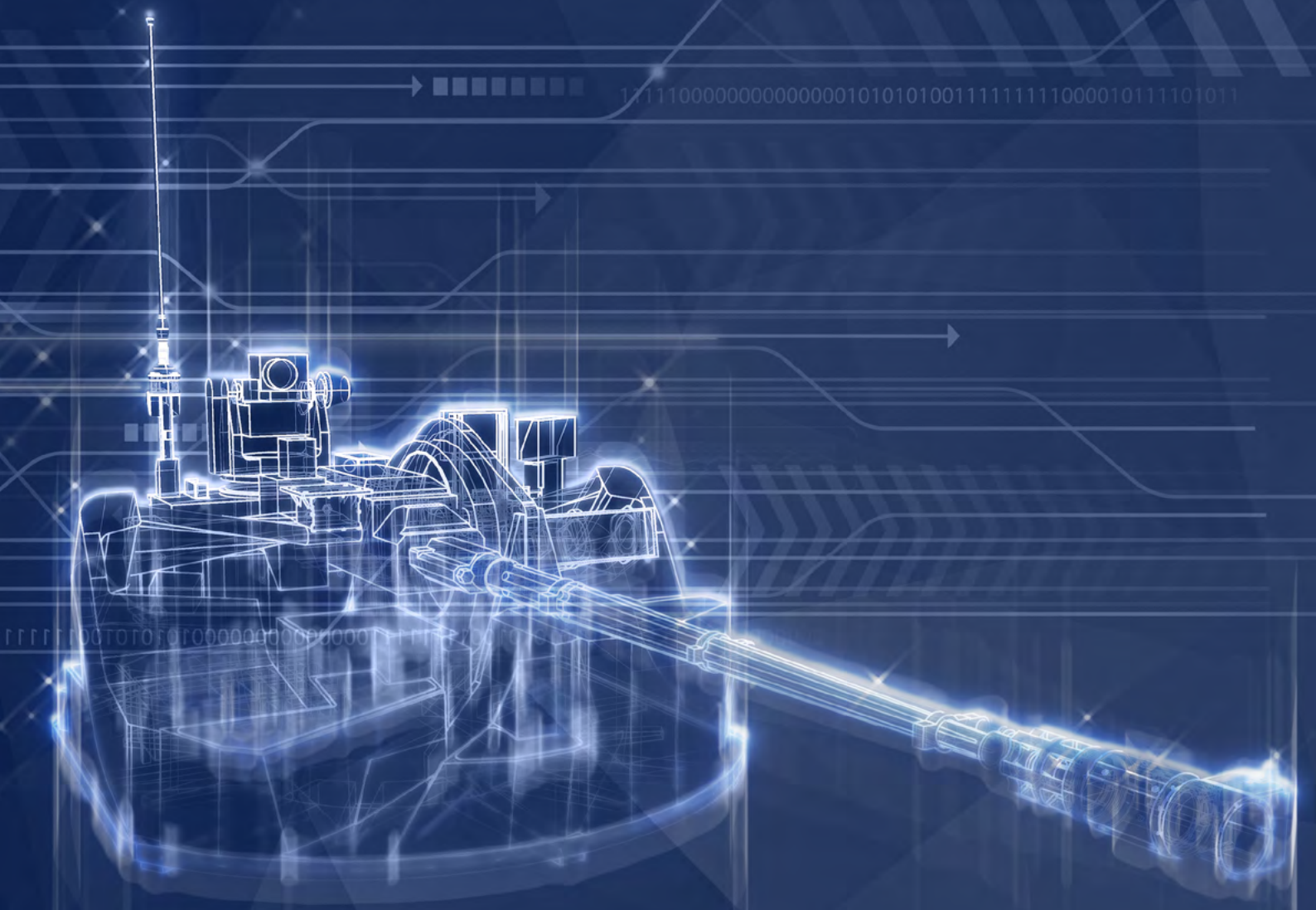
Modular Very Short Range Air Defence System

