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FLYING MEANS OF ATTACK OF SHIPS, POSSIBLE TO BE USED BY A POTENTIAL ENEMY — ANALYSIS OF THE THREATS FOR SHIPS THE POLISH NAVY

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ABSTRACT

The article presents the analysis of the threats to Polish Navy ships resulting from the development by the Baltic Sea countries of missile systems or turbojet missiles. The most popular varieties and types of missiles that could be used against Polish Navy vessels were described and classified taking into account mainly the potential of the Baltic Fleet of the Russian Federation (BF FR), as well as an analysis of the latest global trends in the area of counteracting these missiles. The article presents the conclusions drawn from exemplary simulations of the attack of modern anti-ship missiles. The article also contains references to the ways of determining the probability of avoiding a rocket attack and the measure of the effectiveness of self-defence of attacked ships. The work contains conclusions regarding desirable traits from the systems of self-defence of ships on the modern battlefield with particular emphasis on the character of the Polish Navy. The article presents an analysis of the threats to ships of the Polish Navy, resulting from the development in the Baltic Sea countries, missile/turbojet anti-ship systems. Were described and classified most popular varieties and types of missiles applicable to fight Polish Navy ships and described latest global trends counteracted against these missiles. The article presents the conclusions drawn from exemplary simulations of the attack of modern anti-ship missiles. The article also contains references to the ways of determining the probability of avoiding a rocket attack and the measure of the effectiveness of self-defence of attacked ships. The work contains conclusions regarding desirable traits from the systems of self-defence of ships on the modern battlefield, with particular emphasis on the nature of the Polish Navy.

Key words:

marine combat systems, safety and protection of shipping, armaments and specialized equipment, port and critical infrastructure protection, armament and specialist equipment, anti-ship systems of the potential enemy, self-defence and ship masking systems.

Research article

INTRODUCTION

During the war, Poland's goal in the Baltic will be to refute any aggression from the maritime direction against its own territory. The Navy will not achieve this goal alone, but participating in the combined activities of all types of armed forces, conducted with the cooperation of allies (Article 5 of the Washington Treaty). From the northern (sea) direction, it is likely to take out possible air strikes and launch rocket attacks (including from long distances by warships).

The system of political and military forces in the basin of the Baltic Sea and the course of the latest conflicts on the international arena indicate that the most important means of fighting ships of the Polish Armed Forces will most probably be Anti-Ship Missile munitions (ASM). The ability to launch ASM from platforms: air, surface, underwater or land causes that these types of missiles are the basic weapon for fighting surface units. A characteristic feature of ASM is that they enable effective attacking of ships and ships without directly exposing themselves to the fire reaction of the directly attacked sea unit or convoy. The ASM includes both subsonic (0.9 M) and supersonic shells ASCM[1] (2 M+) flying at low altitude (so-called sea skimmers).

Due to the current international situation, it seems advisable to analyse separately the possibilities of FB FR. In the first place, however, to present the impact potential of other countries in the region. The list of anti-shipment guided missiles located on the armaments of the Baltic Sea region, including NATO members, is presented in tab. 1.

Tab. 1. List of anti-missile missiles of the Baltic Sea basin countries [based on 'Jane's Fighting Ships, 2017–2018', ed. by Commodore Stephen Saunders RN, pp. 291–297, 248, 200–205, 794–796, 584–586]

State	**Carrier**	**SSM missile**	**Characteristic**		
			Speed [Mach]	**Range** [km]	**Weight of the war-head** [kg]
Germany	FFGHM Bremen (type 122)	SSM McDouglas Harpoon	0.9	130	227
Germany	FFGHM Brandenburg (type 123)	SSM Aerospatiele MM 38 Exocet	Sea skimmer 0.9	42	165

[1] Anti-ship cruise missiles.

State	**Carrier**	**SSM missile**	**Characteristic**		
			Speed [Mach]	**Range** [km]	**Weight of the war-head** [kg]
Germany	FFGHM Sachsen (type 124)	SSM McDouglas Harpoon Block 1D	0.9	95	227
Germany	FFGHM Baden--Wurttemberg (type 125)	SSM McDouglas Harpoon Block II	0.9	130	227
Germany	FSGHM Braunschweig (K130)	Saab RBS15 Mk3	0.9	200	200
Finland	PTGM Hamina/Rauma	Saab RBS15F	0.8	100	200
Denmark	AGF/AKR/AH Absalon FFGHM Iver Huitfeldt	Boeing Harpoon Block II	0.9	124	227
Sweden	FSGH Visby FSG Gavle PBO Malmo	RBS15 Mk II	0.8	110	150
Norway	FFGHM Fridtjof Nansen PTGMF Skjold	SSM Kongsberg NSM	0.95	185	120

From the quoted data, it appears that naval forces of individual countries have a limited number of types of ASM (Germany — 2 types, Finland — 1 type, Denmark — 1 type, Sweden — 1 type, Norway — 1 type). Depending on the version of the rockets, they differ in the range of destruction, which affects the tactics of using this type of weaponry. Taking into account the speed parameter, the vast majority of the presented missiles are moving at a speed close to 1 Mach. The value of combat is also determined by the weight of the warhead.

The comparison of the ASM on the armaments of FB FR is presented in tab. 2. Analysing its contents, it is easy to notice that the direction of development of the rods in Russia was aimed at increasing their speed, resulting in values of even 4.5 Mach in the attack phase that the Sunburn missile achieves.

Tab. 2. List of anti-ship missiles on equipment of FB FR forces [based on 'Jane's Fighting Ships, 2017–2018', ed. by Commodore Stephen Saunders RN, pp. 688–700]

Carrier	**SSM missile**	**Characteristic**		
		Speed [Mach]	**Range** [km]	**Weight of the warhead** [kg]
Sovremenny	Raduga SS-N-22 Sunburn	Sea-skimmer 2.5–4.5 (attack)	110	300 HE
Neustrashimy Gepard Steregushchiy	SS-N-25 Switchblade (Kh 35E Uran)	0.9	130	145
Tarantul	Raduga SS-N-2D Styx	0.9	83	513
	Raduga SS-N-22 Sunburn	Sea-skimmer 3.0 (attack)	160	200 HE
Nanuchka III	Cholomey SS-N-9 Siren	0.9	110	500 HE

A list of jet planes carrying out tasks over the Baltic Sea, which may be carriers of anti-ship missiles, is presented in tab. 3.

