. However, "*they are seldom better than the achievement of the best individual*" [20]. In this context the master as the most experienced member and the leader of the team represents potentially the best individual with greatest ability to bear effect. This effect gains its full expression in urgent situations when for some reason the team cannot reach a fast and coordinated solution.

Therefore, in case the prerequisites for team optimum operation have not been satisfied, when making a decision the master will act according to the alternative "leader – participation" model (*He will solve the problem by himself or make a decision using information currently at his disposal*).

In this phase of short-term strategy the previously achieved unity of general and specific knowledge, experience and abilities is emphasised again. On this basis a quick checking of plans and possible correction is attained. The unity of knowledge, experience and abilities results from the previous mutual work in which common attitudes, customs and rules of behaviour within the team are established. Through the unified ability and developed interactivity the team will quickly and effectively select the best plan with regard to the circumstances. The swiftness and effectiveness of acting in such circumstances is a factor which limits the effect of emergency. Each team member with his suggestions can contribute to the master's objective decision (Scenarios 2 and 4 of the set). Cooperation and coordination in these circumstances are the basis for common and individual safety, and they help the master to objectively select the best plan and the least risk. This is also the terminal phase of stress development since the final plan and agreement have been reached and the team progresses to action. In the beginning of operation the common efforts of team members responsible for carrying out the work planned are emphasised which helps coordination be realised to its full extent. In this phase the negative components of stress have been entirely overcome and it has a positive effect on the work results.

## 5.4 Issuing orders

Before issuing orders the plan must be checked for intelligibility by each participant and individual responsibility must be determined in the process of carrying out the plan (coordination). In this connection, care should also be taken of the cultural backgrounds of crewmembers because of possible language barriers as well as different perception of the development of the action. Afterwards, it is necessary to briefly summarise the mutual action (cooperation) and set the directives for coordination during carrying out the action. Cooperation and coordination regarding the intelligibility of the plan and future mutual action are realised by the communication method of *briefing*. The master presides over a short meeting according to the communication model of the *wheel* [20] (*Figure 8*).

Although the communication model of *briefing* shows a certain hierarchy of the flow of information, it is necessary due to the rate of exchange of information and the master's exclusive responsibility for

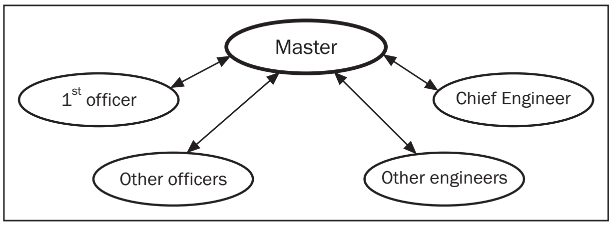


*Figure 8 - Communic ation model of the wheel*

*Source: [2] – according to [20]*

the development of operation approved by him. It is in such circumstances that the master plays his essential role of the leader who in the instant of making a command decision acts, but also takes overall responsibility for the operation which includes elements of mutual planning by all team members. In this sense the element of trust realised by the master with regard to the rest of the team members is emphasized as he takes the responsibility for the common plan. In this way he accepts the dependence on the others, shows trust in their initiative and their assessment of the development of circumstances. The essence of the team is most pronounced since the orders are based on previous plans and information in which mutual thinking and planning are incorporated. In this context the master shows vulnerability which results from trust in information and influence of the rest of the team members. This strengthens the benevolence and dedication to carrying out the tasks assigned by all individuals.

Regarding communication the master becomes the central conductor of all communications within the group which makes it possible for him to exchange information quickly aiming at making such decisions and orders which result from possible new circumstances while carrying out the operation.

The orders which follow must be short, clear and effective. In order for them to be accepted as such, besides the master's management style in immediate operation, the personal components of his authority are also essential. Personal components imply applied and previously accepted authority which is not formal and is based on the master's personal qualities such as: experience, knowledge and ability to manage a team. These components are recognised by the team members as stable features of the leader. This acts as a cohesive force on the team in emergencies.

## 5.5 Checking the implementation

Checking the implementation means controlling the operation, giving support and coordinating activities, in which the adopted principles of internal communication based on the method of checking and answers [21] get their full expression. Besides the method of challenge and response, the information exchange must also be based on the closed loop method. This method, namely, enables fast and accurate exchange of information while the method of challenge and response affects objectivity as well as the accurate analysis of the conditions and procedures implemented. The communication flow during checking of implementation is significantly intensified among operation participants adopting the communication model of all channels (*Figure* 9).

Communication model of all channels implies the recognised communication method of challenge and

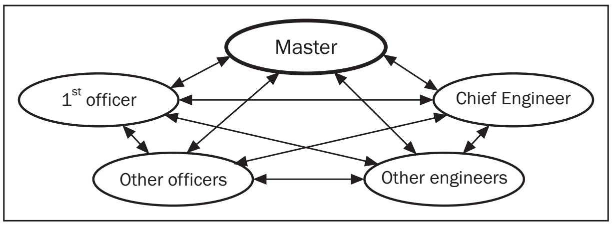


*Figure 9 - Communication model of all channels*

*Source: [2] – according to [20]*

response as well as the closed loop method. This type of communication model is highly characteristic of team communication due to equal presence of all team participants. In this way the basic motive of maximum dedication and contribution of the individual is realised. Such a motive results from significance of and consideration for individual opinions and views.