VSHORAD



PITRADWAR

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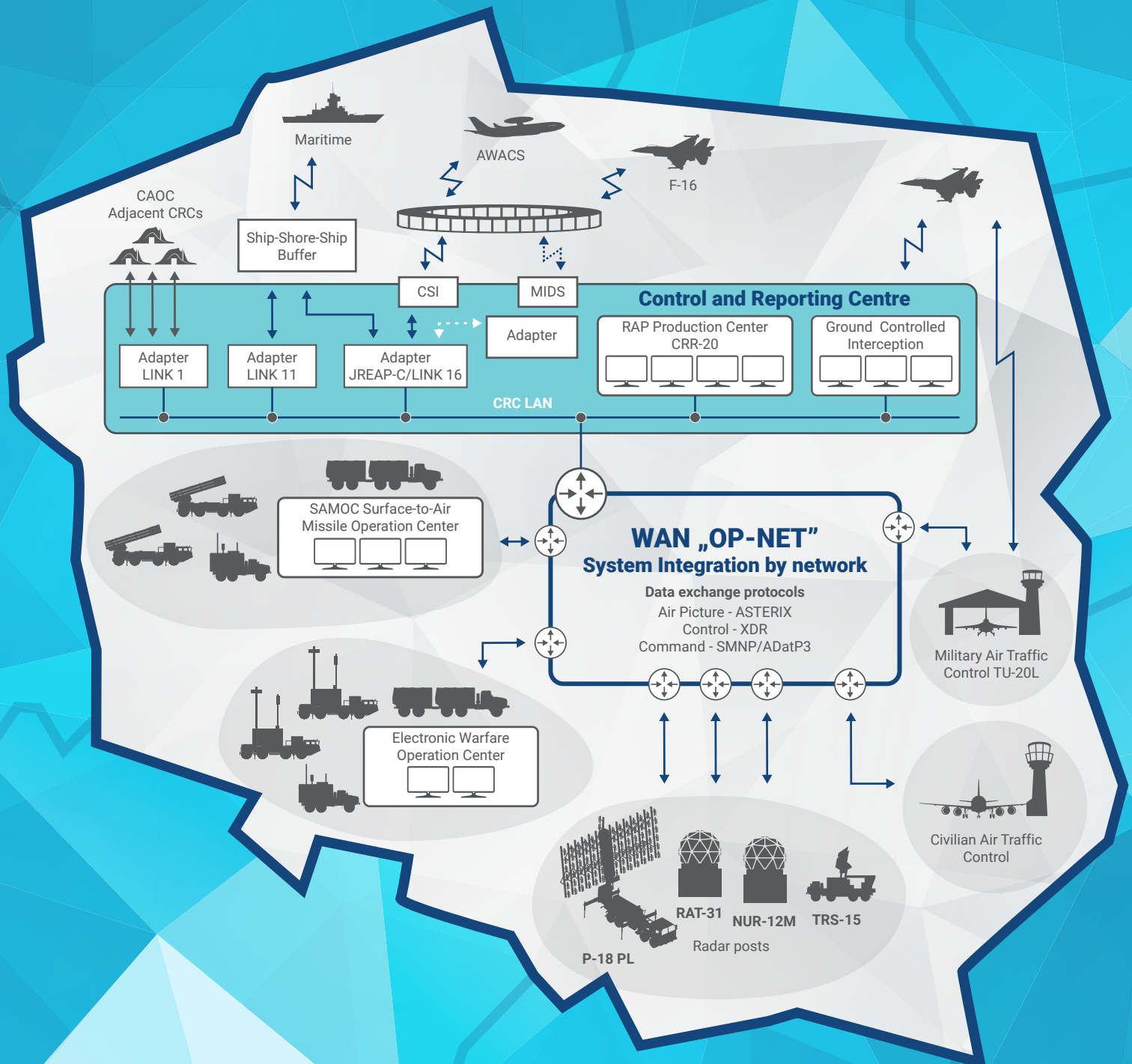
DUNAJ

Air Command and Control System of Tactical Level as a system with network-centric capabilities



