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THE POTENTIAL UNDERWATER RESCUE SCENARIO IN INCIDENT DEFINED BY DIVESMART PROJECT

ABSTRACT

This article is one of the series dedicated to the DiveSMART project conducted to better coordination of international underwater rescue operations in the Baltic Sea. The project DiveSMART Baltic has received Flagship status.

The article is the second from planned cycle of articles referring tasks realised in the Naval Academy in frame of DiveSMART project. It describes a potential scenario of an action carried out in order to determine which of the existing resources should be applied during underwater search and rescue operations. This subject is connected to the work package two 'Determine what resources should be in the database' of the DiveSMART project: Identify different platforms and vessels that the modules could be used on, the adjustment of the transport and rescue modules to these platforms and vessels.

Key words:
SAR, underwater search and rescue.

INTRODUCTION

An unexpected air hyperbaric exposition can occur as a result of submarine damage or survival of people in air traps following sinking of a surface vessel.

In the case of a submarine the crew is trained in damage control (survival) procedures, has access to rescue equipment and the submarine has resources designed to cope with some damage scenarios. An increase in pressure in one of the compartments may not affect the whole vessel. The vessel can retain some energy supplies and

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the crew can seal the vessel, and using compressors can put decompression under control. When the damage is extensive the crew has equipment which can be used to escape to the surface, preventing, in this way, their organisms from becoming saturated.

There do not exist any dedicated elements of the rescue system which people who have got stuck together with the sunken surface vessel could use to counter the effects of air saturation hampering the rescue operation. So far chances for survival of victims under such conditions have been viewed with skepticism. However the case of 'Harrison Okene' who survived for more than 62 hrs in a sunken tugboat 'Jascon-4', which had sunk in the Atlantic on 26 May, 2013 at the depth of 30 mH_2O about 30 km off the Nigerian coast requires a change in approach to this issue.

DEFINING A RESCUE OPERATION

The purpose of using a decision making simulation game is to diagnose the competence and equipment gaps in the context of current knowledge and experience. This scenario is focused on a search and rescue action conducted at sea carried out pursuant to the *International Convention on Maritime Search and Rescue* adopted in Hamburg as of 27th April, 1979. In the decision making game most of the elements accompanying a SAR operation will be omitted. During the exercise a ferry boat is to be searched for. In the hull of this sunken ferry boat a few people have been involved in air hyperbaric exposition in an air pocket.

Despite the fact that floating vessels are designed so as to lie on water at the moment they have lost stability following a collision, providing for high opportunities for abandoning the vessel and preventing people from being trapped inside the hull, and despite the fact that during penetrations of sunken vessels, many a time, bodies of people trapped in the sunken vessel are found, specialists, so far, have been convinced that survival in a wreck is highly unlikely, mostly due to hypothermia. However, the survival of 'Harrison Okene' for more than 62 hrs in the sunken tug boat 'Jascon-4' which had sunk in the 'Atlantic Ocean' on 26 May, 2013 at the depth of 30 mH_2O about 30 km off the Nigerian coast requires change in approach to this issue. The assumption will be the possibility to survive people in a wreck under hyperbaric condition equal to 30 mH_2O for the period of 72 hrs.

The main rescue vessel used for underwater rescue will be a mobile saturation complex type *AF*2 installed on board the vessel AHTS 'Bazalt' operated in support of LOTOS-Petrobaltic S.A. oil rigs. The navy ship ORP 'Lech' will be used to support underwater operations and a tug boat whose engine will produce not less than 800 kM, capable to carry heavy anchors for both of the vessels conducting underwater work, and to haul the rescue chamber for saturation divers.

Each rescue operation is carried out in different conditions. The decision--making simulation game must be based on one adopted scenario. Working out the scenario should involve specifying limitations which must be taken into account at the stage of generalizing conclusions.

RESCUE ASSETS

The rescue assets of the Polish Search and Rescue Service will be able, in this case, to be used only to a limited extent in support of the underwater rescue operation as they will be engaged in SAR procedures. They will be able only to accompany other assets acquired at hoc for the underwater rescue operation. These assets will be able to come from diving companies, The Polish Navy, Police, Border Guard or Fire Brigade.

The Fire Brigade, The Border Guard and The Navy refused to join efforts in building support for an underwater rescue action. The Police agreed to train diving specialists in order to employ their resources in support of an underwater rescue action.

It is possible that the refusal to cooperate is connected with assuming the obligation to allocate assets for such an action, which, so far, has not been part of the responsibilities of these services. Decision makers are afraid to voluntarily increase the scope of missions for the possessed resources, which has been built economically to suit execution of the missions allocated. Assigning additional responsibilities will disperse the assets and may cause their weakening high enough to decrease their efficiency in carrying out missions in the present zone of responsibility.

The concept of using uniformed services takes its origin in the results of the Swedish project carried out in 2013–2016. In this project enormous resources of 611 divers of uniformed services were diagnosed. However, this is not the case in Poland, where the resources are designed extremely economically just to carry out responsibilities which are derived the service's mission.

