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Selected Aspects of Contemporary Air Threats

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Abstract
One of the factors affecting the security of a state is air threats. Their nature often exerts a negative impact on both the functioning of the state and using airspace. The purpose of this article is to define the term of air threats and characterize contemporary air threats, illustrated with numerous examples. The scientific deliberations lead to outlining possible development trends in this respect, in relation to technological progress. The article ends with several concluding statements with regard to an analysis of prospective air threats. It also shows possible development trends in the discussed matter. The final part of the article is devoted to conclusions regarding the transformation of contemporary air threats.

Keywords: air threats, air safety, air assault assets, safety.

1. Introduction

Bearing in mind broadly understood state security, one may ponder on the nature of these threats. One of the factors affecting this security is air threats. The nature of such phenomena is, among others, related to the use of airspace and processes which occur in it. As they can also refer to other issues, the knowledge concerning them is worth systemizing. The purpose of this article is to analyze contemporary security threats and changes which occur in

this environment. On their basis, it will become possible to define the prospective development trends.

2. Determinants of air threats

In order to determine modern air threats, in the first place, it is necessary to explain the concepts that characterize this issue. In general, the term "threat" is associated with an increased likelihood of an emergence of certain danger, thereby disrupting the state of security. This concept was elaborated on in *Leksykon wiedzy wojskowej* (The Lexicon of Military Knowledge), in which "threat" was defined as a situation in which there is a greater probability of a loss of life, health, freedom or material goods (*Leksykon wiedzy wojskowej*, 1979). Next, in *Słownik terminów z zakresu bezpieczeństwa narodowego* (Dictionary of National Security Terminology), a threat is defined as a situation in which there is a likelihood of an emergence of a state which poses danger to the environment (*Słownik terminów z zakresu bezpieczeństwa narodowego*, 2008).

It needs to be stressed that air threats belong to the group of threats to state security. On the one hand, they may result from natural activities such as hurricanes, tornadoes, snow storms, etc. On the other hand, they may be caused by human activity (in particular such tools as aircrafts).

When dealing with threats arising from human activity, the threats will be related to a possibility of launching an attack by an aircraft on military installations or civil objects which are relevant to the functioning of a state (*Leksykon wiedzy o obronności Polska i Europa* [Lexicon of Knowledge on Poland and Europe's Defense], 2014). A more complete definition of air threats is presented by Adam Radomyski, who claims that an air threat must be regarded as a state which disturbs the feeling of security in a state (in all its dimensions), resulting from a threat of the use of aircraft (platforms) by a potential state or non-state aggressor (Radomyski, 2018). It can, therefore, be concluded that an air threat is a dangerous situation, in which there is every likelihood of using an aircraft/apparatus/weapons (civil or military) by a state or non-state actor, or its part.

It is necessary to stress that the most common source of air threats will be military assets such as rockets, missiles, aircrafts equipped with aerial weapons and reconnaissance systems that will be able to launch strikes on other actors (state, non-state, civil, military) from the air. In the available literature, such systems are referred to as Air Assault Assets (AAA).

On the other hand, civil measures may also pose an air threat, as illustrated by the 9/11 attack, during which passenger aero planes were used as a tool in terrorist attacks on the Twin Towers of the World Trade Centre. Terror attacks directed against civil aviation transport pose a serious challenge for every airport nowadays regardless of its location. (Radomyski, and Bernat, 2018).

In view of the ongoing technological changes in terms of military threats, non-military threats have been disregarded in further considerations.

3. Characteristics of contemporary air threats

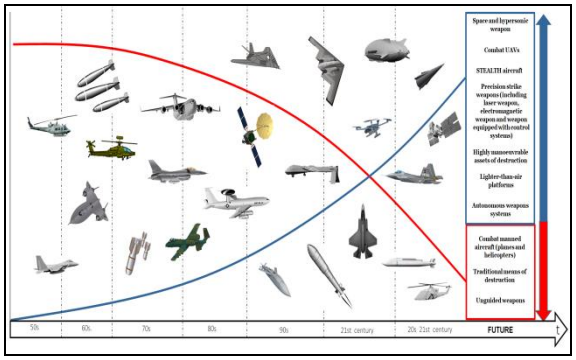
Research into the issues of contemporary air threats show that in the future warfare, there is a possibility of the occurrence of the following air assault as-

sets (Interim conceptual Ideas, NATO Ground Based Air Defense Operations (2020), 2011),:

- Manned Aircraft (MA), including Fixed Wing (FW) and Rotary Wing (RW) aircraft,
- Unmanned Aerial Vehicles (UAVs),
- Cruise Missiles (CMs),
- Tactical Ballistic Missiles (TBMs),
- Rockets, Artillery, Mortars (RAMs),
- Precision Guided Munitions (PGM),
- Lighter than Air Sensor Platforms (LAPs).