Tab. 3. List of jet planes performing tasks over the waters of Baltic Sea [based on 'Jane's Fighting Ships, 2017–2018', ed. by Commodore Stephen Saunders RN, p. 701]

Jet engine aircraft			
	Mig 29 KUB	Su-33 Flanker D/Su-33 UB	Su-24 Fencer C/D/E
Operating speed [km/h]	1400	2500	1.15 Mach
Range [km]	2600	4000	1755
Weapons	AAM, ASM, classic bombs 30 mm on-board gun	10 AAMs (AA-12, AA-11, AA-8) 30 mm on-board gun	on-board gun and various equipment for fighting sea targets

Ship's forces (single ships, teams and tactical groups) during a stop in the port, sea crossings and conduct activities are exposed to strikes and attacks from submarines, surface ships, sea-going air forces and enemy's surface missile units, as well as mine weapons and forces diversionary.

Rarely is it possible to strictly separate threats from air and sea surface and types of combat operations, therefore threats of different character should be expected. Effective planning and running of AWW (Above Water Warfare) depends on the application of principles common to all forms of combat operations. The combat threats of vessels operating in the modern Maritime Theatre of War Act result mainly from the type of means of destruction used by the enemy and the intensity of this agent's influence on the ship [2].

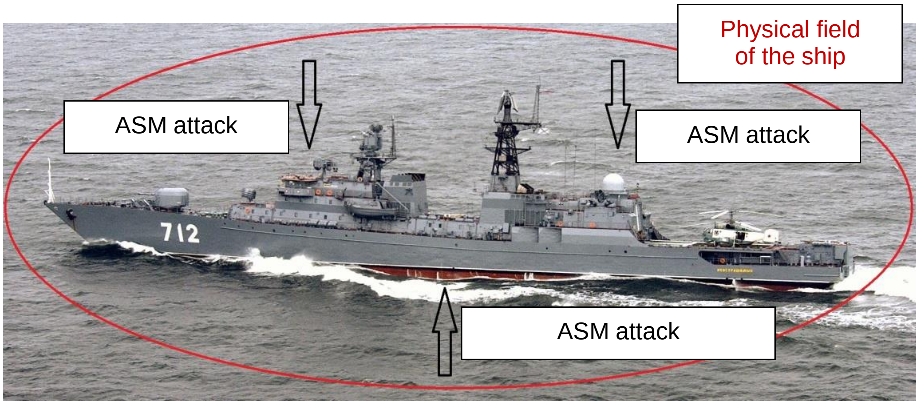

Fig. 1. Ship as a physical object exposed to various warfare agents [8]

The article presents the analysis of the threats to Polish Navy vessels resulting from the development (by the state not necessarily us friendly) of missile systems or turbojet missile missiles. It should be emphasized that the distribution of anti-ship means for missiles with the basic rocket and turbojet propulsion determines the threat that the missile is for Polish Navy vessels (due to the speed and flight time achieved). It should also take into account additional factors such as stealth technology used or not, manoeuvrability of the projectile and mass and effectiveness of the warhead. An additional factor posing a threat is the flight path itself in the final phase of the attack.

MEANS OF ATTACK BY POLISH NAVY SHIPS, WHICH ARE POSSIBLE TO BE USED BY A POTENTIAL ENEMY

The article will mainly discuss missiles that can be used by a potential enemy, their capabilities also to allied units, so that the material presented in the article is not treated as an element of information or advertising war of armaments producers. The means of attack of Polish Navy vessels can be divided due to the basic propulsion used, as shown in tab. 4.

Tab. 4. Classification of missiles due to the main propulsion used [5]

Name	View of the projectile
Rocket Baseline Missile	
Turbojet Baseline Missile	
Ramjet Baseline Missile	

Presented types of basic drives determine their range of use, which is shown in fig. 2 [5]. A classic solid rocket engine is characterized by a low specific impulse expressed in seconds. The engine thrust is carried out in a relatively short period of time, but the missile can reach very high speeds expressed in Mach number [Ma].

In the case of turbine engines, the optimal range of operation is the subsonic range, where we have the highest impulse expressed in seconds, low fuel consumption, and thus a long working time. Missiles with this type of propulsion require an auxiliary rocket launcher at take-off from land or naval launchers. It is inappropriate to call such missiles — missiles, and the media often mislead the public opinion. Fig. 3 shows the efficiency of drives with examples of engine performance as shown in fig. 2.

The threat of attacking ships of the Polish Armed Forces, as well as the area of the entire region, was noticed by the CSIS think tank, the Centre for Strategic and International Studies, based in Washington (United States) and characterized as follows [3]. 'As the heir to the rich Soviet missile arsenal, Russia boasts the widest supply of ballistic and cruise missiles in the world. Russia remains the main force in the development of all types of missiles, and Russia's strategic missile forces are an important element of the Moscow military strategy. Russian missiles carry out a wide range of missions, from anti-access/denying access to areas in local conflicts to the possibility of using strategic nuclear weapons on all continents. A significant modernization program is underway, and new variants of both ballistic missiles and self-steering missiles are being manufactured in Russia with significantly new possibilities. Russia is also making significant progress in the field of precision missiles' (fig. 4, tab. 5).

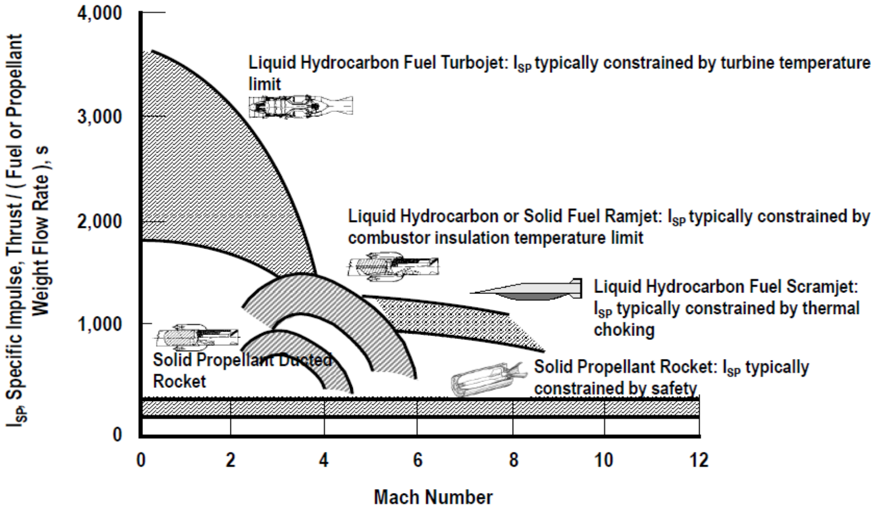

Fig. 2. The dependence of the specific impulse expressed in seconds depending on the propulsion engine used in the projectile [5]

