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TECHNOLOGICAL DEVELOPMENT AS A FUNCTION OF POSSIBILITIES OF AIR FORCE USE

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Introduction

Aviation is now increasingly becoming an element of information-network, digital battlefield. The purpose of this article is to demonstrate the impact of technological development on a range of new opportunities for the use of aviation on the future battlefield. UAVs (unmanned aerial vehicles), precision strike weapons or weapons based on new physics advancements are finding more and more air combat applications. New combat technologies of unmanned aerial vehicles are being developed. UAVs, in the immediate future, are to replace human-piloted combat aircraft (helicopters) to conduct a number of high-risk missions. Another revolution of the aviation propulsion systems leads to a situation when quite soon we may expect a shift of operations from the sphere of supersonic speeds to the sphere of hypersonic speeds and altitudes of near space (air-space area)[1]. One may assume that the ability of aircraft to survive on a likely future battlefield will be conditioned by its small size, low infrared signature and limited active surface of reflecting electromagnetic waves[2]. Besides it will depend upon modern command and control systems[3] and efficient defence systems, both active and passive[4]. Taking into account the above-mentioned facts and prognosis tendencies of its

1 Although space has been militarized for some time, practically there has been no use of power in round-the earth orbits. However, taking into account contemporary capabilities of combat means, in at least some countries, we may assume that such a capability is more real than a few years before. Designing a modern anti-satellite system ASAT (Antisatellite Weapons) allows modern aircraft to conduct operations in (near) space.

2 M. Kaku, *Wizje. Czyli jak nauka zmieni świat w XXI wieku*, Prószyński Media, Warsaw, 2011, p. 28.

development, we may risk a statement that aviation enters new spheres of combat: air-space and information warfare. Its classical application era ends and the future is likely to witness *escape* into near space.

The continuity of 3D battlefield surveillance

It is difficult to detect targets which are well-hidden and concealed. It is also not easy to find dispersed targets. It is even more difficult in case of mobile targets where there are only brief opportunities for their detection and destruction. At present there are not sufficient systems to back up the detection and destruction of such targets. Therefore, we may assume that in the foreseeable future the whole scientific effort will be directed towards solving this particular problem. However, it is essential to conduct constant reconnaissance and surveillance of the airspace to effectively eliminate concealed, disperse and high-value targets (HVTs)[5]. The most difficult issue is to decide whether to direct manned reconnaissance aircraft into the hostile environment as they will have to search for targets over a lengthy period of time, patrol the area, at the same time being exposed to all types of threats. The experience of armed conflicts in the Balkans or in Kuwait, Afghanistan and the second Gulf War prove the previous theses that during an air operation, especially its first stage, the fight over air superiority – aviation still suffers the biggest losses. It must be stressed that the losses concern not only equipment but, first and foremost, the flying personnel. Therefore, it is understandable that currently certain systems or satellite constellations which may provide higher frequency of updating are used. Additionally unmanned aerial vehicles with high loiter capabilities are also used[6]. Although the exploited satellite systems are

3 B. Grenda, J. Nowak, *Dowodzenie siłami powietrznymi*, AON, Warsaw, 2011, p. 67.

4 More and more attention is drawn to providing proper service life and best possible electronic countermeasures in aircraft. A multirole F/A – 18E/F aircraft is equipped with the complex IDEH system with enhanced possibilities of an electronic protection (EP), whereas the F-16 Desert Falcon with the IEWS (*Integrated Electronic Warfare System*).

5 J. Rajchel, E. Zabłocki, *Siły Powietrzne w sojuszniczym systemie obronnym*, WSOSP, Dęblin, 2009, p. 11.

6 J. Nowak, *Charakterystyka militarnych zagrożeń bezpieczeństwa powietrznego*, Zeszyty Naukowe WSOSP, No. 2(17), Dęblin, 2011, p. 61.