Furthermore, many authors (Zajas, Glen, Rosłan, Maślanka et al.) claim that in view of the advancement of technology, new air assault assets are likely to occur. In addition, involvement in a potential conflict of the assets which have already been in operation will also undergo changes. The fact that, ”military superpowers" develop space, electromagnetic and hypersonic weapons seem to prove this thesis. The research which has been conducted in this respect shows that in the future, the role of combat manned aviation, equipped with conventional weapons will decrease in favor of highly maneuverable aerial vehicles, hypersonic aircraft and missiles, laser weapons or space weapons. It must, therefore, be assumed that the level of threat caused by future air assault assets will be similar to the one illustrated in Fig. 1.

Figure 1.
Prognosis of threats caused by air assault assets



It needs to be clarified that the implementation of modern and technically advanced measures into armament will not denote a quick abandonment of conventional piloted aircrafts, within 15-20 years.

Fixed and Rotary Wing Aircrafts

Several countries still use this type of equipment. Thus, in can be expected that the share of manned aircrafts and helicopters, as modern threats, will be phasing out. Older aircraft designs, i.e. 4 and 4+ generation are still in a group of assets, which might pose an aerial threat. Such aircrafts are equipped with various types of armament, such as guided missiles: air-to-air, air-to-ground, air-to-surface, aerial torpedoes, air-to-space, bombs and missiles (high explosive, incendiary, anti-tank, fragmentation, HE fragmentation bombs, aircraft-laid mines and guns as well as cannons (machine guns, cannons, grenade launchers). Moreover, helicopters have different types of weapon and reconnaissance systems. Their basic weapons are machine guns, bombs, guided and unguided missiles and rockets.

A notable contemporary trend among military powers reflects development of their own multi-role 5th and 6th generation aircraft (e.g. 5-th generation: United States (F-22, F-35), China (J-20, J-31), Russia (T-50) and 6th generation: United

States (F/A-XX,), Great Britain, Italy, India (TEMPEST), Russia (T-60 GOLUB), China (J-50), France, Germany, Spain (FUTURE COMBAT AIR SYSTEM-FCAS). On the one hand, they are intended to replace older constructions, while on the other hand, they are intended to gain operational superiority over the enemy. It should be noted that these aircrafts are designed to minimize their detection. Therefore, most of them have irregular shapes of the airframe to redirect electromagnetic radiation waves and are covered with paint reducing or blocking radar signals. In addition, the aircraft design often includes RAM (Radar Absorbent Material) technology to reduce their effective radar cross-section. These types of technologies are called stealth. In the future it is expected that the structures of this type will have a modular design and will be highly maneuverable. They will have reduced susceptibility for detection, achieved by reducing the infrared and acoustic signature. It should also be assumed that due to being equipped with passive reconnaissance and armament systems as well as precision weapons, they will be able to execute a considerably greater range of missions than the contemporary aircraft. Furthermore, it is predicted that 6th generation aircraft will be equipped with laser or electromagnetic weapons. They will have the ability to make a real-time exchange of information (photon technology) and a possibility to control other aircraft (e.g. UAVs). The countries working on the structures of this type also assume that their aircraft will be able to fly in three modes. Firstly, they are to be controlled by a pilot; secondly, they are to be remotely controlled by an operator; thirdly, they are to operate autonomously. It should not be ruled out that in the near future, both fixed and rotary wing aircrafts will be fitted with artificial intelligence (AI) systems, which, in case of the loss of the pilot's ability to operate, will be capable of taking over control and executing the task.