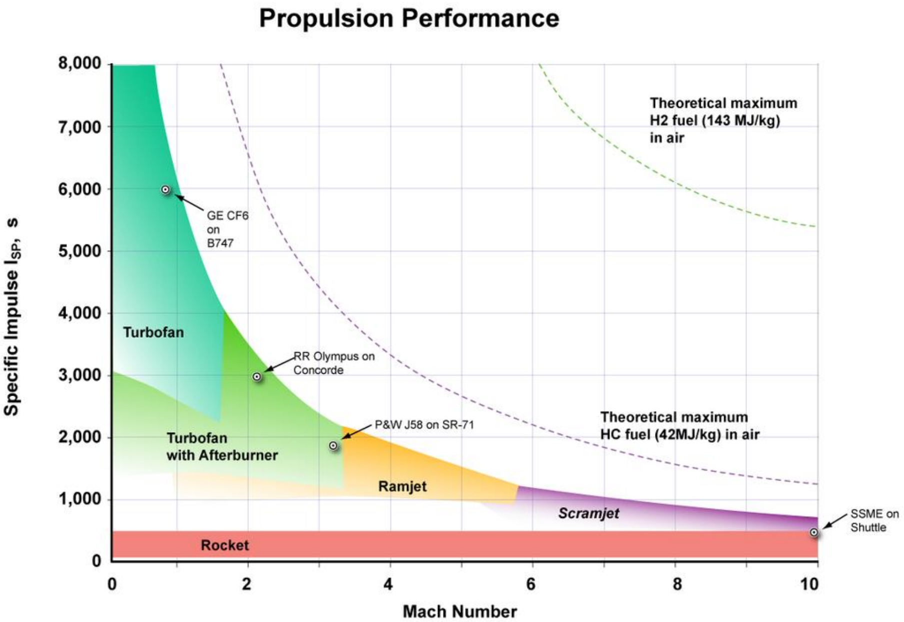

Fig. 3. Relation of the specific impulse expressed in seconds depending on the propulsion engine used in the projectile [https://commons.wikimedia.org/w/index.php?curid=10086744 (access 27.04.2018)]

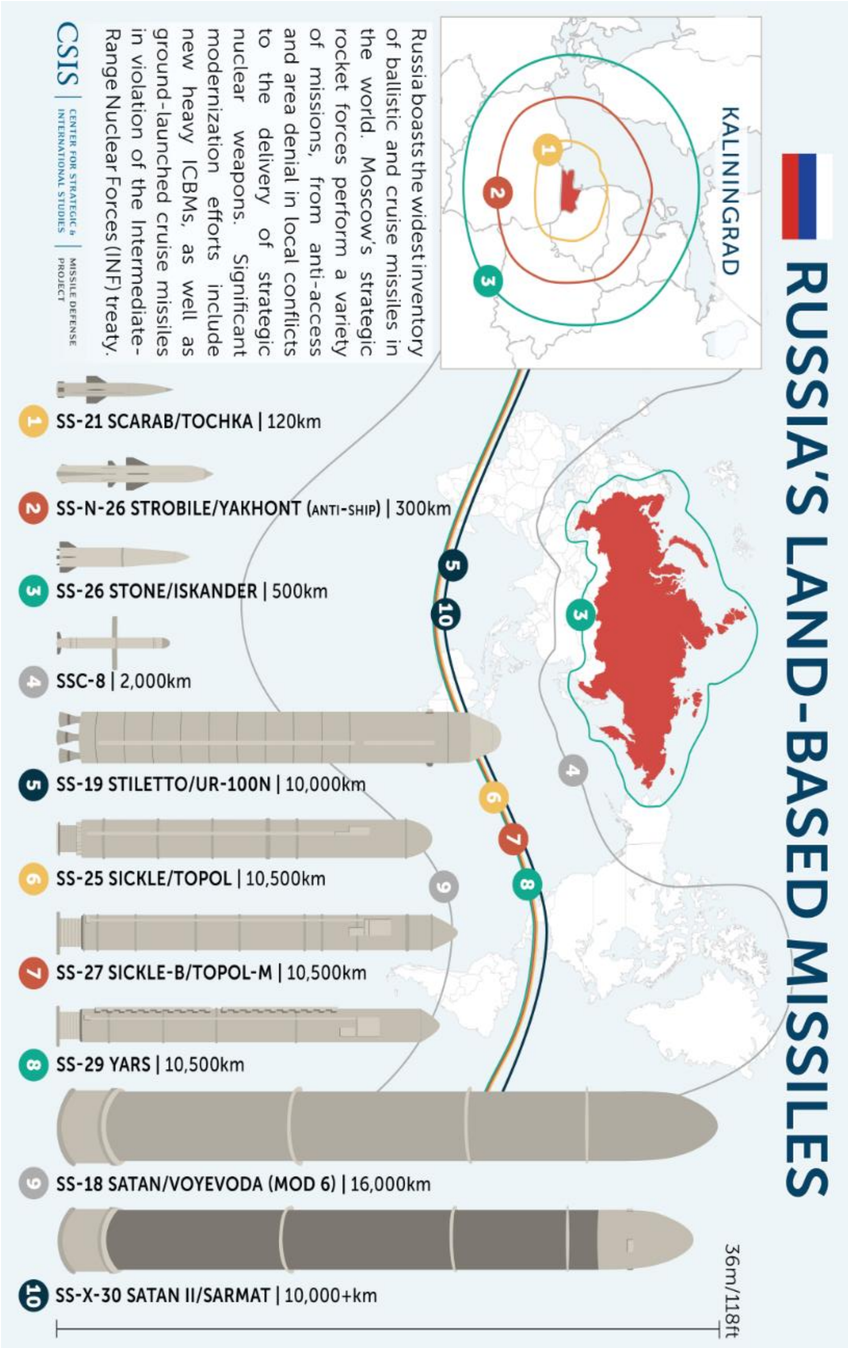

Fig. 4. Russian missiles perform a wide range of missions [https://missilethreat.csis.org/country/russia/ (access 27.04.2018)]

Tab. 5. Types of missiles used and developed (Missile Types)
[https://missilethreat.csis.org/country/russia/ (access 27.04.2018)]

