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The influence of the coordinator attitude on SAR action effectiveness

Wpływ koordynatora akcji SAR na jej efektywność

Zbigniew Burciu, Jarosław Soliwoda

Akademia Morska w Gdyni, Wydział Nawigacyjny, Katedra Nawigacji Technicznej
81-345 Gdynia, Al. Zjednoczenia 3

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Abstract
The success of Search and Rescue action depends on the large number of different factors such as accident characteristics, environmental conditions and human factor. Accident characteristics and environmental conditions are outer controlled factors which have to be considered with respect to the action success assessment. The preparation and conducting of the SAR action can be the decisive factors of action success. Nowadays the organization of SAR action entirely depends on the coordinator decisions. His knowledge, experience and attitudes are the critical factors for the action success. The paper presents the influence of the coordinator attitudes on SAR action efficiency and idea of a decisional model with respect to the tasks of the coordinator. The basic human attitudes to take a risk: aversion to risk, neutrality and predisposition to take a risk have been studied.

Słowa kluczowe: akcje SAR, bezpieczeństwo nawigacji, szacowanie ryzyka

Abstrakt
Sukces akcji poszukiwania i ratownictwa (SAR) zależy od różnych czynników, tj. charakteru zdarzenia, warunków zewnętrznych oraz czynników ludzkich. Charakterystyka wypadku oraz warunki zewnętrzne są czynnikami niezależnymi od nas. Należy je jednak rozważyć w celu oszacowania sukcesu akcji. Przygotowanie i przeprowadzenie akcji SAR może być czynnikiem decydującym o jej powodzeniu. Obecnie organizacja akcji poszukiwania i ratownictwa całkowicie zależy od koordynatora akcji. Jego wiedza, doświadczenie oraz postawa są decydującymi czynnikami. W artykule przedstawiono wpływ postawy koordynatora na efektywność akcji SAR oraz zaprezentowano ideę modelu decyzyjnego w odniesieniu do zadań koordynatora. Zbadano również podstawowe ludzkie postawy przy podejmowaniu ryzyka: niechęć, neutralność i skłonność do podjęcia.

Introduction

The development of coordinated rescue techniques followed by the development of mathematical basis of SAR action planning and execution started during II World War. The coordinated rescue techniques were based on three elements:

- hydrometeorological information and weather forecast,
- coordinated transfer of information,
- availability of rescue units.

Until the second half of the XXth century SAR actions were coordinated directly by the units conducting the rescue action. The acceptance of SAR Convention in 1979 and introduction of GMDSS system moved the weight of planning and coordination of SAR action to the coastal coordination centers – MRCC (Maritime Rescue Coordination Centre).

In principle the person responsible in SAR action is SMC (SAR Mission Coordinator).

The next step of the development of SAR action planning and coordination was introduction of AIS system and possibility of automatic data collection (without involvement of an operator) as well as introduction of systems for safety of navigation information exchange (like for example Polish

system SWIBZ). The information of an accident can be automatically registered by the system and transmitted to the coordination centres.

The development of SAR systems has relocated the influence of the different system elements on the success of SAR action. At the beginning the success was mainly dependent on finding the survivors by chance only and then the technical possibility of taking them up from the water. Then the main factor becomes the successful radio transmission of information.

Nowadays the proper planning and coordination decide of a success of SAR action. Therefore the decisions of SMC are the main objectives of the scientific analysis aiming at the increase of SAR action effectiveness at sea.

Decision making – defined as the process of collection and processing information about the future action (acc. Koźmiński) is one of the management functions. The management functions are as follows:

– planning,
– decision making,
– organizing,
– motivation.

Decision – is defined as a wilful, non-random choice of one of the recognised and accepted versions of future action.

Operator's – SAR action coordinator's reliability factor (considered as an element of the system) – is the probability of faultless work in [0, *t*] time period [1]:

$$R(t) = P(T > t)$$

where T – time to the first mistake of SAR action coordinator.