extremely efficient for this purpose, still they do not provide constant 3D surveillance of the battlefield. However the information provided with a long delay can only be of archival value. When it is possible to discover something of real interest, aviation should be ready to respond immediately. Therefore, this problem needs to be considered in the aspects of knowledge[7], organisational skills[8], combat possibilities of the assets in commission (range, guided weapons), level of training (precision of strikes), weather conditions and time of the day. This may mean that if we expect the engagement of aviation in reaching the targets of joint operations, waged both in wartime and hostilities, to be possibly most effective, it is essential to have thorough reconnaissance of the target, to have the capability to reach the target and to effectively launch a strike, and most importantly do it at a proper time. It is necessary to emphasize the fact that aviation possesses means to provide a sufficiently large range of operations as well as necessary precision strike capabilities, however, the reconnaissance and strike systems are not efficient enough to meet the requirements of the future battlefield. Thus, the bulk of the effort should be directed at increasing even faster reaction, as it is commonly assessed, and shortening the decision making process, in particular. The development of aviation should be aimed not only at the implementation of modern platforms, ammunitions or systems, but also at new organisational structures and new methods[9] and technologies, decision making[10] and conducting certain types of actions. These conditions demand an introduction of solutions which are referred to as “three dimensional prediction of a joint operation” (the ability to understand its nature, character in order to detect and identify objects of interest, connect their previous and current status as well as foreseeing their most probable future actions)[11]. This calls for a necessity of a system which, in the case of target detection by a specialized sensor, will allow surveying archive

7 A. Rurak, *Systemy wspomagania komputerowego w szkoleniu i doskonaleniu kadr dowódczych*, Zeszyty Naukowe WSOSP, No. 2(25), Dęblin, 2015, pp. 159-160.

8 B. Grenda, *Planowanie użycia sił powietrznych*, AON, Warsaw, 2013, pp. 148-149.

9 A. Rurak, *Inspirujące metody dowodzenia w Siłach Zbrojnych*, Zeszyty Naukowe WSOSP, No. 1(20), Dęblin, 2013, p. 119.

10 R. Makowski, T. Smolicz, *Czynnik ludzki w operacjach lotniczych. Człowiek, możliwości i ograniczenia – uwarunkowania psychofizyczne*, Adriana Aviation, Kosowizna, 2012, pp. 168-169.

records, obtained from other sensors, and will facilitate combination of the data with the existing ones.

Information superiority in the military dimension

"The IT revolution, achieved mainly through a fast exchange of information over the Internet and through advanced systems of processing information, allows automatically creating the picture of the situation and enables an increase in profits without a radical growth of investments". While observing the changes in civilian environment, it is necessary to notice possibilities of a similar increase in combat capabilities, including aviation[12], through improving the relationship "committed forces – achieved result". The exploitation of centric networks in aviation makes it possible to achieve information advantage in the military dimension, which in turn facilitates to conduct effective operations at a reduced expense, i.e. by smaller forces and lesser consumption of munitions. The information advantage, i.e. through connecting the elements of combat formation elements by means of an information network, will allow the commander, who is responsible for the use of aviation, to stay ahead of the enemy aviation operations, and in an optimum way, exploit the possibilities of both one's own forces and the enemy weaknesses. All of this contributes to the building and proper use of a network[13] of uninterrupted information and data flow[14], where each user will have full access to the data received simultaneously in any formation place. This will allow performing precision air strikes on the opponent on an unprecedented scale. Thus, it will become possible to launch effective attacks and eliminate highly manoeuvrable objects, which so far exercised considerable vitality. The forces which will incorporate the concept of staging centric network

11 J. Kozuba, A. Rurak, *Proces decyzyjny pilota w sytuacji innej niż planowana*, Logistyka, No. 6/2015, Poznań, 2015, p. 1426.

12 K. Załęski, *Uwarunkowania użycia sił powietrznych w systemie bezpieczeństwa narodowego*, WSOSP, Dęblin, 2011, pp. 91-93.

13 J. Skorupski, *Współczesne problemy inżynierii ruchu lotniczego*, Oficyna Wydawnicza Politechniki Warszawskiej, Warsaw, 2014, pp. 18-20.