Missile	Class	Range	Status
Kinzhal	ALBM[2]	1500–2000 km	Operational
SS-X-31 (RS-26 Rubezh)	ICBM[3]/IRBM[4]	2000–5800 km	In development
SS-X-30 'Satan II' (RS-28 Sarmat)	ICBM	10 000+ km	In development
RS-24 Yars	ICBM	10 500 km	Operational
SS-27 'Topol-M'	ICBM	11 000 km	Operational
SS-25 'Topol'	ICBM	10 500–11 000 km	Operational
SS-20 'Saber'	IRBM	5000 km	Obsolete
SS-19 'Stiletto'	ICBM	10 000 km	Operational
SS-18 'Satan'	ICBM	10 200–16 000 km	Operational
SS-N-27 'Sizzler'	ASCM[5]	220–300 km	Operational
SS-26 'Iskander'	SRBM[6]	500 km	Operational
SS-21 'Tochka'	SRBM	70–120 km	Operational
SS-N-32 'Bulava'	SLBM[7]	8300 km	Operational
SS-N-23 'Skiff'	SLBM	11 000 km	Operational
SS-N-18 'Stingray'	SLBM	6500 km	Operational
SS-N-30A 'Kalibr'	LACM[8]	1500–2500 km	Operational

MEANS OF ATTACK BY POLISH NAVY SHIPS, WHICH ARE POSSIBLE TO BE USED BY A POTENTIAL ENEMY — HYBRID TANDEM DRIVE UNITS

SS-N-26 'Strobile' (P-800 Oniks)/Yakhont/Yakhont-M/Bastion (launch systems) — Russian anti-ship cruise missiles developed by NPO Mashinostroyenia [3]

The SS-N-26 'Strobile' (P-800 Oniks)/Yakhont/Yakhont-M are Russian anti-ship cruise missiles developed by NPO Mashinostroyenia. There are three known variants of the missile. The ship-launched variant is known as the P-800 Oniks and has been designated the SS-N-26 'Strobile' by NATO. The export variant of the ground-launched

[2] An air-launched ballistic missile.
[3] Intercontinental ballistic missile.
[4] Intermediate-range ballistic missile.
[5] Anti-ship cruise missiles.
[6] Short-range ballistic missile.
[7] Submarine-launched ballistic missile.
[8] Land-attack cruise missiles.

version is known as the Yakhont. An air-launched variant was developed in 1999 and is known as the Yakhont-M. A sub-launched version has been proposed and is suspected to be fitted to *Yasen*-class attack submarines. The Oniks can be ground launched using two variants of Bastion launch system: the stationary Bastion-S, and the transportable Bastion-P. This Oniks/Yakhont/Yakhont-M has a range of 300 km. The ASM variant is 8.3 m long, while the SSM variants are slightly longer at 8.6 m. All variants have a diameter of 670 mm and a launch weight of 3000 kg. The missiles have both an active and passive inertial navigation system and are equipped with either a 200 kg high explosive or 250 kg semi-armour piercing warhead. The missiles are powered by a solid propellant, ramjet motor. Improvements were made in 2002 in the form of updating the previous terminal seeker with an active radar seeker and imaging infrared seeker.

<u>Main characteristics:</u>
Originated from: Russia;
Possessed by: Russia, Indonesia, Syria, Vietnam;
Alternate names: SS-N-26 'Strobile', P-800 Oniks, Yakhont, Yakhont-M, (Bastion-P, Bastion-S launch systems);
Class: anti-ship cruise missile (ASCM);
Basing: air-, ship-, sub-launched;
Length: 8.6 m for surface-to-surface missile (SSM), 8.3 m for air-to-surface missile (ASM);
Diameter: 670 mm;
Launch weight: 3000 kg for SSM (2550 kg for ASM);
Payload: single warhead;
Warhead: HE submunitions, semi-armour piercing;
Propulsion: solid propellant, ramjet;
Range: 300 km;
Status: operational;
In service: 2002 (2015 for bastion systems).

Fig. 5. SS-N-26 'Strobile' (P-800 Oniks)/Yakhont/Yakhont-M/ Bastion (launch systems) [https://missilethreat.csis.org/missile/ss-n-26/ (access 27.04.2018)]

The SS-N-27 'Sizzler' — Russian short-range ship-, and submarine--launched anti-ship missile [3]

The Sizzler is part of the Kalibr family of missiles and has several export versions known as the 'Klub' missile series. Along with the rest of the Klub and Kalibr family of missiles, this anti-ship cruise missile began development in 1985 by Novator Experimental Design Bureau and was made available for export in 1997. NATO designated it the SS-N-27 'Sizzler' by NATO after it was first displayed in 1993. It has since been established that the SS-N-27A refers to the 3M54 version of the missile (three-stage propulsion) and that the SS-N-27B refers to the 3M54M1 version (two-stage propulsion).

The 3M54 (SS-N-27A) anti-ship missile is equipped with a three-stage solid propellant turbojet engine and is 8.22 m long, 0.534 m in diameter, and has a launch weight of 1,930 kg. The minimum range of the 3M54 is 20 km with an estimated maximum range is 300 km.

The 3M54M1 (SS-N-27B), although similar to the 3M54, has a two-stage solid propellant turbojet engine and is significantly shorter at 6.2 m, and lighter at 1570 kg, with a diameter of 0.534 m. The 3M54M1 is equipped with a heavier 450 kg HE warhead and has an increased range of up to 300 km. A vertical launch version of the missile, the 3M54TM1, is 6.92 m long, 0.645 m in diameter, and weighs 1780 kg. Also equipped with a 450 kg HE warhead, turbojet engine, inertial navigation system, and GPS, the 3M54TM1 has a maximum range of 275 km.

Main characteristics:
Originated from: Russia;
Possessed by: Russia, Algeria, China, India, Iran, Vietnam;
Alternate names: SS-N-27, SS-N-27A, SS-N-27B, Sizzler, 3M54, 3M54M, 3M54E, 3M-54E1, 3M54TE, 3M54TE1, 3M54AE, 3M54AE1;
Class: anti-ship cruise missile;
Basing: submarine-ship-launched;
Length: 8.22 m for 3M54 (6.2 m for 3M54M1);
Diameter: 0.534–0.645 m;
Launch weight: 1920 kg for 3M54 (1,570 kg for 3M54M1);
Payload: single conventional warhead;
Warhead: 1 x 200 kg HE for 3M54 (1 x 450 kg HE for 3M54M1);
Propulsion: solid propellant, turbojet (3M54 is three stage, 3M54M1 is two stage);
Range: 220 km (3M54), 300 km (3M54M1);
Status: operational;
In service: 1987.

Fig. 6. SS-N-27 ‘Sizzler’ [https://missilethreat.csis.org/missile/ss-n-27-sizzler/SS-N-27 (access 27.04.2018)]

Uran-E — shipborne missile system with Kh-35E, Kh-35UE tactical anti-ship missiles [6]

The Uran-E ship borne anti-ship missile (ASM) system is designed to destroy missile/torpedo/gun boats, surface ships displacing up to 5000 tonnes, and seagoing transports.

Composition :
- Kh-35E (Kh-35UE) tactical subsonic anti-ship cruise missile in transport-launch container;
- quick-release launcher with missile loader;
- ship borne automated control system;
- ground support equipment with test facilities.