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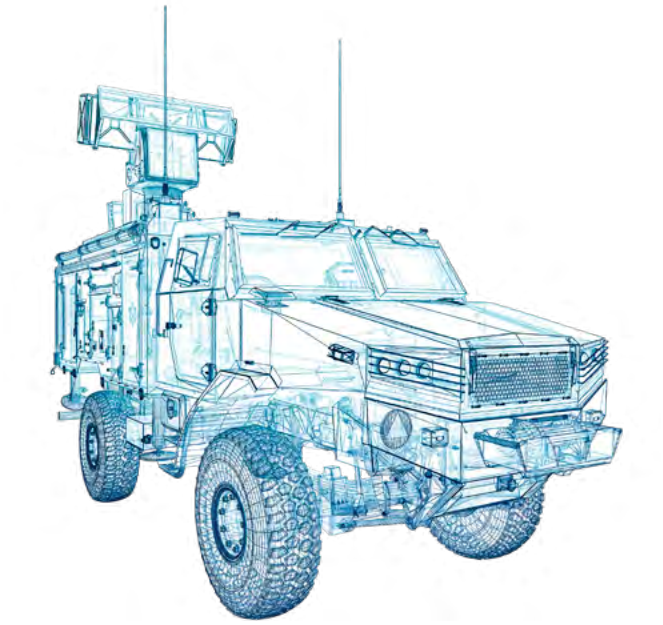
PIT-RADWAR S.A. Competencies in the Air Defence System

For several decades, PIT-RADWAR S.A. („PIT-RADWAR") has been developing and manufacturing command and control systems, radar stations and weapon systems dedicated to air defence systems and the army command systems. The offered systems are developed on the basis of the latest hardware technology and software solutions, which enable quick adaptation of the systems to the user's specific requirements. PIT-RADWAR's products, including solutions meeting the requirements of the very short-range air defence system, are used by all types of the Polish Armed Forces.



Air Surveillance radar systems

PIT-RADWAR offers a wide range of products, which, among others, include radars in the L, S, C and X bands for short, medium and long-range air surveillance systems, low-probability of intercept (LPI) coastal radars, weapon locating radars and also Electronic Support Measures (ESM), and passive location systems. Most of these products are already used by the Polish Armed Forces. Specifically these currently used include long-range radars from the NUR-12 family, mobile medium-range radars TRS-15M and TRS-15C, PRP-25 GUNICA Electronic Support Measures passive system and the LIWIEC Weapon Locating Radar that is a versatile artillery reconnaissance radar integrated with the artillery fire control system, tested in severe combat conditions during the peacekeeping missions in Afghanistan (ISAF).

The Polish Armed Forces are also equipped with the SOLA radars, developed and manufactured by PIT-RADWAR for very short range anti-aircraft artillery and missile systems. The ZDPSR SOLA Redeployable Radar is designed to control the designated airspace as well as detect and track air targets therein. The radar output data contains complete characterization of the tracked targets, including three location coordinates, velocity, heading and classification of helicopters, including helicopters in hover, as a separate target category. In addition to typical airborne objects, the radar detects unmanned aerial vehicles (UAVs) and mortar shells. The radar is mainly used in the anti-aircraft defence systems of the Army to provide protection for military units, troops and facilities of special importance.

PIT-RADWAR is currently performing a contract for the production and delivery of ZDPSR BYSTRA radars, the country's first radar with active antenna (AESA) – designed to detect and assign targets in very short and short range artillery and missile anti-aircraft systems. The ZDPSR BYSTRA is a multifunctional and multipurpose radar with versatile applications. It supports the detection and tracking of typical air threats such as combat aircraft and helicopters (also those in hover), missiles, as well as unmanned aerial vehicles and mortar grenades, precisely determining projectile's launch and impact points. The radar has extensive capabilities to operate in interference and avoid or survive anti-radar missile attacks.

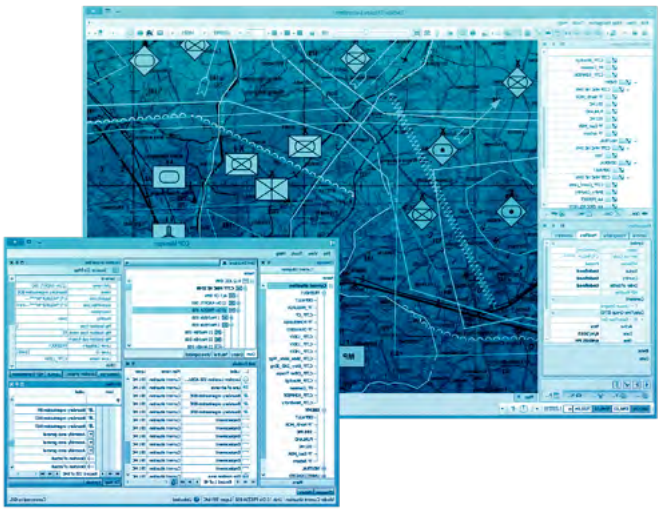
One of the key products currently being developed at PIT-RADWAR is the SAJNA the Multifunctional Fire Control Radar (RWKO) that is designed to support the short-range air defence missile system ZROP-KZ NAREW. The RWKO SAJNA is a 3D radar that is used to detect and track air targets at short to medium distances, providing the accuracy necessary to guide anti-aircraft missiles. The radar is equipped with modern communication and data transmission means, which support the NAREW missile system and other components of the air defence system. SAJNA is a solid-state radar with an active two-dimensional AESA antenna based on transmit/receive modules using MMIC GaN technology. The radar can be transported by air, sea and land . Depending on the mission, SAJNA can operate either with a rotating antenna providing full azimuth coverage (360°) or with a fixed antenna enabling sector operation with a high refresh rate of information on the tracked target. The RWKO SAJNA is a mobile unit characterized by high survivability on the battlefield.