Despite the refusal of the Polish Navy to build the system for support of underwater rescue operations, the decision-making simulation game will take into account their resources, without engaging specialists from the Polish Navy in the exercise.

COLLISION SCENARIO

The initially adopted scenario of a rescue operation is codenamed Sewoul in memory of the accident of the Korean ferry MV 'Sewol' which happened in the morning on 16th April, 2014:

Conststruction: Ferry
Number passangers: ca 1000 (200 people missing)
Accident: Collision
Risks: Contaminated water
Depth: Trapped people max 30 m
Weather/Seastate: 1 m Waveheight / 8 m/s, Current 1 knot
Location: Open Sea. Baltic Sea, defined by Interreg
Period: All year around

Depending on the vessel involved in the collision some contamination can, additionally, happen. This contamination usually affects the water surface in the area. However, before sinking some polluting agents can flow into the inside of the ferry. There always exists a threat of pollution by oil-related products. Large vessels are at the same time small tankers as they carry substantial amounts of oil-related products necessary to operate vessels.

With the intrinsic of leak of oil-related products, they can start to burn and the products of burning can penetrate the wreck, contaminating the breathing air reserves remained in the hull.

In the assumptions to decision simulation game it has been adopted that an oil leak has taken place. It was, to a large extent, dispersed by waving and wind. Neither was there a case of fire of oil-related products.

ASSUMPTION TO DAMAGE CONTROL

Damage control (survival) will involve efforts aimed at saving people trapped in a sunken vessel in an air trap, having access to such an amount of free of uncontaminated breathing air that the content of carbon dioxide will not cause hypercapnia.

In the air trap there will be enough space for the survivors to stay clear of water. In the trap beverages such as mineral water and Coca-Cola, will be available but they have to be sought for in the water.

The survivors will have only typical clothes. They will be frightened, distraught, resigned but panic will not break out. They will accept their situation, waiting for death caused by hypothermia, placing their confidence of survival in their faith. The resources at their disposal will allow the survivors to survive for 72 hrs in the condition good enough to be saved.

THE ANALYSIS OF THE CONTEXT

The analysis of the context capable of ensuring the sufficient quality of conduct of an underwater rescue operation was carried out using the SWOT method.

Tab. 1. Generated strengths S, weaknesses W, opportunities O and threats T [own work]

S	1	possessed scientific research
	2	possessed scientific-research potential
	3	$SMER$ procedures
	4	$NSRS$ research
W	1	gap in knowledge
	2	gap in technology
	3	small experience base
	4	lack of specialists in hyperbaric rescue
	5	time pressure in underwater rescue operation
O	1	priority in UE
	2	international cooperation
	3	access to modern technologies within NATO
T	1	disappearance and lowering of the significance of hyperbaric centers
	2	low effectiveness of underwater rescue systems
	3	gaps in coordination of underwater systems with SAR
S (Strengths) — all that constitute a strong point, advantage, superiority of the analyzed system W (Weaknesses) — all that constitute weak point, barrier, disadvantage of the analyzed system O (Opportunities) — all that generate a chance for a positive change in the analyzed system T (Threats) — all that generate threats for negative change in the analyzed		

Tab. 2. The results of the analysis of association power between Strengths and Weaknesses, and Opportunities and Threats [own work]

		O. Opportunities			*T*. Threats		
		1	2	3	1	2	3
S. Strengths	1	0	1	1	2	1	0
	2	0	1	2	2	1	0
	3	0	2	2	2	1	0
	4	0	2	2	2	1	0
W. Weaknesses	1	2	2	2	2	2	2
	2	2	2	2	2	2	2
	3	1	1	1	1	1	1
	4	2	2	1	2	1	2
	5	0	0	0	0	0	2

0 no action
1 weak action
2 strong action

Tab. 3. The analysis results of implications for strong associations between strengths *S* and weaknesses *W*, and opportunities *O* and threats *T* [own work]

		O. Opportunities			*T*. Threats		
		1	2	3	1	2	3
S. Strengths	1				N		
	2			T	N		
	3		T	T	N		
	4		N	T	T		
W. Weaknesses	1	N	N	N	T	T	T
	2	N	N	N	T	T	N
	3						
	4	N	T		T		T
	5						T

The results of generating strengths and weaknesses as well as opportunities and threats are presented in table 1. The strengths include everything that constitutes the superiority or advantage of the analyzed system. The weaknesses include everything that constitutes the weakness, barrier or deficiency of the analyzed system. The opportunities include everything that generates a chance for a positive change in the analyzed system. The threats include everything that generates a threat of a negative change to occur in the analyzed system.

For the generated Strengths S, Weaknesses W, Opportunities O and Threats T for internal and external conditions relating to the execution of the scope of the project an analysis of the power of associations was carried out using the three-degree scale:
- 0 absence of association;
- 1 weak association;
- 2 strong association.