The main methods of fault analysis are as follows [2]:

- TESEO (*Technica Empirica, Stima Errori Operatori*) – empirical technique of operator's faults estimation (Bello G.C. & Colombari V. 1980),
- HEART (*Human Errors Assesment and Reduction Technique*), worked out by Williams in 1985 modyfied in 1988,
- THERP, (*Techniue for Human Error Rate Prediction*) – determination of human errors probability in the ergonomic system, proposed by Swain & Guttmann in 1983,
- SHARP (*Systematic Human Action Reliability Procedure*),
- HCR (*Human Cognitive Reliability*), determines the probability of human fault (no proper action – no answer to the situation), worked out by Hannaman in 1985.

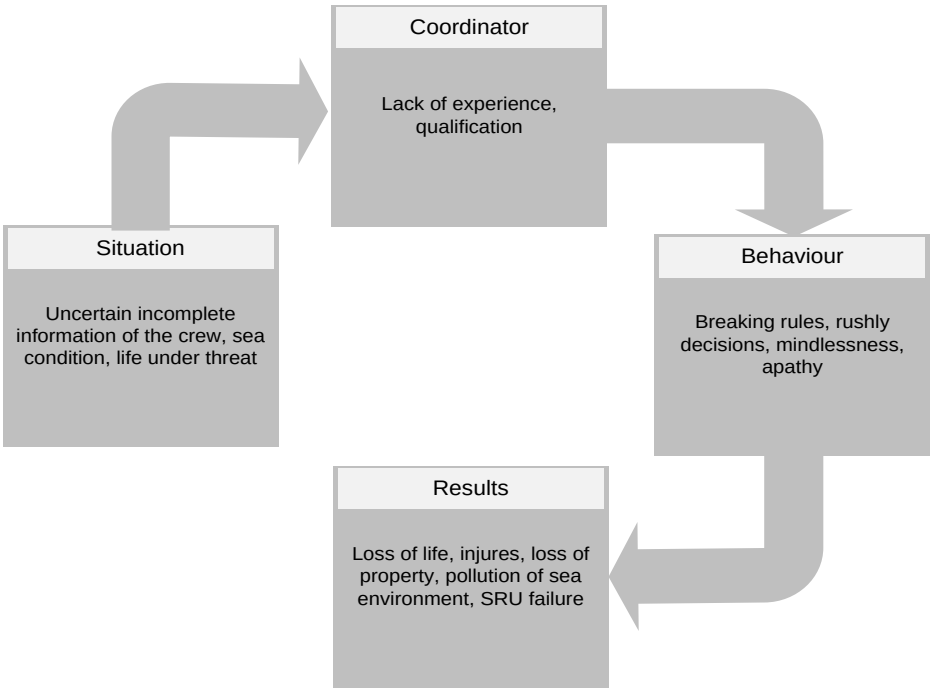

Fig. 1. Model of casual analysis of coordinator's faults generation [2, 3]
Rys. 1. Model analizy przyczyn powstawania błędów koordynatora akcji [2, 3]

In case the human errors can cause life hazard the following methods should be applied:

- THERP,
- SHARP,
- HCR,
- TESEO.

The coordination activity of SAR action coordinator should be characterised by [4] the following action attributes:

- constructive,
- intentional,
- conscious.

The improper coordination of SAR action can be characterised as follows:

- lack of interrelations between aims and coordinator's decisions,
- delay in making decision,
- the results of all possible versions of action are not considered and compared,
- achievement of aims with the use of not effective life saving appliances (redundancy, insufficiency),
- SAR action execution without considering safety criteria.