During this phase the master must be ready not only for active coordination within the plan applied but also for possible corrections and alternative solutions, *Figure 10*. According to Scenario 5 of HAZOP method in certain phases of the operation, circumstances can emerge in which it is not possible to make instantaneous (*ad hoc*) decisions. These circumstances require a fast and general flow of information through "all channels" on the basis of which it is possible to make a decision on correcting current procedures. The possibility of corrective action and alternative solutions during carrying out of the plan is realised according to the following algorithm:

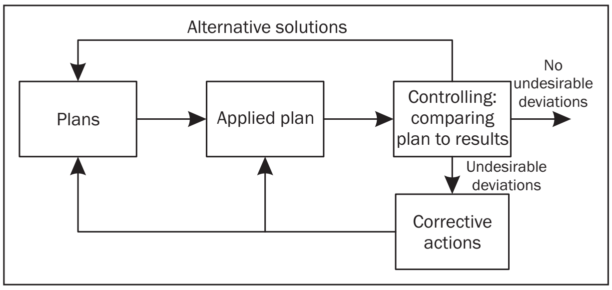


*Figure 10 - Algorithm of corrective actions during implementation*

*Source: [2] – according to [5]*

Possible corrective actions and alternative solutions are approved by the master who is entirely responsible for their implementation. Dedication and unity of the participants in the operation must be supported by the master in order to increase efficiency and ensure feedback information. When checking the implementation the master acts as participative leader and applies the style of management which provides support. Taking into consideration that the tasks have been structured in the previous phases of short-term strategy, with the application of supportive management style it is reasonable to expect effective implementation of the operation plan accepted.

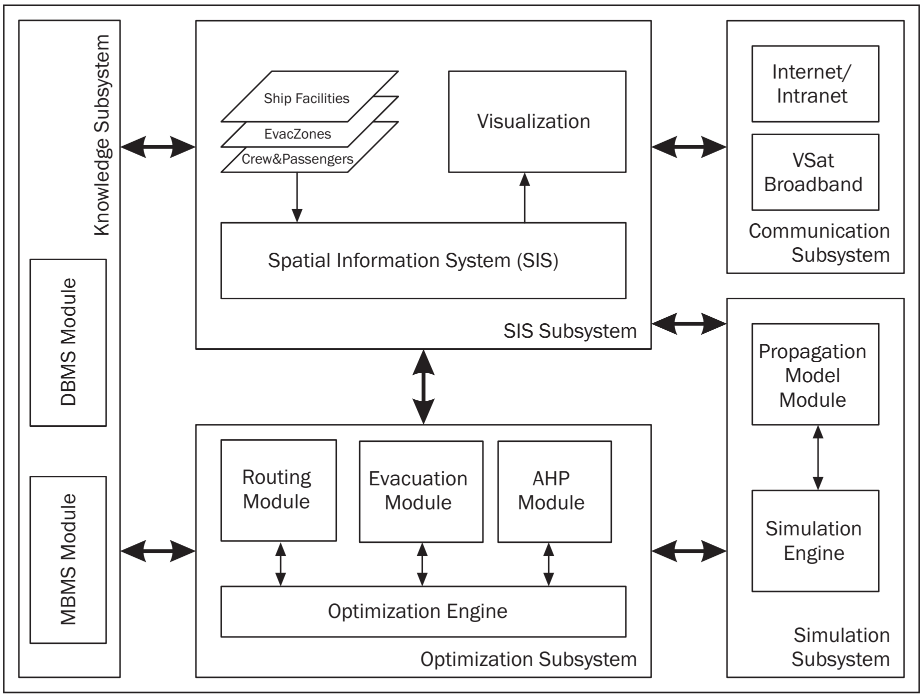


*Figure 11 - DSS structure*

*Source: [4]*

### 5.6 Decision support system

An emergency management system is a high-level decision support system that shall give the operator (typically someone in charge of the coordination of the emergency handling) information/ instructions/suggestions about how to best handle the situation. The satisfactory operation of Decision Support Systems (DSS) for emergency management requires the management of complex information (recourses, spatial information, ship system status, etc). The system will typically give an overview of:

1. Status of the situation in terms of severity, position and spatial extent.
2. Status of physical units or persons that can be used in the management of the situation.
3. Decision support in terms of checklists, advice, prognosis, etc.
4. Other information (e.g. trends or history) that can be helpful [22].

Decision Support System (DSS) capable of supporting most needs of emergency management is usually divided into five subsystems [4].