The Kh-35E and Kh-35UE tactical anti-ship missiles are composed of the body, active radar seeker, high-explosive fragmentation penetrator warhead, independent self-destruct system, inertial navigation system, radio altimeter, air intake, fuel system, efficient sustainer turbofan and solid-state rocket booster. Missiles in TLCs are loaded for launch into shipborne launchers. One launcher can be armed with up to four TLCs. The automated control system is used to implement missile combat preparation and pre-launch procedures. Target designation data is fed from onboard organic and external sources, including airborne ones.

Cruise flight phase is controlled by inertial navigation system to keep the missile on the preset path and to steer it to the target area. Terminal guidance is provided by an ECM-resistant active radar seeker. Thanks to the drastically reduced radar cross-section and sea-skimming flight profile the Uran ASM penetrates enemy ship’s self-defences with enhanced probability, providing covert combat employment and surprise strike capabilities. Uran-E missile system can be installed on fighting ships both under construction and in service (after due retrofit), transport and merchant vessels.

<u>Main characteristics:</u>
Operational range, km:
maximum Kh-35E: 130, minimum Kh-35E: 5;
maximum Kh-35UE: 260, minimum Kh-35UE: 7;
Flight altitude, m:
cruise phase Kh-35E, Kh-35UE: 10–15;
terminal phase Kh-35E, Kh-35UE: 4;
Max flight speed;
Mach number: Kh-35E: 0.8;
Kh-35UE: 0.8–0.85;
Total system weight (8–16 missiles), t: 12.5–23
Weight, kg:
missile at launch Kh-35E: 620;
missile at launch Kh-35UE: 670;
warhead Kh-35E, Kh-35UE: 145;
Missile length, m: 4.4;
Missile diameter, m: 0.42;
Launch interval in any salvo sequence, s: 2–3;
Max horizontal missile turn after launch, deg;
Kh-35E: ± 90, Kh-35UE: ± 130.

Fig. 7. Launchers Uran-E [http://roe.ru/eng/catalog/naval-systems/shipborne-weapons/uran-e/ (access 27.04.2018)]

Fig. 8. The launch of the Uran-E missile [http://roe.ru/eng/catalog/naval-systems/shipborne-weapons/uran-e/ (access 27.04.2018)]

Moskit-MVE — anti-ship missile system with 3M-80MVE anti-ship cruise missiles [6]

The Moskit-MVE anti-ship missile (ASM) system with 3M-80MVE anti-ship cruise missiles is designed to destroy large-displacement surface ships and transports making part of naval task force, amphibious assault groupings, convoys and single ships of both displacement- and hydrofoil or air cushion types sailing at speeds of up to 100 knots, in intensive hostile fire and ECM environment. Moskit-MVE ASM system is designed for all-weather employment (snow, rain, fog, thunderstorms, etc.), by day and night, in any season of the year, in strong winds blowing from any direction with surface speed of up to 20 m/s, and in sea point 6 conditions.

Composition:
- 3M-80 MVE supersonic sea-skimming anti-ship cruise missiles;
- missile launchers;
- missile control system;
- ground support equipment.

<u>Main characteristics:</u>

Range of fire, km:

maximum with low-altitude trajectory: 140;
maximum with combined trajectory: 240;
minimum: 12;

Missile speed, km/h:
on low-altitude trajectory: 2800;
on combined trajectory: 2900;
Missile flight altitude on route:
low-altitude trajectory, m: 10–20;
combined trajectory, km: 10–12;
Firing sector from ship's centerline plane, deg: ± 60;
System ready-to-launch time, s:
from power supply to missiles to the first missile launch: 50;
from advanced alert state: 11;
Missile launch weight, kg: 4450;
Warhead weight, kg: 300;
Fuel tank capacity, l: 1290;
Missile length, m: 9.745;
Wing span, m: 2.1.

Fig. 9. Moskit missile [http://roe.ru/eng/catalog/naval-systems/shipborne-weapons/moskit-mve/ (access 27.04.2018)]

The development trend of anti-tipping missiles is currently determined by the construction of drive units determining the possible performance of missiles. Increasing the speed of these measures reduces the effectiveness of all ship defence systems. Missile missiles and artillery must have even higher speeds. An extreme but the most effective theoretically available means is a laser pulse or microwave pulse with adequate (sufficient) energy, then we 'shoot' not in the point overtaken but in the aim. The mere possession of such a measure does not completely solve the problem of counteracting anti-ship missiles, we must still have the ability to detect and track a possible target. Without having laser or microwave guns (directed energy), we must have anti-missiles characterized by appropriate speeds

$$K = \frac{V_{pp}}{V_{po}}. \tag{1}$$

For the coefficient from $K \geq 1.0$, the homing is technically feasible now, and the curvature of the anti-charge track (and thus the normal overload) decreases with the increase of this coefficient. Due to the transport efficiency of missiles, we have more and more complex constructions of propelling drives.

Fig. 10. The launch of the Moskit projectile [http://roe.ru/eng/catalog/naval-systems/shipborne-weapons/moskit-mve/ (access 27.04.2018)]

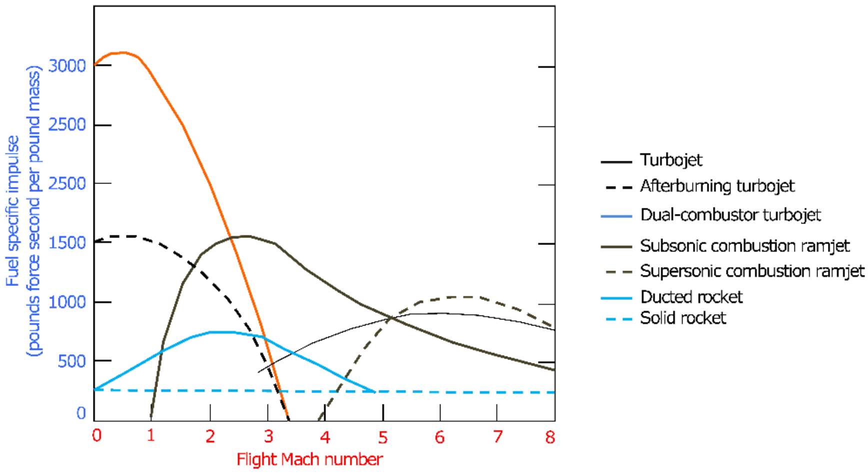

Fig. 11. The dependence of the specific impulse expressed in seconds depending on the propulsion engine used in the project shown in fig. 12 and 13, was developed on the basis of [1]