The results of the analysis of these associations are included in table 2. Numbering of the generated Strengths S, Weaknesses W, Opportunities O and Threats T for internal and external conditions relating to the execution of the project is identical for table 2 and table 3.

The analysis of implications of strong associations identified for the left side of table 3 was carried out by answering the questions below:
1. Will the strength allow us to seize the advantage?
2. Will the strength allow us eliminate the threat?
3. Does the weakness limit the possibility to seize the opportunity?
4. Does the weakness strengthen the risk associated with the threat?

The analysis results of implications for strong associations presented in table 3 have the same numbering for Strengths S, Weaknesses W, Opportunities O and threats T as in table 2 and table 3.

THE RESULTS OF THE ANALYSIS OF CONTEXT

Only strong associations were described, for which deterministic associations were identified in form of positive answers to the questions listed in table 3.

Will the possessed scientific research potential allow us to seize the opportunity of having access to the state of the art technologies within NATO?

It seems that the scientific research potential in Poland is capable of absorbing the achievements available within the NATO, operational, medical and technological.

It must be noted, however, that year by year the scientific research potential has become more and more modest since the 1990s and at the moment it has reached a residual state. This is associated with substantial reductions in financing of R&D programs in the broadly understood hyperbaric field. At the moment the prevalent view is that the present state of technology allows for replacing people with the remotely controlled system to do work under water. There is a tendency to forget rescue potential is indispensable, at least ,because of the fact that a human being will always try to stay under water, e.g. for recreational reasons.

Although submarines continue to be considered one of the most dangerous kinds of weapon, some regress in technologies in the field of submarine rescue can be noticed when compared with the state of the technology reached 20 years ago, despite efforts made to develop new systems, e.g. NSRS. The Polish experience in rescuing miners from a flooded mine shows that hyperbaric rescue is important not only with regard to human activity at sea, as such accidents may happen in mines, tunnels, under rivers, as a result of sinking of vessels operating on rivers, or during spelunking, etc.

Will the SMER procedures allow us to seize the opportunity for international cooperation under the framework DiveSMART?

The SMER procedures constitute a valuable base for the knowledge and procedures considered under the DiveSMART project. The results of the DiveSMART project will constitute development of the SMER procedures for the most difficult, unsolved scenario of an operation to rescue a crew from a distressed submarine DISSUB.

Underwater Diving Working Group NSO has not come into cooperation in this field, stating that this kind of activity is not covered by the tasks of this working group. Despite this, it seems justifiable to voice again the willingness to cooperate and also to submit a proposal for cooperation with The International Submarine Escape and Rescue Liaison Office (ISMERLO) and Submarine Escape and Rescue Working Group NSO (SMERWG).

Will the SMER procedures allow us to seize the opportunity of having access to state of the art technologies?

Access to the intellectual, technical and technological achievements of SMERWG constitutes an important base for the DiveSMART project. Further contact with manufacturers of rescue equipment may accelerate implementation of know-how needed in the DiveSMART project.

Will the NSRS research allow us to seize the opportunity of having access to state of the art technologies?

The NSRS research, like the SMER procedures and equipment, constitutes the key base for the DiveSMARTproject.

Will the NSRS research allow us to eliminate the threats relating to the disappearance of and lowered the prestige of hyperbaric centers?

The NSRS research is a good example of a solution which mitigates the effects of absence of government sponsoring in the field of hyperbaric research, leading to lowered prestige and disappearance of research activities by hyperbaric centers. Establishing a science-industry partnership in the presence of the needs in the defense or public areas is at the moment the preferred method in the EU. There exists a big chance to obtain *EU* sponsoring for industrial fulfillment of the needs, which will be an added value to the DiveSMART project.

Will the weakness concerned with the absence of qualified specialists limit the possibility for international cooperation?

It seems that the absence of qualified personnel in Poland hampers the international cooperation under the DiveSMART project. Efforts should be taken as soon as possible to promulgate the idea and publicize even small achievements made under the project. If it is possible, a rescue course which can allow training a wider group of specialists should be established. Then they could lobby for further research and implementations of the achievements initiated under the DiveSMART project, also in cooperation with industries.

Does the weakness relating to the gap in knowledge enhance the risk of disappearance of and lowered prestige of hyperbaric centers?

The gap in knowledge may result in calming emotions concerned with disappearance of and lowered prestige of scientific hyperbaric centers, whose mission have come the end. Hyperbaric treatment centers which are set up in Poland on massive scale may enhance the belief that the demand for their services has been satisfied by the market of medical services.

Does the weakness related to the gap in knowledge enhances the risk of threat posed by small effectiveness of underwater rescue systems?

The gap in knowledge, if it is not diagnosed under the DiveSMART project will enhance the threats of perpetuating the small effectiveness of underwater rescue. There is a hope, however, that fruitful execution of the tasks under DiveSMART project may, in future, significantly increase this effectiveness.