Ballistic missiles

One of the main air threats is Ballistic Missiles (BM). They are mostly classified depending upon the range (in practice this is the maximum distance from the launching point to the target, measured in a straight line over the surface of the ground) and the type of the launch platform. When referring to the first case, such means can be divided into (Shuey, 2001):

- SRBM (Short-Range Ballistic Missiles), whose operational activity is within the range of 70-1000 km,
- MRBM (Medium-Range Ballistic Missiles), whose operational activity is between 1,000-3,000 km,
- IRBM (Intermediate Range Ballistic Missiles), operational between 3,000-5,500 km,
- ICBM (Intercontinental Ballistic Missiles), whose operational activity is above 5,500 km.

In the second case, missile launchers can be differentiated into stationary and mobile. The first type is the silos, which are usually deployed in particular combat formations. Their mobile equivalents are typically to be found in submarines (Submarine-Launched Ballistic Missiles - SLBM), road platforms (tracked or wheeled) and other, e.g. railways. Using ballistic missile depends upon the exploited warhead, which can be armed with conventional weapons or weapons of mass destruction (e.g. nuclear). For this reason, the states which possess the missiles in their inventories can use them for both military and political purposes. On the one hand, they may serve as a tool to, ”deter" a potential enemy. On the other hand, they are capable of destroying targets in the area of deep operations, such as command and control centers, objects of the state's critical infrastructure, or in extreme cases, in places populated by civilians. An example of this type

of an air threat for Poland is Russian ISKANDER missiles, deployed in the Kaliningrad Region, whose range depends upon a version, i.e. 300 or 500 km, with the time of reaching the target equal to 5-9 minutes.

In conclusion, it should be underlined that modern ballistic missiles are characterized by high velocity and reduced radiolocation characteristics. The most modern ones possess mobile maneuvering homing heads that are capable of independently seeking and destroying targets.

Cruise missiles

A common air threat of recent years is cruise missiles. They are equipped with different guidance systems and conventional or nuclear heads (Dobija 2014). This type of assets is unmanned, homing devices which execute a flight in a set air corridor, tasked to deliver a combat load to a particular target. Cruise missiles are used to destroy objects of critical state infrastructure (political and industrial), airports and seaports, command and control centers, logistic centers and infrastructure as well as troops in assembly areas. A characteristic feature of such assets is high maneuverability, effectiveness and precision of destruction. In addition, they are characterized by a significant range, high operating velocities, small radar cross-sections and terrain contour matching capabilities. In their classification, depending upon the type of carrier, it is possible to distinguish missiles launched from aircraft (Air Launched Cruise Missiles - ALCM), from ground-based launchers (Ground Launched Cruise Missiles - GLCM) and from surface-combat vessels (Sea Launched Cruise Missiles - SLCM).

Hypersonic weapons

Ballistic missiles are fast, but not maneuverable. Cruise missiles, on the contrary, are highly maneuverable but unable to achieve high velocities. Hypersonic weapons are to combine the best features of both by flying at velocities exceeding the speed of sound several times, at the same time remaining highly maneuverable. In this category of weapons, it is possible to distinguish Manoeuvrable Hypersonic Glide Vehicles (HMGVs) and Hypersonic Cruise Missiles (HCMs). It should also be noted that hypersonic glide vehicles are launched by a ballistic missile, whereas hypersonic cruise missiles from aircraft.

Hypersonic missiles can fly at altitudes ranging from several dozen to 100 km, maneuver and travel at velocities above Mach 5. The modern propulsion system is called SCRAMJET (The present designs reach velocities of Mach 5 (6,174 km/h) - Mach 10 (7,672 km/h). They are likely to reach the velocity of even 25 000 km/h in the foreseeable future). They differ from ballistic missiles in their ability to fly at lower altitudes and influence the change in trajectory. As a result, the last minutes of a flight are unpredictable with regard to the designated and achieved targets (Speiner, Nacouzi, Lee, Moore, 2017). This makes it possible to assume that hypersonic weapons, as a new class of air threats, may ,“break through” the majority of contemporary air missile defense systems.