In combination with a high antenna mast, the radar provides good low-level airborne target detection capabilities, physical and radio-band protection, as well as advanced Electronic Warfare (EW) capabilities.

The Company has also been working on active and passive medium and long-range air surveillance radar stations. These are the P-18PL multifunctional radar, the PCL/PET passive air surveillance system

and Mobile Three-Coordinate Long Range Radar – a modern, long-range semiconductor-based radar operating in the L-band.

PIT-RADWAR also offers its own development of IFF and RIFF identification devices, based on its own technologies and experience in the production of IFF Mark XII A identification devices, which are owned by only six NATO Member States. The developed IFF system uses advanced query and reply encryption techniques and is compliant with NATO standards – STANAG 4193.



Command and control systems

PIT-RADWAR has broad experience in developing modern network-centric command support systems, especially in generating the air picture. The acquired competence is essential for the development of both long-range and very short-range air defence systems.

So far, the work on command systems have included the following areas: air defence system, support of land forces, imagery intelligence (IMINT) using unmanned aerial vehicles and electronic warfare (EW).

The key products for the air defence system are: the DUNAJ system – integrating information from radars deployed in the territory of the Republic of Poland and responsible for the production of Recognized Air Picture (RAP) at the designated airspace and the SAMOC (Surface-to-Air Missile Operation Centre) – command centre and fire control system – dedicated to tactical formations (Ground Based Air Defence) (e.g. AD Missile Brigade). The work related to the SAMOC system allowed us to really increase the possibility of automatic management of anti-aircraft defence systems and the combat capability of the existing weapon systems by including all elements of the Ground Based Air Defence group (sensors, effectors and C2 units) in the network.

The Dunaj system supports the implementation of basic air defence functions, ensures permanent airspace control, as well as command and control of air force, Ground Based Air Defence units and electronic warfare. In addition, it supports the fighters control and the monitoring of tactical air missions.

The Dunaj system has been designed in accordance with the Network Enabled Capability, an idea of network-centric activities, and is a system with an open, scalable and distributed architecture based on an extensive IP WAN network (covering the territory of Poland) referred to as OP-NET. Information exchange between the air defence system components takes place in time close to real time with the use of sophisticated network mechanisms (including multicast transmission), which allows the available transmission band to be limited and used effectively. The combination of information from active radar system (DUNAJ) and electronic support measure system (WOLCZENICA) with the battlefield management capabilities of the SAMOC system – introduces a new quality to the national air defence system, based on national solutions to build a system, which is fully governed by the Armed Forces and Government of the Republic of Poland.

As part of the ACCS Alternative Study conducted by NATO in 2006-2007, the DUNAJ system was rated very highly – as one of the three best of its kind in Europe. In addition, in 2019, the system was submitted by the Ministry of National Defence for the next review carried out by the essential NATO Commands (SHAPE and ACT) – "Air Command and Control (AirC2) Systems, Analysis of Alternatives (AoA)". The Dunaj system was qualified for the third stage of talks, which proves its mature architecture, achieved through continuous work on the system improvement.

SDP-20 SAMOC is a tactical-level air defence command and control post for a mixed group of short-range anti-aircraft missile systems (PZR), developed at the missile brigade level and intended for the implementation of the command process of Air Defence units in operational, logistics and combat security areas. The SAMOC also includes SDP-10N – command post developed at the battalion level.