14 J. Bednarek, A. Andrzejewska, *Zagrożenia cyberprzestrzeni i świata wirtualnego*, Difin, Warsaw, 2014, pp. 128-133.

warfare, the fire assets will exercise much higher striking power than before, and they will be much more effective. The condition of using the possibilities offered by general information network will be possessing fire assets, capable of striking any object with a high degree of accuracy, in any weather conditions and at any time of the day or night. It must be stressed, however, that the ability to the quick overpowering of enemy troops, thanks to the exploitation of efficient surveillance and reconnaissance, general information network and high precision strike weapons may partly free high level commanders from the need to possess elaborate manoeuvrable units to achieve superiority over the enemy in a traditional way, i.e. fire and manoeuvre, on the tactical and operational level. Thereby the aim of an air operation, or at least its part, will be achieved by small groups of aircraft (occasionally single ones), using the effect of precision fire strike on enemy forces. Thus the thesis that achieving the set goals of future air operations, waged both in wartime and hostilities, will increasingly depend upon the dominance in the information sphere, where the aerospace area will play a key role[15]. It will become possible due to well-planned combined air operations, which make massive use of assets that are less vulnerable to ground fire and that are less costly[16]. The conducted research confirms the assumed thesis that the dynamics of aviation activities, the dynamics which largely affects its usage, grows proportionately to the degree of its equipment with the state-of-the art combat assets, surprising to the enemy. Today they include such technologies as “stealth” and air components of reconnaissance and strike systems that facilitate both remote and immediate detection, reconnaissance and assault on installations (control and command centres, centres emitting electromagnetic waves, airports, airfields, communication centres, and other) as well as highly manoeuvrable cruise

15 After the assessment of the effects of activities in Afghanistan and Iraq, the American Secretary of Defence, D. Rumsfeld, tried to accelerate the work over a modern MC2A platform (Multisensor Command and Control Aircraft), tested on the Boeing-767, which in the near future will become one of the main systems to protect the Global Response Strike Force. He noticed that the stratospheric reconnaissance U-2 and unmanned aerial vehicles RQ-1A Predator and RQ-4 Global Hawk satisfied the demands in an excellent manner, however, the collected information was insufficiently used. MC2A platform combines the characteristics of early detection and guidance E-3A AWANS aircraft, an aircraft to observe ground installations E-8 JSTARS and machines of electronic reconnaissance and countermeasure RC-135. Apart from the reconnaissance tasks, the coordinated activities of jet, assault and unmanned aircraft will continue.

16 A. Rurak, *Możliwości zastosowania bezzałogowych statków powietrznych*, Zeszyty Naukowe WSOSP, No. 2(23), Dęblin, 2014, p. 104.

and ballistic missile launchers. It is not surprising that more and more often we encounter signals concerning the necessity to use unmanned aerial vehicles practically on a massive scale, carrying homing and guided weapons. One can assume that there is an ongoing metamorphosis of the architecture of a possible use of aviation in joint operations, waged in the near decades.

Unmanned aerial vehicles on a future battlefield

UAVs constitute one of the most sophisticated and advanced technologies of battle combat assets of all military forces. They are flexible enough to operate and launch strikes with pinpoint accuracy on even the most remote regions of the enemy's territory. They are capable of reaching the most valuable, strongly protected installations. The assumptions of preparing and staging a targeted battle in the net will tremendously add to devising and introducing newer generations of combat unmanned aerial vehicles into service. We should pay particular attention to the fact that these aircraft will be much faster to use in operations rather than manned aircraft, where the crew typically requires additional preparation. The practical experiences conducted so far in using unmanned aerial vehicles in the analysed operations indicate that their activities aimed at:

- firstly, decreasing the quantity deficit of manned aviation;
- secondly, executing tasks which are typical of manned aviation in extreme conditions, i.e. involving a considerable risk of suffering huge losses to personnel and equipment, also in urban terrain.