Currently, only a few states possess hypersonic weapons, with China, Russia and the United States playing the leading role. The latter plans to spend annually over 2 billion dollars on the development of this type of weapons A budget proposal made by the Pentagon for the fiscal year 2020, earmarks 2.6 billion dollars for developing hypersonic weapons, while only 157 million of this sum (approximately 6%) is intended for defense against hypersonic threats (Thompson, 2019). A potential threat to Poland, of this kind, may be Russian hypersonic missiles Kh-47M2 Кинжал (Kindżał), carried by the MiG-31 aircraft. It is expected that these missiles, apart from

conventional warheads, will be capable of carrying nuclear payloads.
In addition, it is estimated that they are able to move at velocities of up to Mach 10 and their range is approximately 2,000 km. In practice this means reaching a target over a maximum distance in just over ten minutes. Thus, it is possible to destroy practically all targets in Europe.

Apart from hypersonic missiles, military powers are working on HMGVs systems. The examples of this type of armaments is Chinese Wu-14, Russian Ju-71/Ju-74 and American Falcon, HIFiRE, X-51. However, it should be stressed that most information about them is top secret and the generally available pieces of information are based on residual data and assumptions.

Unmanned Aerial Vehicles

A UAV is an aircraft which does not have a human-operator on board, uses lift to remain airborne, can fly independently on a pre-programmed route, or can be controlled remotely. It may also be reused and can carry weapons or other equipment (Joint Publication 1-02, 2009). Depending on the range of the conducted operations, they can be divided into tactical (very short range up to 60-80 km), tactical and operational (short range up to 120-150 km), operational (mid-range up to 300 km) and strategic (long range - above 300 km).

Currently Unmanned Aerial Vehicles are in the structures of the Air Force, Navy, Army or Special Forces, in many cases being an alternative for manned aircraft. It may be assumed that in the longer perspective, they will change the quality of conducting combat operations, aspiring to be a turning point in the application of military technologies (Zieliński, 2018). Owing to advances in technology, UAVs have the ability to perform the tasks of air reconnaissance, combat or support operations. In addition, they are capable of conducting operations individually or in groups (e.g. in a swarm), regardless of atmospheric conditions at any time of the day. In October 2016, the United States carried out a successful attempt of dropping a swarm of 103 UAVs Perdix from pods mounted on the F-18 Super Hornet.

It must be noted that the bulk of them, due to a very small radar cross-section, are difficult to detect. Such a state of affairs is certainly affected by the STEALTH technology during their construction. This type of aircraft is capable of performing tasks at high altitudes, beyond the range of small arms, onboard and air defense systems, or quite contrary, at extremely low altitudes, taking advantage of a terrain. In the future, it is possible that they will take an active part in the fight over air superiority or supremacy. They may also execute tasks using artificial intelligence to select weapons and make autonomous “kill or no kill” decisions.

Laser weapons

The Laser Weapon System (LaWS) and Electromagnetic Weapon are new items on the list of modern air threats. Despite the fact that many projects associated with them were terminated due to technical and technological difficulties and financial constraints, more and more often there are signs of relaunching research into this type of weapons.

Laser weapons are universal. They can be used in both offensive and defensive operations. The advantage of LaW is no recoil, almost unlimited magazine capacity, low discharge cost and the possibility of destroying small objects in a relatively short space of time (The ability to hit the target of approximately 20 mm, in diameter). When using laser weapons, it is possible to destroy a target or disrupt its operations by blinding its radar or optoelectronic systems. For several years, research has been conducted in the United States into a prototype laser gun mounted on board an aircraft. The

Air Force Research Lab (ARLB) is in charge of this project. In agreement with Lockheed Martin, it has started a program of building a Self-Protect High-Energy Laser Demonstrator (SHiELD). In the framework of the project, a creation of three basic subsystems is planned (Lockheed Martin, 2019):

- LANCE (Laser Advancements for Next-generation Compact Environments) - jet-configured high-energy small laser pod.
- LRPF (Laser Under Research & Development) - a pod which will be responsible for powering and cooling of the laser,
- STRAFE. SHiELD Turret Research in Aero Effects) - a control system of a beam fitted in a movable head, which will direct the laser onto a target.

ARLB announces that the flight tests of the SHiELD demonstrator are to be launched in 2021. It is expected that the F-15 aircraft will be designated for this purpose. Furthermore, completion of the final prototype system is scheduled for 2025, while 2029 will presumably see an integration with the ultimate system carrier. In this case, mounting laser weapons on AC-130J Ghostrider and other combat aircrafts is also taken into consideration. Ultimately, laser is planned to be used defensively as an aircraft protection against attacks from anti-aircraft missiles, ballistic missiles and drones.