Does the weakness related to the gap in knowledge enhances the risk threat posed by the existing gap in coordination of underwater rescue with SAR?

This gap in knowledge, if it is not diagnosed, under the DiveSMART project will enhance the threat of perpetuating the weak coordination of underwater rescue during SAR operations. The basic result of the DiveSMART project will be to increase, in not the distant future, the effectiveness of underwater rescue in SAR operations.

Does the weakness related to the technological gap enhances the risk threat of disappearance of and lowered the prestige of hyperbaric centers?

The technological gap, if it is not diagnosed, under the DiveSMART project will continue to enhance the threat of lowered prestige of hyperbaric centers. An effort aimed at developing new hyperbaric equipment is a chance for development of these centers. The lack of such orders will enhance further stagnation.

Does the weakness related to the technological gap enhances the risk connected with the threat of the current low effectiveness of underwater rescue?

Undoubtedly, the technological gap makes it impossible to increase the effectiveness of underwater rescue. One of the basic tasks in the DiveSMART project is to completely diagnose this gap, to the extent possible.

Does the weakness related to the absence of specialist enhance the risk disappearance of and lowered prestige of scientific hyperbaric centers?

The influence of the lack of specialists on the disappearance of and lowered prestige of scientific hyperbaric centers is obvious. The lack of specialists does not produce any requirements to make use of such centers as places where knowledge is generated and transferred. If there is no demand the results of their activity, the scientific hyperbaric centers are doomed to have their prestige lowered and in the long run to disappear.

Does the weakness related to the lack of specialists enhance the risk of perpetuating the gap in underwater rescue coordination?

The lack of specialists is a significant impediment to changing the way in which underwater rescue issues are perceived. People who could lobby for bringing about the change are hard to find. The fact that uniformed services invited to cooperate under the DiveSMART project are not willing do so may be the result of this situation.

Does the weakness related to time pressure in conduct of an underwater rescue action enhance the risk of perpetuating the gap in underwater rescue coordination with SAR?

The short period of time from the moment an accident occurred to the moment of an underwater rescue action discourages from undertaking efforts aimed at solutions to be used in an underwater rescue action. This is connected with economic calculations concerning conduct of such an action. On the one hand life of a human being is invaluable and leaving survivors without a chance for help in such a stressful situation does not seem humanitarian. On the other hand, allocating substantial resources which may never be used causes resistance, as the resources allocated for this purpose can be put for a better use for less humanitarian activity.

It is undertaking the tasks under the DiveSMART project that should provide a strong base for working out an economic decision in relation to investing in underwater rescue.

A review of context has been made with regard to a potential scenario of an action carried out in order to determine which of the existing resources should be applied during underwater search and rescue operations has been presented in the article. This subject is connected to the work package two 'Determine what resources should be in the database' of the DiveSMART project: Identify different platforms and vessels that the modules could be used on, the adjustment of the transport and rescue modules to these platforms and vessels.

THE POTENTIAL UNDERWATER RESCUE SCENARIO

A theoretical wreck model of mf 'Jan Śniadecki' has been selected as an application-centered underwater rescue operation carried out in form of a decision making game.

Tab. 4. Main ferry lines to izobath of maximum up to 30 mH_2O

GDAŃSK — NYNASHAMN	
From the harbor of Gdańsk to the position $\phi =$ 540 00.9'N, $\lambda =$ 0180 47.0'E	distance of approx. 9 Nm
From position to the harbor of Nynashamn	distance of approx. 5 Nm
GDYNIA — KARLSKRONA	
From the harbor of Gdynia to position $\phi =$ 540 02.0'N, $\lambda =$ 0180 45.2'E	distance of approx. 6.5 Nm
From position $\phi =$ 550 59.9'N, $\lambda =$ 0150 34.9'E to the harbor of Kalskrona	distance of approx. 9 Nm
ŚWINOUJŚCIE — TRELLEBORG	
From the harbor of Świnoujście to position $\phi =$ 540 44.8'N, λ = 014^{0} 14.4'E	distance of approx. 50 Nm
From position $\phi =$ 550 17.7'N, $\lambda =$ 0130 09.2'E to the harbor of Ystad	distance of approx. 5 Nm
ŚWINOUJŚCIE — YSTAD	
From the harbor of Świnoujście to position $\phi =$ 540 44.8'N, $\lambda =$ 0140 14.4'E	distance of approx. 50 Nm
From position $\phi =$ 550 21.0'N, $\lambda =$ 0130 48.0'E to the harbor of Ystad	distance of approx. 4.5 Nm

The collision scenario assumes 30 mH_2O as the maximum depth for an for search and rescue operation — figure 1a. Table 1 shows main ferry lines between Poland and Sweden with the marked area of maximum depth up to 30 mH_2O. In order to carry out an application-centered underwater rescue action in form of a decision game a theoretical object of a wreck of the ferry mf 'Jan Śniadecki' was selected — figure 1b.