Taking into account the fact that the unmanned aircraft is a specific type of flying apparatus, we can conclude, by analogy to the contemporary views on the use of aviation and experiences with the local wars, that in future air operations in the next few decades UAVs will be designed to carry out the activities such as: reconnaissance (identifying and showing objects to strike hits), strike (incapacitating ground, air and maritime objects by means of electronic and fire measures) and special (in support of other types of armed forces). While the concept of using manned aviation will be directed at conducting activities which are on a strategic and operational level, the use of UAVs is conducted on a tactical, operational level, especially the tactical one. The real possibilities of UAVs' use in conflicts prove that their priority will be narrowed down to air reconnaissance[17]. This is the area where both the construction concepts and their outcomes will find the biggest application. There are a great deal

17 M. Creveld, *Era lotnictwa wojskowego*, Instytut Wydawniczy Tetragon, Warsaw, 2013, p. 288.

of causes of such a possible application. However, it is difficult to point to any hierarchy of importance. Undoubtedly, the most important applications concern their tactical and technical capabilities of obtaining current data about the enemy, both prior to and during combat operations. The new type of threat, and in effect armed conflicts, the scientific and technical development, arising new conditions and rules of the use of military power in resolving potential conflicts, including conducting joint operations at the beginning of 21st century enable a different approach to reconnaissance activities conducted by means of aircraft and unmanned aerial vehicles as compared to the past. This "difference" will involve e.g. a different attitude to the current types of reconnaissance. Taking into account the pinpointed conditions and capabilities used in air operations, we may assume that instead of insofar types of reconnaissance (initial, direct and control), it will be possible to differentiate reconnaissance of a situation, targets and signals. The extent and contents of the tasks would depend upon the chain of command which supervise the reconnaissance missions as well as types and tactical-technical properties of the used aircraft, as long as:

- situational reconnaissance (location) involves specifying type, composition of the force, activities and intentions of the enemy; also disposition, direction and speed of movement, terrain and weather conditions;
- reconnaissance of targets, which involves detection, location and identification of targets with necessary accuracy to destroy them by own fire assets (land, aerospace and maritime);
- signal reconnaissance which involves gaining information about targets which are electromagnetic emitters[18].

Other activities of unmanned aerial vehicles are closely linked with electronic warfare as well as demonstration and deception missions. This group includes such tasks as:

- interception, identification, locating the sources of electromagnetic radiation;
- executing active and passive jamming of electromagnetic source radiation (land, sea and air);
- disrupting the functioning of enemy electronic equipment, used in command and control, reconnaissance systems, engagement of weapons, and other.

Unmanned aerial vehicles may also be used to strike land and sea-based enemy targets[19]. They will also be able to cover our own strike

18 J. Rajchel, A. Rurak, *Profesjonalne siły zbrojne w społeczeństwie XXI wieku*, Zeszyty Naukowe WSOSP, No. 2(21), Dęblin, 2013, p. 110.

19 A. Rurak, *Możliwości*…, p. 100.

aircraft and combat enemy aircraft. However, they will have to be treated as a platform, which in the first place will be capable of carrying "air-to-air weaponry", and secondly of functioning within the detection system and target designation. It needs to be stressed, however, that despite much larger capabilities than manned aircraft (higher G-load), using them in direct combat with enemy fighters will be problematic. It will be possible to fight targets at larger and medium distances (both aircraft and ballistic missiles), however, fighting at a smaller distance, due to lack of sufficient situational awareness, will remain beyond their capabilities, at least in the considered time span. Therefore, we may assume that at least within the nearest several decades, the requirement of high manoeuvrability in UCAV constructions perhaps will not utterly lose its relevance. Still, it will not be as essential as in the case of manned aircraft. In conclusion, we can assume that:

- the development of unmanned aerial vehicles will aim towards the creation of highly-specialized apparatuses, with the ability to fight land and sea targets within reconnaissance-fire systems as well as providing safety of aircraft crews which perform missions in a particularly dangerous environment, i.e. aerospace;
- in the concept of the development of unmanned combat aerial vehicles (UCAVs), high manoeuvrability will not be the essential feature, however its design should incorporate the "stealth" technology; it should also be autonomous to perform missions, yet the decision to engage should be taken by the ground operators;
- the use of intelligent weapons will allow performing actions against well-protected, reinforced and well-concealed stationary installations, also in urban terrain;
- unmanned aerial vehicles will complement, but not replace manned aerial vehicles (aircraft, helicopters) in the execution of extremely hazardous missions.