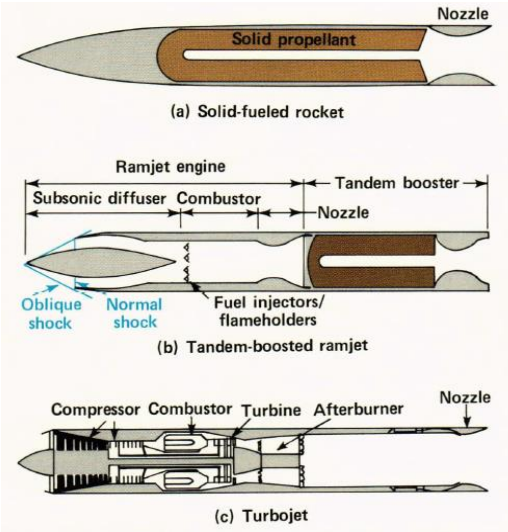

Fig. 12. Construction of complex missile engines: a) solid rocket,
b) tandem jet engine enhanced with a jet engine, c) turbojet engine [1]

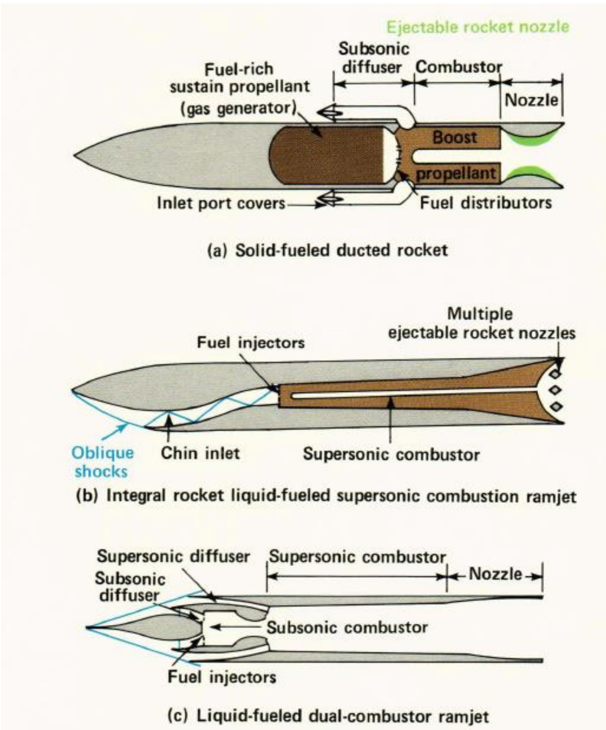

Fig. 13. Construction of complex missile engines: a) rocket for solid fuel, b) jet engine
with supersonic combustion chamber, c) jet engine with double combustion chamber [1]

MEANS OF ATTACK BY POLISH NAVY SHIPS, WHICH ARE POSSIBLE TO BE USED BY A POTENTIAL ENEMY AND THE POSSIBILITY OF COMBATING THEM

Detection, tracking, evaluation and making decisions about the involvement of the ship's self-defence systems must be made (from the initial detection of ASCM to the ship's fire engagement) usually within several dozen seconds. At that time, detection must be made, a threat is found, command decisions must be taken and the on-board defence measures must be started. Due to the negligible ability of human reaction in such a short period (especially in the period: inclement weather, outside the watch, at night), most or even all defence decisions should be subject to automation. The extraordinary dynamism of the contemporary maritime theatre of the activities of the additional complicating element adds the additional character of the described threats (programming of points of return, simultaneous attack of many rockets to reduce the self-defence chance of the attack object is one of the factors of the anti-ship missile tactics).

The development of autonomous and mobile systems as well as the progressive miniaturization of combat means allow the opponent to use tactics that have hitherto been encountered sporadically or not at all. The principle propagated by tactics of many Navy 'fight the archer — not arrows', lost its significance in a world in which the launch of anti-ship's means takes place far beyond the reach of the ship's autonomous means of detection. Examples of such threats are shown in fig. 1. ASMs seem particularly dangerous because of their small radiolocation signature, low flight altitude and a huge distance of discharge/launch reaching hundreds and in the future, thousands of kilometres.

With the increase in the distance of the use of water-water missile weapons beyond the range of radiolocation stations located on the carriers' decks, the problem of indicating the target appeared. At this moment, we can deal with the situation of the so-called 'Blind boxer', although having a strong blow, but too short-sighted to see the opponent.

The development of light surface impact forces in the Baltic Sea basin took place since the 1960s. Currently, many journalists dealing with maritime issues question the legitimacy of keeping small vessels equipped with counter-concealed rockets (cutters, small missile ships) in the composition of the Polish Armed Forces. One of the reasons is the total domination of aviation in the area and the inability to manoeuvre such units in the event of the enemy's dominance in the air. This element is also adversely affected by the lack of a properly shaped shoreline. In the case of the Polish coast differently from the shores of Sweden or Norway, there are no archipelagos, small islands, skerries and fjords that constitute a natural form of refuge, making it difficult to detect and are basically a starting point for making rocket attacks for own forces. The land mobile launchers that make up the offshore rocket artillery batteries are much better in this field, such as the native Marine Missile Unit (MJR). For this reason, it seems advisable to equip ships with effective systems for detecting air attack agents (airplanes, helicopters, manoeuvring missiles) at long distances and means of at least medium range destruction. Respectively effective air defence systems, capable of simultaneously combating several/several objectives at the same time have the chance to take an equal fight against the threats of the upper hemisphere. Only in this way will it be possible, on the one hand, to protect valuable offshore platforms, to create a protective umbrella over smaller units dedicated to the implementation of specialized tasks (e.g. sea mine combat units). On the other hand, there is a real possibility of using the potential of naval vessels as part of the national air defence system from the north.

An important element of the self-defence of the ship can be an automated network-centric self-defence module and masking ships of the Polish Navy with the use, for example, of miniature missiles with calibre of 40 and 70 mm.

Computer simulation of a model of 70 mm projectiles was carried out with the following assumptions:

- the projectile has a self-guided system based on proportional navigation method with a coefficient of a = 2,5;
- the switch-on delay is 0.1 s, the angle error of the target indication is 1 degree in the facade;
- the velocity of the counter-weapon V_{pp} = 900 m / s, and the velocity of the anti-ship missile V_{po} is parametrically varied in the range from about 5 Ma to 0.66 Ma and is described by the previously defined factor K;
- the height of the launch tube guide and flight height is h = 10 m above sea level, and the launch of the projectile is made when the anti-ship missile is located at a distance of 2000 m from the ship.

The change in the flight path parameters of the counter-flight to the meeting with ASM is shown in fig. 14–19.