Another concept of using a laser in aviation was introduced by Raytheon. Jointly with US Special Operations Command and Project Management Office Apache Attack Helicopter, they attempted at mounting a high energy laser (HEL) on a stub-wing pylon of the AH-64 Apache. In the future, the system will be used to detect and track down manned and unmanned aircrafts, and ground and mobile platforms.

It is likely that in the coming years, the laser designs will be used as a weapon to destroy air defense weapons, armored or mechanized weapon systems.

Electromagnetic weapons

The essence of the electromagnetic weapons is to generate a short pulse of electromagnetic radiation of great power, the so-called High Power Electromagnetics (HPE). An example of this type of a solution is the American Railgun, developed by the BAE System. Owing to the high velocity of the launched projectile, reaching 6 Mach, it allows destroying any target merely with kinetic energy, without an explosion. Currently, there is ongoing effort to deploy this type of a weapon aboard US Navy warships.

A similar version of electromagnetic railgun systems is being prepared by General Atomics System, i.e. Blitzer, whose tests have shown the ability to destroy targets at a distance of 400 km. In the future, the railgun systems are to destroy UAVs, ballistic missiles and cruise missiles. However, in the near future, the weapons of this type will not be fitted on board aircrafts due to their size and weight. It is quite likely that in the future the system will be miniaturized and aircraft will be equipped with such weapons.

However, in the case of microwave weapons, the prospects of their introduction on board aircraft are realistic. Today, mounting the weapon in future 6th generation aircrafts is currently being considered. The microwave weapon is in the inventory of China and Russia, however, the United States has been conducting research into its enhancement. For several years, the Americans have been working over a non-lethal weaponry within the Joint Non-Lethal Weapons Program (JNLWP) (Casey-Maslen, 2010). Developed by the Air Force Research Laboratory (AFRL) and the Department of Defense's Non-Lethal Weapons, the Active Denial System

(ADS) facilitated initiation of research on effective stopping and deterring potential enemies, without loss of life or inflicting any physical injuries (Świętochowski, 2018). Its operating principle is based on the use of millimeter electromagnetic radiation, in which the waves of microwave beams pass through the clothing of a potential enemy, making them experience intense heat or burning, and thus forcing them to retreat. This type of weapons is to disperse crowds or protect a convoy, although the most recent research into a Raytheon radar, based on Gallium nitride (GaN) prove that it can also be used for eliminating a sniper in a crowd, or stopping a selected vehicle, by targeting the driver, without the risk of a losing lives among the passengers. Presumably, this type of armament will be fitted in aircraft to execute the tasks of "show of force"

An example of using an electromagnetic weapon is electromagnetic bombs, the so-called E-bombs, developed within the CHAMP project (Counter-electronics High-powered Microwave Advanced Missile Project). The purpose of this type of weapons is to destroy, incapacitate, disorganize air defense, vehicles, ships, command and control centers, by damaging their electronic and IT systems with an electromagnetic pulse (EMP). It is predicted that the latest advancements of this type of a solution will be able to eliminate even camouflaged assets by repeatedly generating an electromagnetic pulse. However, one should bear in mind that the effectiveness of a classic E-bomb is a compromise between the load designated for the target and its resistance to this type of strike (Coop, 2014). "E" warheads are expected to be mounted on guided long-range missiles AGM-158 JASSM-ER (Joint Air-to-Surface Standoff Missile), which is to directly translate into their effectiveness.

Space weapons

Researchers from the RAND Corporation have noticed the relevance of outer space in incoming conflicts (Triezenberg, 2017). Although there is no official information about the militarization of outer space, this process has lasted for several decades. One example is the deployment of reconnaissance satellites in the Earth's orbit which can run reconnaissance operations on the territory of other countries. The founding of Russia's and the United States' Space Force as well as the introduction into American doctrines in 1998 of concepts such as air and space superiority, air and space supremacy should also be stressed (Michalak, 2013). Also, it is also vital to include the role of the People's Republic of China and other countries aspiring to be included in a group of potential powers in the conquest of space.