New technologies in aviation

Despite numerous benefits of unmanned aerial vehicles, the main strike force of aviation will still be launched by strike and support aviation, based on modern multirole aircraft. Even now, combat aircraft, currently introduced to armament, re-equipped with complex systems enabling battlefield surveillance, detection of both air and land targets by means of radars and electro-optical equipment. They are mounted both independently and as suspended pods, so as to better adjust the aircraft for the needs of the staged operations. At present almost every element of air equipment contains more or less sophisticated electronic systems,

which become a target for a new type of weapons. The technology of destroying targets by means of a microwave beam is currently so advanced that before long it will find practical applications[20]. Thus, in the conditions of exploiting information network (according to the network centric data concept of warfare), there arises a need to place reconnaissance and surveillance means on separate specially designed platforms. Therefore, these systems should be capable not only of designating targets, but also tracking them down, practically targeting. This will contribute to the dismantling of heavy navigation combat equipment platforms, which will result in their more effective usage[21]. Moreover, onboard sensors will have to be fully replaced by fast exchange tactical information platforms, which will make it possible to execute targeting functions "from the outside", from command and control positions, linked to the general information network. In the future, however, when aircraft crews are to be replaced by UAVs to a larger extent (in most cases the pilot-operator will remain on a ground post), flying apparatuses will be highly reduced in size and they will serve mainly as platforms carrying standoff weapons. It will allow increasing tremendously the service life of an aircraft in theatre, since its small size and decrease in the number of elements emitting electromagnetic radiation will allow reducing its detection dramatically. This denotes that the used electronics in the projected combined operations will become the element which will significantly influence the effectiveness of using e.g. aviation[22]. Electronic instruments, reasonably laid out on various types of carriers will first gather, rapidly analyse, work out variants of possible solutions and then distribute the data among addressees. The growing role of aviation in achieving the goal of a combined operation enforces further intensive training of manned aircraft. First and foremost there is the introduction, into its structures, of multirole aircraft, built in the "stealth" technology and equipped with modernized onboard observation-targeting systems along with precise aviation combat assets, in co-operation with them, in the aspect of full separation from weather or daytime conditions, and also further hampering enemy combat capabilities. The analysis of solutions applied in currently exploited aircraft[23] allowed establishing a rank of fundamental requirements made for future multirole aircraft, which should be characterized by e.g.:

20 Even now, during one combat mission an experimental aircraft, equipped with a proper quality generator, may attack one hundred ground targets and use at least 1,000 impulses.

21 J. Rajchel, A. Rurak, *Profesjonalne*…, p. 102.

22 R. Bartnik, *Lotnictwo w walce z siłami nieregularnymi*, AON, Warsaw, 2014, p. 78.

- a wide range of available speed and altitude;
- a broad assortment of armament and steering systems which secure efficient activities both in the conditions with or without visibility of air, land and sea targets;
- high manoeuvrability;
- operating in adverse weather conditions and at night (without no visibility);
- shielding the most vital elements of aircraft, doubling major installations as well as simplicity of design and maintenance.

In order to raise the aircraft service life, there is a growing tendency to use the stealth technology, which will concern not only the airframe itself, propulsion system, but also its electronic equipment[24]. In this field, the efforts will be directed at lowering, in the first place, the effective electromagnetic reflecting surface, the infrared signature and the emitted electromagnetic energy. However, research needs to be conducted into decreasing the likelihood of visual detection (shrinking of size, proper camouflage, smoke-free propulsion systems) and lowering the level of the emitted noise. We may assume that the technologies and techniques of impeded detection will be developing dynamically in the future, parallel to the development of technology and techniques aimed at detecting stealth. It all proves that aviation in the considered time span will have to seek and create more and more advantageous space for combat activities, and conditions which enhance the efficiency of the executed tasks, than it is the case at present. This results from the fact that proper space shaping for combat operations is much more than applying traditional fire power in deep operations[25]. In order to launch an effective strike, in the first case it will be necessary to lower the reconnaissance, manoeuvre and fire capabilities of the enemy, and then effectively deny the enemy an opportunity to prosecute operations. It will not happen automatically and continuously, however. It will be an extremely complex process, where on a continuous basis, it will be necessary to seek a certain kind of dominance, which, if properly used, will contribute to achieving the set goal (success). For these reasons, e.g. the construction plans of aircraft will also encompass radar stealth technologies, systems of active and passive jamming and increasingly advanced ambushes. These and other novel

23 R. Bartnik, *Lotnictwo w zarysie*, AON, Warsaw, 2013, pp. 135-136.

24 J. Kozuba, A. Rurak*, Szkolenie lotnicze – zarys dobrych praktyk. Cz. 2. Organizacja lotnicza versus szkolenie lotnicze*, Logistyka, No. 6, Poznań, 2015, p. 1476.