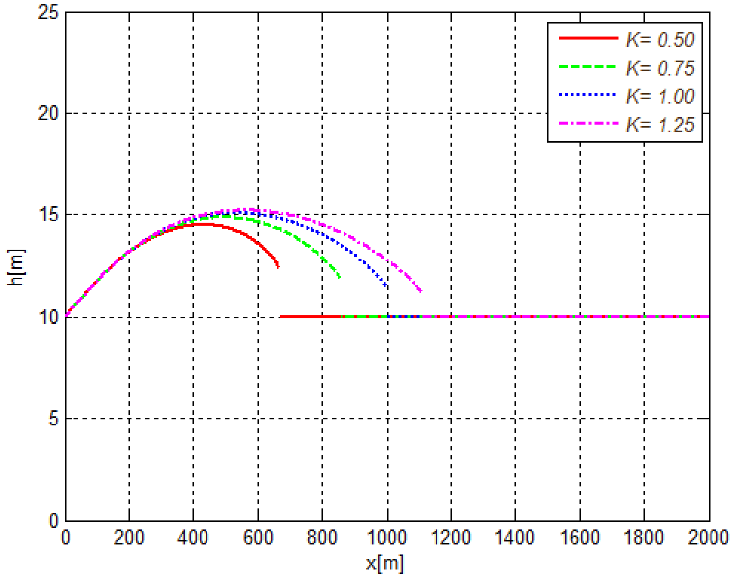

Fig. 14. The flight paths of the projectile calibre 70 mm to the target, different target speeds determined by the factor *K* with the value of 0.5, 0.75, 1.0, 1.25

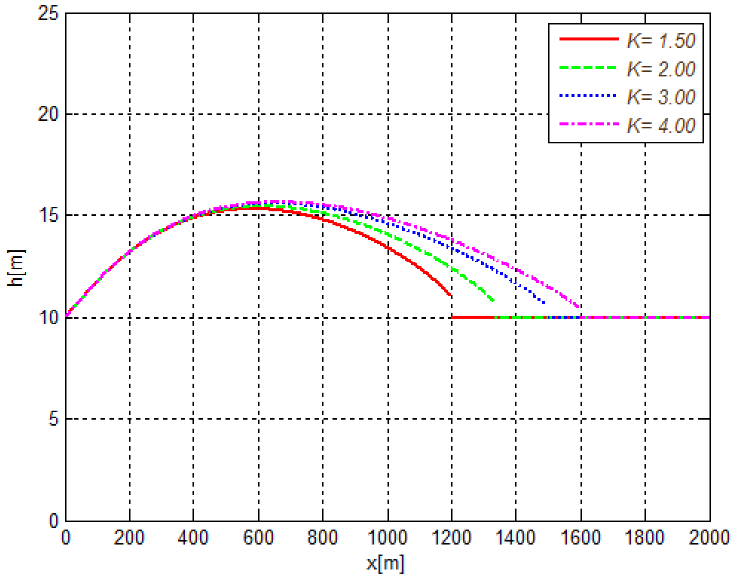

Fig. 15. The flight path of the projectile calibre 70 mm to the target, different target speeds determined by the factor *K* with the value of 1.5, 2.0, 3.0, 4.0

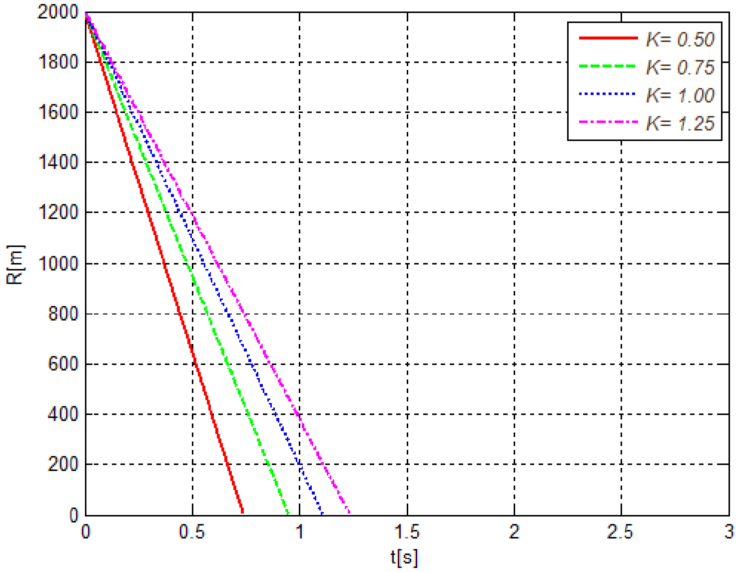

Fig. 16. Changing the distance of the projectile calibre 70 mm from the target, which is a waveform in the function of flight time, different target speeds determined by the factor *K* with the value of 0.5, 0.75, 1.0, 1.25

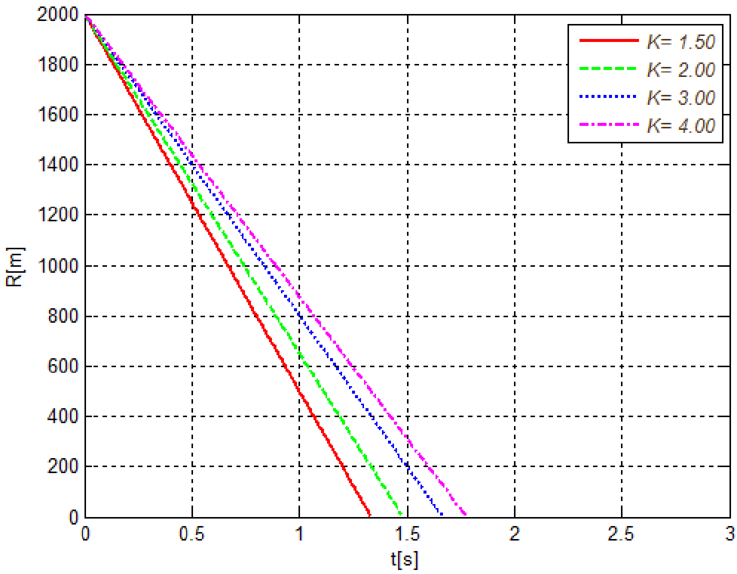

Fig. 17. Changing the distance of the projectile calibre 70 mm from the target, which is the function of the flight time, different speed of the target determined by the factor *K* with the value of 1.5, 2.0, 3.0, 4.0