1. Communication Subsystems (CS) are supported DSS by advanced data acquisition, positioning and communications technologies to better understand the current state of operations,
2. Optimization Subsystem (OS) optimizes the most controllable processes in emergency situation (Network Optimization, Evacuation Routing, Resource Allocation, etc),
3. Spatial - Geo-information Subsystem (GIS) for Crisis Management,
4. Simulation Subsystem (SS) simulates partial problem of the real-world environment for the supervised area (pollution propagation, dynamic of own and other ships, dynamic of fire, etc.),
5. Knowledge Subsystem (KS) gives the corresponding reasoning methods required to perform the monitoring and management of emergency situations.

The Knowledge Subsystem provides the appropriate knowledge reasoning required for the planning and actions in emergency management. It consists of several parts, but the most important include:

- Model-Base Management System – MBMS. Its main function is to build relationships between the models used and the specific applications that are used in decision support system. MBMS transforms data from the DBMS in the information that is useful in the decision making process. Since many real problems are unstructured, MBMS is also used in the construction of appropriate models.
- Data-Base Management System - DBMS. It serves as a database system for decision support. It stores large amounts of data that are relevant to the class of problems for which the decision support system is designed. Its principal feature is that the data are logically structured.

## 6. CONCLUSION

The algorithm gained (*Figure 7*) serves the purpose in relation to its four functional components and the master's appropriate management style in emergencies. The aim of such management is to timely prevent the development of the event which occurred and its harmful effect on people, ship, environment and cargo. This makes the acting planned come true in the emergency in the narrower sense.

In case of the emergency in the broader sense the algorithm (*Figure 6*) enables effective and timely measures of abandoning ship, saving human lives and minimising the consequences of the accident. Such effectiveness of the algorithm is made possible by the application of the *method of risk and hazard assessment* related to organisational prerequisites, as well as the above described measures and procedures influencing synergic use of human knowledge, skills and technical resources.

The course of a team's operation is determined by functional components (*Figure 1*, 4-5) on the basis of which the team achieves consistency in its work not only regarding the prevention of emergency, but also regarding optimum acting once an emergency has happened. In that sense, *the method of short-term strategy* with specific knowledge applicable in team work enables optimum effectiveness even in the worst conditions of emergency. This entirely establishes the need for effective implementing and conducting of previous methods through the algorithm of decision making in relation to circumstances.

Beside the active effect and logistic prerequisites of effective acting, the algorithms (*Figure 6*, 7-10) diminish the possibility of potential technology submissiveness through implemented communication models (*Figure 8* – 9) during the action. With its organisational prerequisites and the management style defined it prevents the occurrence of the negative influences of the company and leadership. The negative aspect of self-induced complacency also disappears due to actual exhibition of individual values both within the team, and in the ship-to-company relation.

The basic prerequisite of the model application on board is the predisposition of the shipping company to form the decentralised organisational structure on shore. The reason lies in the fact that the decentralised organisational structure of the company is compatible with the principles of participative management on board which enhances reciprocity of interests of the company and the ship and finally improve the ship's safety.

Dr. sc. **TONI BIELIĆ**
E-mail: tbielic@unizd.hr
Sveučilište u Zadru, Pomorski odjel
Mihovila Pavlinovića bb, 23000 Zadar, Hrvatska
Dr. sc. **SADKO MANDŽUKA**
E-mail: mandzukas@fpz.hr
Sveučilište u Zagrebu, Fakultet prometnih znanosti
Vukelićeva 4, 10000 Zagreb, Hrvatska
Dr. sc. **VINKO TOMAS**
E-mail: tomas@pfri.hr
Sveučilište u Rijeci, Pomorski fakultet
Studentska 2, 51000 Rijeka, Hrvatska

### *SAŽETAK*

### *MODEL UPRAVLJANJA BRODOM U IZVANREDNIM OKOLNOSTIMA*

*Članak istražuje uvjete i okolnosti nastanka izvanrednih okolnosti tijekom eksploatacije broda. Definira se pojam i različiti pojavni oblici izvanrednih okolnosti te se simuliraju njihovi uvjeti nastanka kao i moguće prevencije od njihovog nastanka ili razvoja. Na osnovu dobivenih rezultata istraživanja na uzorku od 240 profesionalnih pomoraca definira se prikladan organizacijski algoritam participativnog upravljanja brodom kao okosnice za primjenu modela upravljanja u izvanrednim okolnostima. Na toj osnovi primjenjena je metoda Procjene rizika i opasnosti. Također i algoritam Procesa donošenja odluka je razvijen iz navedenih istraživanja. Osim na organizacijskim pretpostavkama participativnog upravljanja dobiveni model se temelji i na kompleksnim međuljudskim odnosima te djelovanju u stresnim okolnostima kroz sve faze izvanrednih okolnosti. U radu je opisan i odgovarajući sustav za potporu odlučivanju kao pomoć donositeljima odluka tijekom izvanrednih okolnosti.*

### *KLJUČNE RIJEČI*

*izvanredne okolnosti, algoritam, timski rad, participativno upravljanje, hijerarhijsko djelovanje, komunikacija*

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