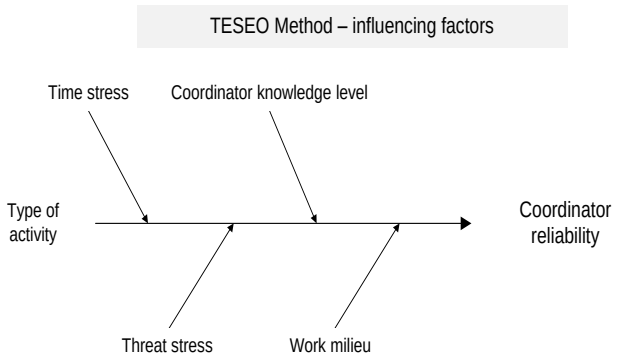

Fig. 2. Method TESEO – factors structuring human reliability – reliability of SAR action coordinator acc. Bello, Colombari [5]

Rys. 2. Metoda TESEO – czynniki mające wpływ na niezawodność człowieka – niezawodność koordynatora akcji SAR wg. Bello Colombari [5]

SAR action effectiveness

The greatest effectiveness of SAR action means that all the survivors are rescued without own rescuers losses [4].

The evacuation is effective, when the crew and passengers are onboard the launched life saving appliances and time of launching is less then the time of vessel sinkage, time to vessel large list, time to vessel turn over side or breakage of the hull.

According to the accepted standards [6], the evacuation time should be calculated as follows:

$$1{,}25(A+T)+\frac{2}{3}(E+L)\le n$$

$$E+L\le 30\text{min}.$$

One of the measures preferably characterising the success of SAR action is the operational effectiveness, which means the rescue of as many survivors as possible with respect to the external conditions during SAR action. Accepting this measure means that not all the costs and losses incurred during the action are taken into account.

The operational effectiveness is a two element set of decisional effectiveness and technical reliability of the rescuers.

Decisional effectiveness is understood as the probability of taking the proper decisions when SAR action has been initiated. Decisional effectiveness of SAR action coordinator [7, 8] can be presented as the probability of the following events:

- A – the event of both receiving the proper hydrometeorological information, perfect interpretation of accident data by the coordinator and then the use of the above data to determine the search area;
- B – the event of choice of the proper rescue units for the action and proper planning of their use;
- C – the event of the coordinators ability to correctly make the optimal decisions in assumed time of SAR action, what means that the coordinator will be able to introduce changes in the action according to the variation of conditions and received information.

The coordinator will fulfill his task when all the events mentioned above occur simultaneously. The measure of the decisional effectiveness is probability p_{Di} of fulfilling the task:

$$p_{Di}=P(A\cap B\cap C)=P(A)\cdot P(B|A)\cdot P(C|A\cap B)$$

During the evaluation of operational effectiveness the decisional problem of the beginning of SAR action is ignored. It is assumed that the beginning of SAR action is certain, however the events A and B consisting of the second and third phases of SAR action are functionally assigned to the decisions which have been already made.

The phases 2 and 3 defined in IAMSAR Manual [9] start in practice simultaneously, in the slightly shifted time periods.

The presented relationship consists of decisional process related to the existed condition only, the results of the action as for example the numbers of detected survivors and number of the rescued survivors are disregarded.

The effectiveness describes the serious of linear events and allows to determine the value of the chosen decisional path.

The measure which describes more detailed the possibilities of SAR action coordinator is the function of operational effectiveness.

Coordinator attitudes towards a risk

People have different risk attitudes, dependent on the psychological aspects. The attitudes of SAR action coordinator directly influences SAR action. The main three attitudes of the coordinator towards a risk are as follows [10]:

- aversion to a risk – the coordinator minimises a risk of health or risk of loss of life of rescuers due to the main aim of rescuing the survivors,
- neutrality towards a risk – the coordinator have the neutral attitudes towards risk of health or loss of life of rescuers and survivors,
- predisposition to take a risk – the coordinator would bear any cost – incur any risk – to rescue the survivors.

The subjective expression of attitudes in risk analysis can be presented in form of the principle of maximization of the expected utility [10]. The principle is expressed by the following equation:

$$E(U) = \sum_{i=1}^{m} p_i \cdot U_i$$

where: $E(U)$ – expected utility, p_i – probability of obtaining the i-th assumed value of a parameter (for example decisional effectiveness), U_i – expected utility corresponding to the i-th assumed value of a parameter.