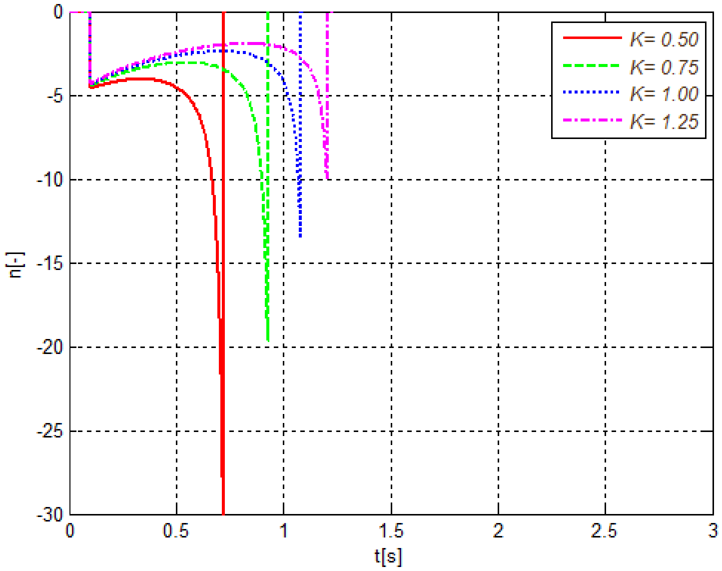

Fig. 18. Changing normal overload of a projectile as a function of flight time, different target speeds determined by the factor *K* with the value of 0.5, 0.75, 1.0, 1.25

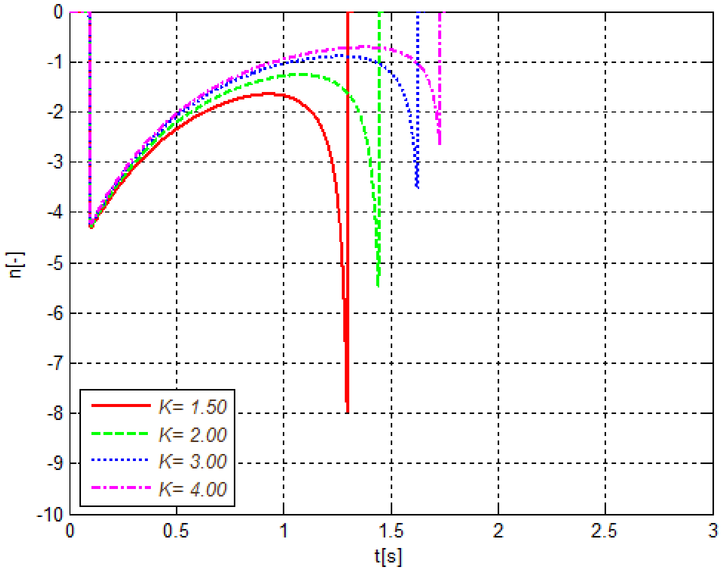

Fig. 19. Changing the normal overload of a projectile as a function of flight time, different target speeds determined by the factor *K* with the value of 1.5, 2.0, 3.0, 4.0

The results shown in the graphs were collected for greater clarity in tab. 6.

Tab. 6. Basic parameters related to the self-guidance of the counter-projectiles against the anti-ship missile

V_{po} [m/s]	**1800**	**1200**	**900**	**720**	**600**	**450**	**300**	**225**
V_{po} [Ma]	5.3	3.5	2.6	2.1	1.76	1.32	0.88	0.66
K	0.5	0.75	1.00	1.25	1.5	2.0	3.0	4.0
t_s [s]	0.74	0.95	1.11	1.23	1.33	1.48	1.66	1.77
x_s [m]	655	855	998	1108	1197	1330	1496	1596

The t_s in the table, determined in seconds, it defines the time for collisions of missiles at a distance x_s from the ship. In the perspective, it is possible to use missiles of small calibres as a defence of the last chance, even for very fast objects attacking the ship, provided that the control system will be completely automated (time — everything, including decision). For fast objects attacking the ship, we must ensure high-energy missiles to defend, for $K \geq 1.0$ required normal overload falls to the value of modern used missiles.

CONCLUSIONS

1. Contemporary activities at sea are characterized by enormous dynamics and rapidly changing tactical situation, and threats occurring in the marine domain are of an occasional character.
2. Air assault means (both in the form of aviation and missile defence missiles) constitute one of the main threats limiting the operational freedom of surface forces.
3. The basic parameters of the bars, with particular emphasis on the speed of their movement, affect the growth of the dynamics of the modern maritime theatre of activities. The increase in the speed of anti-missile missiles from the range of 0.8–0.9 Ma to 2.5–8 Mach reduces the ship crew crew response time from several dozen to several seconds (or even less). This forces the necessity to develop automated, network-centric self-defence modules and masking ships of the Polish Navy using, for example, miniature missiles of 40 and 70 mm.
4. The increasing possibility of making coordinated strikes regarding the time and object of the attack (attack from many directions) creates a serious challenge for defence systems (self-defence) of surface units.

5. The intellectual potential of the entire scientific community should be fully utilized in ensuring the defence capabilities of the state. First of all, scientists, designers, engineers, working on the creation of new sets and systems. Such teams will provide the Armed Forces with the ability to adequately respond to existing and possible future challenges and threats to Poland's military security.

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LATAJĄCE ŚRODKI ATAKU OKRĘTÓW MOŻLIWE DO ZASTOSOWANIA PRZEZ POTENCJALNEGO PRZECIWNIKA — ANALIZA ZAGROŻEŃ OKRĘTÓW MW RP

STRESZCZENIE

W artykule przedstawiono analizę zagrożeń okrętów MW RP wynikającą z rozwijania przez państwa Morza Bałtyckiego systemów rakietowych lub turboodrzutowych pocisków przeciwokrętowych.

Opisano i sklasyfikowano najpopularniejsze odmiany i typy pocisków możliwych do zastosowania przeciwko okrętom MW RP, biorąc pod uwagę głównie potencjał Floty Bałtyckiej Federacji Rosyjskiej, a także dokonano analizy najnowszych trendów światowych w obszarze przeciwdziałania tym pociskom. Przedstawiono ponadto implikacje, jakie niosą ze sobą zmieniające się zagrożenia dla przyszłych potrzeb obronnych. W artykule sformułowano wnioski płynące z przykładowych symulacji ataku współczesnych pocisków przeciwokrętowych. Odniesiono się też do sposobów określania prawdopodobieństwa uniknięcia ataku rakietowego i miary skuteczności samoobrony atakowanych okrętów oraz scharakteryzowano pożądane cechy systemów samoobrony okrętów na współczesnym polu walki, ze szczególnym uwzględnieniem charakteru MW RP.

Słowa kluczowe:

morskie systemy walki, bezpieczeństwo i ochrona żeglugi, uzbrojenie i sprzęt specjalistyczny, rakietowe systemy samoobrony okrętów, doktrynalny model zagrożeń atakiem rakietowym pojedynczego okrętu.

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