The car and train ferry mf 'Jan Śniadecki' operated between Ystad and Świnoujście every day. The ferry carries only drivers and truck crews so the scenario for the exercise differs from the one adopted as a model scenario with regard to the number of victims.

Fig. 1a. The alleged position of sinking of mf 'Jan Śniadecki' [own work]

Fig. 1b. Mf 'Jan Śniadecki' [http://ferry-site.dk/ferry.php?id=8604711&lang=en (access 06.04.2017)]

MARITIME ACCIDENT

0850 MRCK[1] was notified of a probable explosion aboard mf 'Jan Śniadecki' on her way to Ystad. Probably the freight train carrying ammonium sulphate exploded. The ferry sank immediately. Probably, there could be some people in air zones still alive. The highest probability for survival relates to the crew of the engine watch, who could have been trapped in an air cushion ECR[2].

INITIAL STAGE OF INITIATING SUPPORT

MRCK Gdynia agreed with the duty detail of the Polish Navy that they would take over the coordination of the underwater rescue operation, whereas MRCK would coordinate the SAR[3] operation.

0920 The duty detail of the Naval Academy was notified that some people may have survived in the sunken boat and a request was made for consultations concerned with organizing the underwater rescue operation.

0930 The head of Underwater Work Technology was notified and asked for urgent consultation.

Fig. 2. AHTS 'Bazalt' with diving complex *AF*2 placed aft [http://www.tsmanagement.pl/flota (access 06.04.2017)]

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1 **M**aritime **R**escue **C**oordination **C**entre.
2 **E**ngine **C**ontrol **R**oom.
3 **S**earch **a**nd **R**escue.

STAGE OF ANALYZING POSSIBILITIES

The Naval Academy carried out consultations concerned with the possibility of carrying out an underwater rescue operation. It appeared that system for saturation diving $AF2$ placed on board the AHTS 'Bazalt' (fig. 2) is available and ready for use. The owner of the system was LOTOS-Petrobaltic S.A., and it was prepared for use by the Naval Academy. To use this equipment permission by the Supervisory Board of LOTOS-Petrobaltic S.A. is required.

Fig. 3. OPR 'Piast — ORP 'Lech's' sister with diving bell visible
[http://www.mw.mil.pl/index.php?akcja=piast (access 06.04.2017)]

The height of the ferry mf 'Jan Śniadecki', over $h > 38$ m and breadth $l > 23$ m at the deapth in the area of sinking below $H < 30\ mH_2O$, indicates that the ferry will protrude above the water surface or she will lie just below the sea level, generating a potential threat of collision with the wreck. It was necessary to immediately send a vessel to the area to recognize the underwater situation. Using the availability analysis the ORP 'Arctowski' was selected for this mission — figure 4. A specialist in rescue operations should be on board the vessel so that he could plan anchorage for the rescue force which will be sent to the area of the accident.

Fig. 4. The ORP 'Arctowski' [https://pl.wikipedia.org/wiki/ORP_Arctowski (access 06.04.2017)]

Normally the ORP 'Lech' uses four Hall anchors weighing approximately $m \cong 1250$ kg and the AHTS 'Bazalt' uses an anchorage composed of two Hall anchors fore and two dead anchors aft weighing approximately $m \cong [6000; 7000]$ kg. It is need another AHTS ship for handling anhors, e.g. AHTS 'Bazalt'. The initial analysis of the anchorages indicated a collision of anchor cables — figure 6.

A solution to this situation can be deploying heavy anchorage composed of dead anchors weighing approximately ca. $m \cong 6000$ kg. However, the AHTS 'Bazalt' will use her own anchors placed fore in order to be able to quickly withdraw from the place of work — figure 7. As a result of an analysis the AHTS 'Agat' owned by LOTOS-Petrobaltic S.A. (fig. 5), was chosen as a vessel to be tasked with collecting and deploying anchors.

Fig. 5. AHTS 'Agat' [http://www.shipspotting.com/gallery/photo.php?lid=1453799 (access 06.04.2017)]

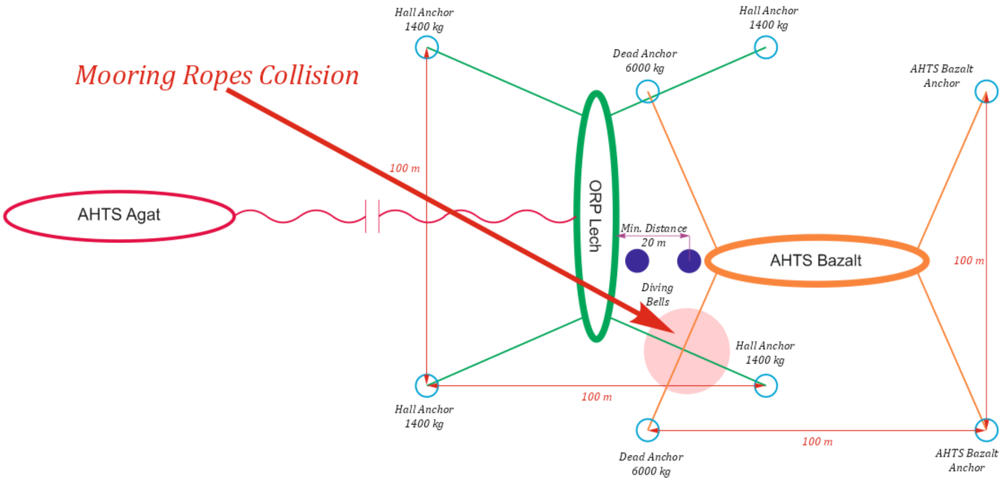

Fig. 6. Initial analysis of cooperation between AHTS 'Bazalt's' and ORP 'Lech's' own anchors [own work]