For many years, Russia has been facing problems related to the space industry. In view of the increasing role of private entities in the development of aerospace technology (e.g. Space X), its revenues have significantly shrunk. It is assumed that in order to maintain competitive edge in the foreseeable future, Russia will make decisions to reverse this negative trend. This trend is noticeable with 70 billion dollars allocated in the 2013-2020 budget for this particular purpose (Al-Ekabi, et al., 2015). It is also important to remember that despite the problems, the state has a significant contribution to the development of aerospace technology, indicated by its own cosmodromes (Bajkonur, Plesiecki or Wostoczny), the satellite navigation system (GLONASS) and a successful landing on the Moon. Its tremendous experience in building rockets and control systems may in the future lead to the development of a weapon that will find its application in space.

New trends in the development of space weapons are set by the United

States. One example might be attempts to down a malfunctioning satellite in 2008, which in the future may prove to be a valuable experience in similar missions directed against other states. An important part of their space program is the unmanned space shuttle X-37B, which has remained in the orbit for almost two years. Some media indicate that its goal may be to spy on China's activities or testing the ability to intercept satellites. Others suggest that this might be a new generation weapon or an aircraft. The commander of the American Space Force, Gen. William Lee Shelton claims that the X-37B has "game-changer" capabilities. Hence, there is a likelihood that, if necessary, it will be used to fight with China. One may presume that in the near future, the United States will possibly make every effort to avoid a conflict with the People's Republic of China. However, if it broke out, there is a high probability that the key battle ground might be space, in which cutting edge information technology could be applied (Kotasińska, 2012).

For the Americans, an important issue is the development of hypersonic weapons. Today, due to its properties, experts wonder on ways to counter such weapon. Taking into account its high velocity, presumably, it is likely to be neutralized only in space. One of the solutions, proposed by the US Missile Defense Agency, is to develop a system of sensors in space that would be able to track down this type of weapons throughout the world and could be one of the first steps in a defense against these new projectiles.

Also, the declaration of the United States to renew their involvement in space should not be disregarded. On 18 June 2018, during a ceremony at the White House, President Donald Trump accompanied by the vice-president Mike Pence and Head of NASA Jim Bridenstine stated that the USA will have the Space Force as a separate branch of the armed forces. Furthermore, he declared that the USA must gain supremacy in space. The beginning of the supremacy is a return of American astronauts to the Moon and a future mission to Mars, by the year 2024.

The aspirations to develop space weapons can also be noticed in China.

Similar to India, China possesses anti-satellite missiles (Anti-Satellite Weapon), which is a serious threat to the presence of the United States in space. Furthermore, it should be noted in this respect that they possess their own satellite navigation Beidou-2. One of their most recent space achievements is a successful landing of Chang'e 4 spacecraft on the dark side of the Moon in January 2019.

4. Conclusions

The transformations concerning modern air threats result from constantly upgraded and developed technology, an informal arms race or a desire to possess armament which could guarantee an advantage over the enemy. Research into this type of a phenomenon leads to an assumption that over the next five to ten years the transformations will also enforce changes in tactics, operations or a strategy of countries using the technology. It should also be assumed that future air threats will be characterized by:

- multitasking - expressed through the ability to accomplish a variety of tasks (missions);
- interoperability - characterized by a possibility of conducting tasks combined with other assets and components;
- networking (network centric warfare) - including cooperation with

others with regard to acquiring information (about the enemy);
- modularity - characterized by the ability to change flight parameters (change in velocity and altitude), operational parameters (change in target selection) depending upon the situation and target characteristics;
- high maneuverability;
- velocity exceeding multiples of speed of sound;
- adaptation through artificial intelligence elements - expressed by subsystems which are capable of learning and selecting optimal solutions;
- autonomy - expressed by an ability to make independent decisions in the event of loss of contact with the pilot, operator, control position.
- other.

In view of the changes occurring in the environment of air threats, it is necessary to make every effort to initiate and develop countermeasures. This might prove to be rather challenging, since on the one hand, they will be costly and, on the other hand, the states which possess assets to eliminate them might be reluctant to share the technology. Thus, it is advisable to develop and invest in one's own defense potential so that such capabilities could be achievable in the future.

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