The expected utility is a weighted mean of utility and the probabilities of the utilities realisation are taken as the weights.

During the process of making decisions the coordinator is guided by the criteria of the expected utility:

$$U(X) = Eu(x) = \sum_{i=1}^{n} u(x_i) \cdot p_i$$

The utility function $U(x)$ determines the attitude towards a risk of the coordinator.

The dependences between the utility function and coordinators attitudes are as follows:

- aversion to risk – the coordinator described by the convex utility function is characterised by aversion to make decisions with the high level of risk, he has got the inclination to limit a risk;
- neutrality – the coordinator described by the linear utility function is characterised by balance in making the risky decisions;
- predisposition to take a risk – the coordinator described by the concave utility function is characterised by inclination to make decisions laden with high risk probability.

Each of the above attitudes can be described by the shape of it's utility function as it is presented in figure 3.

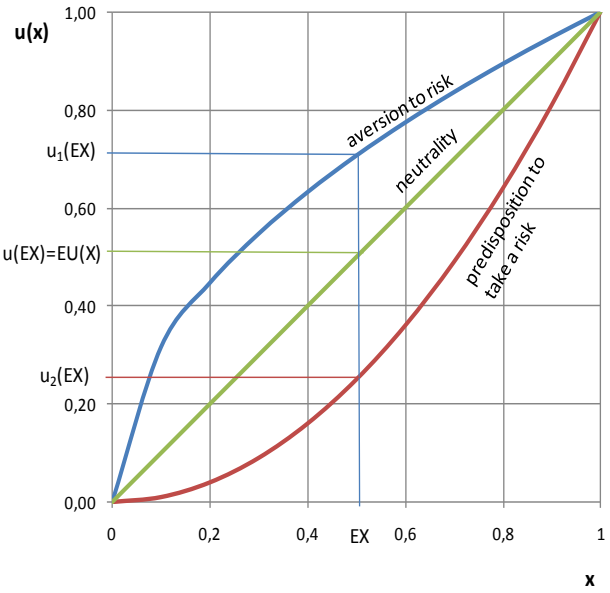

Fig. 3. Types of SAR action coordinator attitudes. Worked out on the basis of [10]
Rys. 3. Typy postaw koordynatora akcji SAR. Opracowane na podstawie [10]

Examples of the coordinator subjective evaluations of hazards

There are the three basic coordinator attitudes towards a risk:

a) aversion for risk – underwriter
The utility of actions free from risk (equal to the expected utility of the risky actions) is higher than the value of the expected utility of an individual version of a risky event [10].

$$Eu(X) < u_1(EX)$$

The coordinator prefers to make decisions free from risk assuming that undertaking a risk can reduce the success of SAR action. The underwriting can be a reason of the reduction of

effectiveness in rescue actions because the coordinator does not consider all solutions.

b) neutrality towards a risk
The utility of the actions free from risk (equal to the expected utility of the risky actions) is equal to the expected utility of an individual version of a risky event [10].

$$Eu(X) = u(EX)$$

The coordinator does not care for the character of an undertaken decision. His aim is always to obtain the optimum increase of action effectiveness.

c) Predisposition to take a risk – risk taker
The utility of the result of an action not free from risk (equal to the expected utility of risky actions) is less then the expected value of an individual version of a risky event [10].

$$Eu(X) < u_2(EX)$$

The coordinator expecting a success (increase of SAR action effectiveness) prefers to make decision burden with a risk. He assumes that not making decision causes the decrease of the effectiveness of SAR action.

In the cases in which the uncertainty of events exists it is also possible to introduce the criteria of decisions.

The uncertainty often means the situation in which the coordinator knows the possible consequences of the undertaken actions, however he does not know the probabilities of their occurrence.