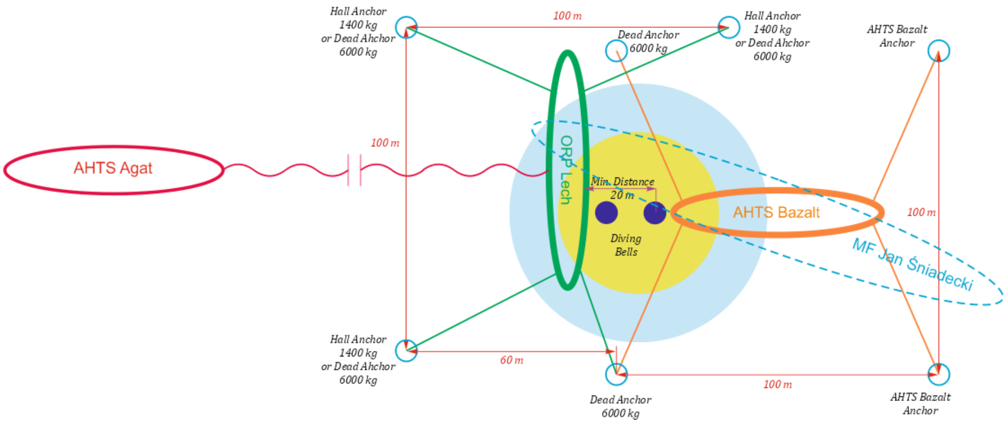

Fig. 7. A variant of common anchorage for the AHTS 'Bazalt' and ORP 'Lech' [own work]

Still, another variant is to use a group of floating vessels secured to ground with an anchorage composed of four dead anchors weighing approximately $m \cong 7000$ kg. In this case, however, the distance between the bells will be 35 m. Carrying a victim to the rescue bell becomes problematic. Outside the wreck this task should be taken over by support divers. In such a case, thrusters in the vessels allow for easy disconnection of the set or for support in easy transit over the place of operation, outside the time when diving operations are carried out.

Once the anchors have been deployed the AHTS 'Agat' will remain on standby to assist the ORP 'Lech' and AHTS 'Bazalt'. She can also be used for the rescue operation in case the evacuation chamber for saturation divers has to be hauled.

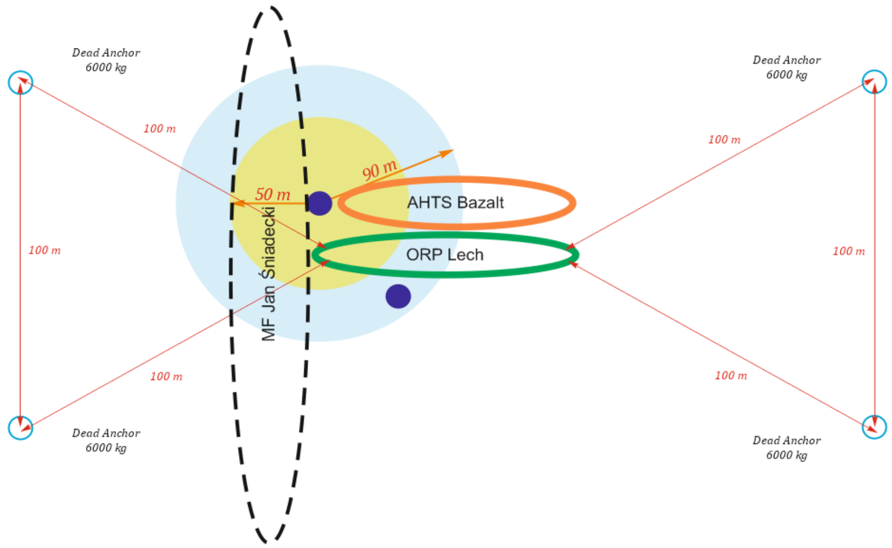

Fig. 8. A variant of the set for the AHTS 'Bazalt' and ORP 'Lech' [own work]

In the rescue operation the bell in complex $AF2$ placed on board the AHTS 'Bazalt' will be used as a working bell for the divers penetrating the wreck in Heliox saturation[4]. Four divers can be kept in saturation environment. This allows for work for 24 hrs a day. Two divers work during a 12 hrs long shift, for 4 hrs outside the bell. The divers can be kept in the bell up to 4 hrs in total. In a rescue operation divers can extend the time of staying outside the bell up to 6 hrs per diver.