25 P. Nita, *Projektowanie lotnisk i portów lotniczych*, Wydawnictwa Komunikacji i Łączności, Warsaw, 2014, pp. 351-353.

electronic counter-measures are becoming more important for the survivability of the aircraft in aerospace rather than speed, ceiling or manoeuvrability. Thus, we may make a thesis that aviation should be prepared to confront enemy aviation, surface-to-air missiles, along with still dangerous air defence artillery, and also its richer, more advanced and capable electronic infrastructure. In the light of the above, it seems that in the nearest decades, the fundamental influence upon the shape and the body of the structure of a multirole aircraft will be exerted by requirements of stealth technologies, mounting internal armament chambers and more and more common use of appropriate construction materials for the outer elements of the airframe[26]. Successful achievement of these objectives may render a combat aircraft invisible on ground-based and onboard radars, at any point of the aircraft flight. The thesis that the stealth technology will make future air force operations invisible to the warring parties, should not be taken for granted. It would turn out to be a misleading way of consideration, since the reality might prove utterly different. We may risk an assumption that although the stealth technology is mostly exploited in offensive activities, it will not guarantee achieving the objective of the operation, yet its absence may also prove it impossible. The analysis of the use of aviation in the operations at the turn of the 20th and 21st centuries shows that the used conventional weapons appears far too insufficient. Effective launching of strikes by means of the classic bomb armament required attacks made by means of diving or at low altitudes, which in turn exposed the aircraft to heavy fire of small-bore weapons and consequently frequent downing. Bombing at high altitudes, however, increased the dispersion of bombs, at the same time diminishing their effectiveness. As a result, in order to destroy the target it was necessary to perform several attacks or involve a higher number of aircraft, which entailed larger use of ammunition or fuel. Thus, in order to eliminate these drawbacks, and particularly to increase the probability of striking the target, the bombs had laser or electronic guidance systems fixed, which were not totally reliable in adverse weather conditions. Therefore, there emerged a need to mount combat weapons fitted with the guidance system that operated regardless of various types of weather and contact with the platform, which ensured high pinpoint accuracy and effective elimination of various types of targets, provided their price would be low enough for the cost-effect ratio to enable its widespread use. Devising a new type of short range guidance weapons was a response to the above demand[27]. The

26 M. Kaku, *Wizje*…, p. 30.

27 R. Bartnik, *Lotnictwo w walce*…, p. 131.

aircraft armoured with precision guided bombs may attack multiple targets simultaneously during one single sortie. However, the targets should be selected in such a manner that the "intelligent bomb" could strike a properly selected target. This tendency will presumably exert a wider influence in the future. We may assume that the introduction of precision strike guidance weapons into aviation armament (bombs, missiles) will become a norm. We can also expect that the range of this type of armament will be expanded (homing munitions). Yet, this type of weapons has both advantages and disadvantages, the most important of which being the high expense. Therefore, the decision to use such munitions, within the considered time span, will still have to be taken in a well-considered manner, by making judgements about the selection of the targets from the standpoint of reaching the pre-set operation objectives. Guided weapons, used on a massive scale will allow to make a radical change in striking the enemy. In the attack of non-guided armament, a certain target had to be struck by a group of several or several dozen aircraft. This number will be tripled with involvement of combined air operations (COMAO). The examination of practical activities of aviation indicates that, depending on the target, attacked by traditional, classic, non-guided destruction weapons, the number of aircraft which are necessary to eliminate such a target with precision weapons, has decreased by 4-5 times[28], within a decade. Thus, even during an attack on massive-sized targets, only the units which are of primary importance for its functioning need to be chosen. On the other hand, in attacks performed by guided weapons on one target only, it is enough to involve perhaps one or two, but no more than several aircraft. The number of simultaneously destroyed targets is dramatically growing, with a high rate of elimination. Besides, with a properly selected concentration of strikes, we may achieve an appropriate extent of overpowering the enemy, without recurring strikes. The exploitation of aviation guided destruction weapons with kinetic concrete warheads will influence further effective use of aviation in urban terrain. This will manifest in e.g. minimizing collateral damage, and consequently attacking targets located in the proximity of unlawful targets. It appears that another direction which may influence the effectiveness of the use of aviation should be the development of cheap, guided and homing precision strike weapons, co-operating with external systems which provide target information to enable:

- independent analysis of the situation within the area of operations, by crew members, as well as independent selection of targets;
- launching precision strikes with a selected standoff weapon;

28 S. Augustyn, *Żywotność lotniczego systemu antropotechnicznego*, AON, Warsaw, 2013, pp. 172-173.

- using weapons and launching them at large distances, no matter whether the launched missiles (bombs) will be sufficient to identify the target in a precise way, update its location in the area, and then destroy it;
- raising the possibilities of destroying targets in difficult weather conditions and during the night.

Meanwhile, we may state that the use of guided and homing precision strike weapons, by aviation, changes the "powerful swarm" of hundreds of assault aircraft and support aircraft, which attempt to obliterate selected targets, into a narrow flexible "rapier" that accurately eliminates the enemy forces and means. In turn, mounting the first analogue computation machines on board jet-bomb fighters gave rise to navigational sophisticated systems, and later with the advent of digital machines to targeting-navigational complex systems[29]. Due to land-based and onboard radio navigation systems, navigation of an aircraft at large distances, with no visual contact with the ground, has become possible. However, most of all, the distances to detect high-resolution objects, small-sized and manoeuvring, and also the possibilities of their precise detection and identification have risen. In the successive years, these system were corrected by onboard radiolocation stations, and even laser stations. A high degree of accuracy of these instruments created an opportunity to devise the so-called navigational bombing (without target visibility). Mounting autonomous navigation systems in contemporary aircraft, allowing to navigate without the backup on the side of external navigational systems, should provide effective staging of operations, even in disruptive conditions. These aircraft should also be equipped with electronic warfare (EW) means (stations: RWRs – radar warning receivers, active electronic jamming) as well as devices to perform passive jamming. The standard should be to equip them with compatible onboard IFF transponders and assembling active response devices which secure co-operation with ground, sea and air radio location stations of friendly forces. All of this leads to abandoning classic piloting-navigational instruments, their replacement by integrated multi-function sensors which give the pilot clear and complex information, necessary in a given phase of flight. We should always bear in mind that the fixed or rotary-wing aircraft, its avionics and

29 They initially included: inertia navigation and Doppler radiolocation stations. These devices, digitally linked to the computer, even before a mission, allowed programming the flight path to its destination, according to certain coordinates. Any course corrections, resulting from the influence of external factors or the automatic pilot were corrected by the computer. The pilot's role gradually was reduced to monitoring the navigational system and the indications of other control instruments. However, the pilot was not stripped off his duty to carry out continuous visual inspection of the outside environment. Z. Czekała, *Parada radarów*, Wydawnictwo Bellona, Warsaw, 1999, pp. 380-384.

armament may only be used within the confines of our level of knowledge, combat training and crew experience.

Since new types of propulsion systems were introduced into aviation (replacement of piston engines with turbo-fan jet engines), we may observe a constant growth of the importance of using this type of force in operations. This quantitative leap in the field of aviation power systems enabled certain types of aircraft (fighter-bomber) to conduct, already at the turn of the 40s and the 50s, combat missions at high subsonic speeds; and as far as the 50s – supersonic speeds, significantly increasing their tactical-technical characteristics. It must be underlined, however, that the requirements for the engines of combat aircraft of a successive generation, have remained the same, for many years. Briefly they can be listed as:

- the thrust-to-weight ratio;
- high technical efficiency;
- resistance to damage and high reliability, ease of operation and maintenance.