In fact when the decisions are made, the coordinator could consider different potential scenarios, however he is not able to determine the probability of their occurrence. In this case the different behavioral scenarios and different decisional criteria are proposed:

- pessimistic criteria – states that whatever decision is made the worst result is expected. Therefore for any possible decision the worst possible consequence should be pointed out and then the decision for which this consequence is better than for the others should be chosen. The worst consequence of SAR action is when the survivors are not found or they are found but not alive;
- optimistic criteria – states that whatever decision is made, always the best result is expected. Therefore it should be checked, which consequence is the best for any possible decision and then the decision for which this consequence is the best should be chosen. The best solution in SAR actions is finding of the search objects;
- rationality (Laplace) criteria – states that if the probabilities of the likely states of nature are unknown, it should be assumed that they are equal and the decision of the greatest expected utility should be chosen, this means that the maximum number of rescued survivors in given conditions;
- disappointment criteria – states that the decision connected with the possibly less disappointment should be chosen. To satisfy this objective the matrix of disappointments – unsuccessful action scenarios should be constructed.

The application of the above criteria in SAR actions carried out in different conditions can be crucial for their success.

Conclusions

The demands of the effective operation of SAR action coordinator are as follows [11]:

– accurate prediction,
– deep knowledge,
– synthesis for the extreme circumstances,
– infallibility,
– effectiveness, promotion and motivation.

The success of SAR action is directly dependent on the four following factors:

– accident parameters: place of accident, number of survivors, rescue units,
– hydrometeorological conditions,
– availability of life saving appliances,
– proper planning and conducting the rescue action.

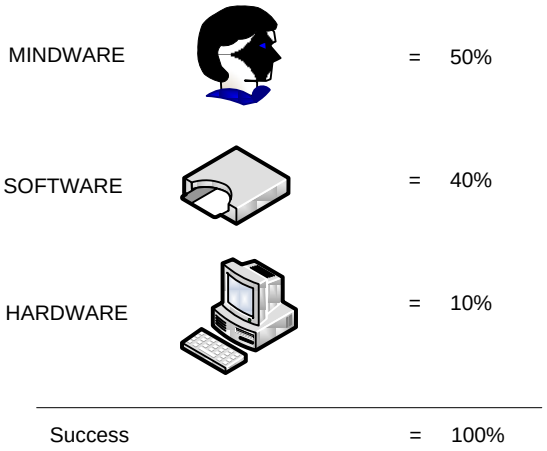

Fig. 4. Factors of success according to the research conducted in US [12]
Fig. 4. Czynniki „sukcesu" (warunkujące sukces) według badań przeprowadzonych w Stanach Zjednoczonych [12]

The coordinator leading the rescue action has got an influence on the last from the above mentioned factors only. He must adapt action plans, number of rescue units, search areas and methods of conducted search to the environmental conditions and theatre parameters.

The success of SAR action is mainly dependent on the decision of the coordinator. Conducting the action by the coordinator and his decisions are related with his psychophysical state which influences the search process.

The proper attitude towards a risk (underwriter, risk taker) is a critical factor in SAR action.

In the cases of insufficiency of life saving appliances, heavy weather conditions conducing the action by the coordinator having the extreme personal features can be a reason of success or complete fail of SAR action.

Therefore the examination of the individual features of coordinators and recognition of their aversion or inclination to risk with respect to the SAR action conditions is so important.

The tool used to assess the coordinators' attitudes can be the SAR action coordinator simulator.

This simulator allows for verification of SAR action coordinators in different action conditions.

Using the modern computer systems supporting decisional process, the decisions of the coordinator can be analysed without the influence of psychophysical elements.

The suggested decisional path is repeated as a standard. In critical situations accepting the same suggestion can result with different decisions made by the coordinator, in dependence on his attitudes towards a risk and his psychophysical condition.

The full range of data of the decisional process should allow to construct a system supporting the decisions with respect to the attitudes towards a risk of a particular coordinator.

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Recenzent:
prof. dr hab. inż. Bolesław Mazurkiewicz
Akademia Morska w Szczecinie