The diving bell in complex $AF2$ can be equipped with two kinds of umbilical — 35 m/100 m. The possible radius of operation of the divers is marked in figure 7. In support of placing the umbilical the AHTS 'Bazalt' can assign two divers working in air surface supplied equipment outside the zone of saturation diving, one working and one rendering assistance in case of need. The same underwater support can be provided by the ORP 'Lech'.

The diving bell in the ORP 'Lech' will be used the rescue bell and will serve as shelter for survivors. Both bells are of the same dry type, capable of transporting people under pressure to a diving complex.

The diving complex in the ORP 'Lech' is not fully equipped for conducting saturation. Nevertheless, it can be used in a rescue operation. Wastes can be transported by means of lockage through one of the chambers in the hyperbaric complex. Regeneration of atmosphere will be achieved through constant ventilation or use of

[4] As he remains on standby having appropriate work and emergency gases on board.

the internal regeneration systems. The partial lowering of oxygen can be achieved through thinning the atmosphere with Nitrox, e.g. by using the oxygen line.

In order to support the underwater rescue action ROVs[5] type Seaeye Falcon, which are part of the ORP 'Lech's' and AHTS 'Bazalt's' equipment (fig. 8), will be used.

STAGE OF THE RESCUE FORCE GETTING UNDER WAY

1010 An M-28B 'Bryza'-1R plane having the side number 1017 was sent to the scene of the accident to carry out aerial reconnaissance.

1011 The Hydrographic Bureau of the Polish Navy was notified of the necessity to provide updated weather forecast for the accident area every hour.

1011 Mobilization of the ORP 'Lech's' crew and the team of divers from LOTOS-Petrobaltic S.A. was ordered.

1012 The ORP 'Arctowski' left the navy harbor in Gdynia to carry out a reconnaissance mission. The expected time of arrival, for the speed of 12 knots (max. 13.7 kn) over the distance of approximately200 Nm, will be 17 hrs.

1015 The first helicopter to transport a rescue specialist to the ORP 'Arctowski' was put on standby at the aerodrome of the Polish Navy Aviation Brigade. Reserve Cmdr Stanisław Skrzyński, Ph.D. was chosen for this task.

Fig. 9. Seaeye Falcon [advertisement materials]

1055 The M-28B 'Bryza'-1R having the side number 1017 reached the scene of the accident. No protruding elements were noticed. Hence, a conclusion was drawn that the mf 'Jan Śniadecki' was lying on her side.

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5 **R**emotly **O**perated **V**echicle.

Fig. 10. The M-28B Bryza-1R having the side number 1017
[https://pl.wikipedia.org/wiki/Brygada_Lotnictwa_Marynarki_Wojennej#/media/File:M-28_Bryza.jpg (access 06.04.2017)]

1110 After collecting anchors from the storage pile in the base of LOTOS--Petrobaltic S.A. in Gdańsk-Przeróbka the AHTS 'Agat' left for the scene of the accident. The expected arrival time, for the speed of 9 *w* over the distance of approximately 200 Nm, was approximately 22 hrs.

1412 The helicopter W-3WARM 'Anakonda' having the side number 0815 took off from the aerodrome of Babie Doły with maritime rescue specialists on board in order to transfer them at sea to the ORP 'Arctowski'.

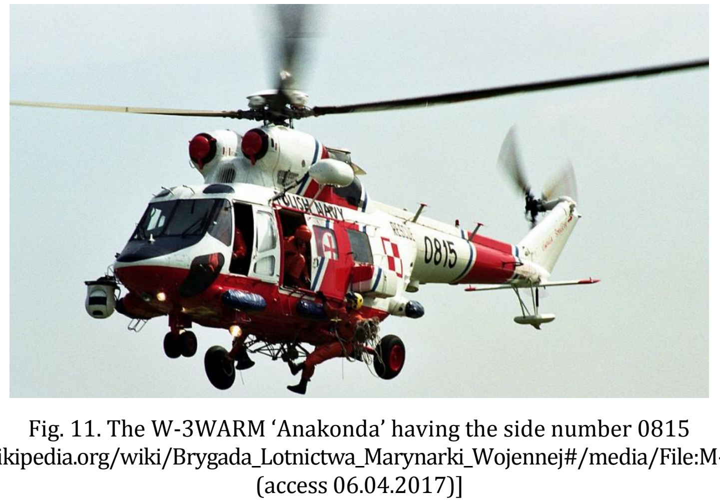

Fig. 11. The W-3WARM 'Anakonda' having the side number 0815
[https://pl.wikipedia.org/wiki/Brygada_Lotnictwa_Marynarki_Wojennej#/media/File:M-28_Bryza.jpg (access 06.04.2017)]

1508 The airborne transfer of rescue specialists was completed, an then the W-3WARM 'Anakonda' having the side number 0815 was able to return to the aerodrome of Babie Doły.