Parallel to the change in aircraft propulsion systems, the airframe also has undergone evolution. Thanks to new solutions in the sphere of technology and material engineering, it has become possible to construct an airframe which has a longer fuselage, wings of a high sweep-back angle and supersonic profile, withstanding heavy G-load[30]. The airframe of a future aircraft should be constructed as a modular one. If necessary, this will facilitate simplified overhaul, modifications, and even replacement of all systems. Simplifying, we may assume that the development of aircraft propulsions and the airframe will directly affect aviation operational capabilities in combined operations, and in particular depth of usage and types of operations. This depth may also be increased (with air-to-air refuelling), with effects noticeable for the aircraft operating from remote bases and for aircraft on air patrol duties.

A significant characteristics of aviation capabilities will be durability of restoring combat readiness of aircraft. The side which will be the first to restore combat readiness of their aircraft will react faster than the enemy. The time for restoring readiness should be determined by defined intensity of operations. Yet, it must be remembered that this intensity will not remain on the same level in the staged operations, but it will differ in their phases. In the most important stages, particularly at the beginning of the operations, the use of the air force will be directed towards the actions to obtain a proper level of control in aerospace. It will call for the maximum intensity, which estimated, may equal three, or even four sorties of all available air assets.

30 M. Creveld, *Era*…, p. 475.

Conclusion

The above-mentioned deliberations and conclusions, which concern the influence of implications of technological advancement of aviation equipment on aviation combat capabilities in combined operations of the 21st century, waged in warfare and conditions other than war, indicate a need for:

- detection, tracking and elimination of air targets in all weather day and night conditions, from any direction, against the ground and in conditions of electronic jamming; additionally, support for manoeuvre air combat in relation to target designation and simultaneous elimination of several air targets;
- detection, tracking and launching precision strikes on land installations, both stationary and mobile, in open and urban terrain, including hardened targets, in all weather conditions, day and night;
- detection, tracking and launching precision strikes on naval targets, in all weather conditions, day and night;
- detection, identification and destruction of radar stations by means of anti radiation missiles (ARMs), in any weather conditions, day and night;
- conducting air reconnaissance with optical, optoelectronic and electronic instruments, capable of relaying data in real time to data collecting centres, in all weather conditions, day and night[31].

The presented considerations facilitate proposing a thesis that searching for new concepts of modernising air equipment, which can affect aviation capabilities to be used in combined operations should evolve in the following directions:

- fitting aerial vehicles (manned and unmanned) with such optoelectronic and thermal imaging reconnaissance-identification equipment which will allow maintaining information advantage;
- ensuring the highest possible life time of aircraft;
- technological expansion of possibilities of continuous global reconnaissance, in all weather conditions, day and night, with restrictions for manned reconnaissance aviation;
- introducing changes in means and systems of relaying reconnaissance data, as well as conducting future warfare, taking into account the concept of net-centric warfare[32];

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31 B. Grenda, *Planowanie użycia sił powietrznych*, AON, Warsaw, 2013, pp.148-130.

32 J. Rajchel, B. Grenda, J. Nowak, *Problemy dowodzenia Siłami Powietrznymi w Sojuszu Północnoatlantyckim*, WSOSP, Dęblin, 2012, p. 180.

- designing new platforms of combat assets, paying particular attention to providing the strike effectiveness in the destruction of targets, the elimination of which will add to gaining at least advantage in time. They should provide not only pinpoint accuracy in destroying hostile electronics, but also concealed, reinforced and mobile manoeuvring targets. Increasing the range and precision of fire power, launched at small, medium and large distances, will allow diminishing human losses and material damage;
- paying particular attention to efficiency and precision of commanding crews in aerospace;
- after quick usage of upper atmospheric layers for air force missions (above 30 000 m) and outer space, obtaining a possibility of affecting space systems and relevant regions on the Earth (from the economic and military standpoint).

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TECHNOLOGICAL DEVELOPMENT AS A FUNCTION OF POSSIBILITIES OF AIR FORCE USE

Abstract: The article presents the importance of technological development in the context of the new possibilities of using the air force on a complex digital network battlefield. The role of continuous 3D surveillance of a battlefield while gaining air supremacy was described. It was demonstrated how the use of the precision weapons, weapons based on new achievements in physics, and revolution in propulsion systems are changing the face of future combat and of the role of the use of aviation.