1530 The mobilization of the AHTS 'Bazalt's' crew and divers was completed. The tug boat left for the place of the accident. The expected time of arrival, for the speed of approximately 9 kn (max. 10 kn) over the distance of approximately 200 Nm, was approximately 22 *hrs*. The moment the harbor was left the diver compression process to the saturation plateau of 12 mH_2O was begun.

The mobilization of the ORP 'Lech' crew and divers was completed and the ship left for the place of accident. The expected time of arrival, for the speed of approximately 14 kn (max. 16 kn) over the distance of approximately 200 Nm, was approximately 14 hrs.

STAGE OF REACHING THE SCENE BY THE RESCUE FORCE

0250+1 day The ORP 'Arctowski' reached the scene of the accident and began scanning the bottom.

0429+1 day The scanning of the bottom was completed and the plan for deploying anchors was worked out. The plan was radioed to the AHTS 'Agat'. After reporting the completion of her mission and making some arrangements with MRCK 'Gdynia' the ORP 'Arctowski' remained at the scene of the accident in order to support the AHTS 'Agat' deploying anchors.

0551+1 day The ORP 'Lech' reached the area of the accident.

0811+1 day The rescue specialist were transferred from the ORP 'Arctowski' to the ORP 'Lech'. A rescue decision making game was carried out and a plan for penetration of the sunken boat was worked out on the basis of the data supplied by the ORP 'Arctowski'.

0932+1 day The AHTS 'Agat' reached the scene of the accident and commenced deploying anchors in accordance with the received plan.

1100+1 day The AHTS 'Agat' reported the conclusion of deploying anchors and making sure they were deployed in accordance with the received plan. The ORP 'Lech' commenced anchoring.

1140+1 day The ORP 'Lech' concluded anchoring and was getting ready to carry out reconnaissance using tele-controlled ROVs and divers operating in surface supplied diving equipment. The reconnaissance was expected to real the wreck penetration plan.

1302+1 day The AHTS 'Bazalt' reached the scene of the accident. Immediately, the initial reconnaissance carried out from the board of the ORP 'Lech' was concluded. The rescue specialists were transferred from the ORP 'Lech' to the AHTS 'Bazalt'. Steps were commenced to anchor and get the AHTS 'Bazalt' ready for work.

1452+1 day Preparation of the ORP 'Lech' and the AHTS 'Bazalt' for underwater work was completed.

CONCLUSIONS

It seems that at present heavy rescue equipment cannot reach a wreck in the Baltic Sea region and a rescue operation cannot be undertaken within the first 24 hrs of an accident.

At present a rescue operation supported by divers can only be carried out at low sea states of up to 3°B and wind of up to 4°B. Hence, it follows that underwater rescue is only possible in relation to accidents which are not caused by weather conditions, such as strong wind or sea state. Despite the humanitarian premises, building a dedicated[6] rescue system which would use equipment for saturation diving does not seem profitable from the financial point of view. From the economic point of view, i.e. after considering social effects, it seem rational to coordinate the support system employed to rescue people at sea with the resources developed for sea exploration purposes, such as equipment used for maintenance of underwater fields where oil or gas is obtained from the sea bottom or those used to rescue submarine crews.

To build such a system within the framework of submarine rescue bodies can bring about benefits for civilian rescue, at the same time enhancing the effectiveness of submarine rescue. Assigning such tasks to submarine rescue units and providing them with capabilities necessary to carry out civilian rescue seems profitable from the economic point of view and possible to implement.

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[6] Such role could be played by submarines having a diver compartment equipped for saturation diving, e.g. the French (1; 2).

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POTENCJALNY PRZEBIEG AKCJI RATOWNICZEJ DLA KATASTROFY ZDEFINIOWANEJ W PROJEKCIE DIVESMART

STRESZCZENIE

Artykuł należy do serii dotyczącej projektu DiveSMART, który związany jest z zapewnieniem lepszej koordynacji międzynarodowej akcji ratownictwa podwodnego w rejonie Morza Bałtyckiego. Projekt ten otrzymał status „projektu flagowego".

Artykuł jest drugim z planowanego cyklu opisującego realizację zadań przez Akademię Marynarki Wojennej w ramach harmonogramu projektu DiveSMART. Opisano w nim potencjalny przebieg mobilizacji w akcji ratowniczej z wykorzystaniem istniejących zasobów możliwych do wykorzystania w ratownictwie podwodnym. Przeprowadzona gra decyzyjna jest związana z realizacją drugiego pakietu roboczego projektu DiveSMART pt. „Określenie zasobów, które powinny znajdować się w bazie danych", polegającego na zidentyfikowaniu różnych jednostek pływających, na których możliwy jest transport i wykorzystanie sprzętu ratowniczego.

Słowa kluczowe:

SAR, poszukiwania i ratownictwo podwodne.