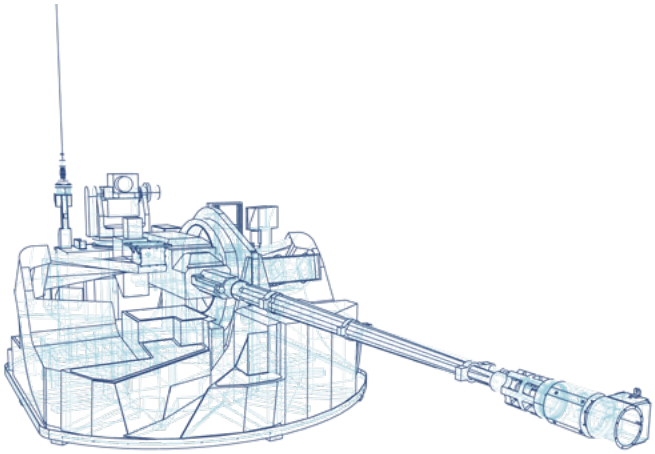
The LOWCZA/REGA systems play a key part in command and control of the air defence in the Land Forces.

LOWCZA-3 is an anti-aircraft command and control system at the regiment or battalion level, designed to support the threat assessment process and optimization of decisions made in the fight against the targets. It allows the user to control the tactical actions of batteries with homogeneous and mixed patterns, such as artillery, missile/artillery and missile systems. The REGA equipment sets form a system intended for lower tactical air defence units to support the command and control process by automating it. The REGA system makes it possible to precisely indicate air targets to weapon systems. It allows the user to fully visualize the tactical situation and to cooperate with other REGAs sets that work simultaneously.

A supporting part for the defence system is played by the WOLCZENICA system, which integrates data from radio and microwave radiation sensors. Based

on the identified radar parameters, it is possible to classify the air platform by taking the pilot's correspondence and communication language into account. Information from the active radar system (DUNAJ) and Electronic Support Measure system (WOLCZENICA) combined with the battlefield management capabilities of the SAMOC system introduced a new quality to the national air defence system based on national solutions and fully governed by the Polish Armed Forces and Government.

The key solution for the Land Forces is the SZAFRAN command and control system, which is successfully operated by the Multinational Corps Northeast (MNC NE). The upgraded version of the SZAFRAN system has been accepted by MNC NE and will be used as a command support tool in successive years. Since 2007, the SZAFRAN system has been supporting the military operations of the Corps, being the only Polish system of this class operated by the Land Forces. As part of the activities of the Corps, the SZAFRAN's ability to cooperate with the following systems was confirmed: SHAPE (LC2IS), the NATO Common Operational Picture (NCOP), 1st Dutch-German Corps (HEROS) as well as with specialized systems providing situational awareness of the NATO Joint Operations Centre. Currently, PIT-RADWAR is working on the next generation of software for the Land Forces system under the working name FENIKS, based on a prospective architecture, implemented as part of two development projects: FENIKS C2IS for the WIERZBA system (successors of the SZAFRAN system) and FENIKS BMS for the ROSOMAK BMS combat management system.



Weapon systems

The Company offer for effectors includes: POPRAD Mobile Anti-Aircraft Missile Systems – being already a part of the national air defence system, a 35 mm automatic anti-aircraft gun system (in towed and mobile version) with a programmable air-burst ammunition system and the OSU-35, a naval armament system.

The POPRAD Mobile Anti-Aircraft Missile System, used by the Armed Forces of the Republic of Poland, is designed to engage air targets at very short distances and low altitudes with the use of very short-range self-guided missiles, equipped with a tracking / aiming head, ensures high effectiveness in anti-air warfare. It is characterized by high mobility, short deployment time from marching position to combat position and the ability to work stealthily during the day and night.

The 35 mm automatic anti-aircraft gun along with the programmable air-burst ammunition system is a system complementary to missile systems used for engaging very short-range air threats. It is characterized by high efficiency and accuracy, as well as the ability to engage air targets at altitudes of up to 3.5 km and at distances of up to 5.5 km. As part of the system, the AG-35 gun and its A-35 variant were developed. The AG-35 gun, equipped with an integrated optoelectronic head, can create an aiming channel of full value, capable of intercepting and engaging the targets. On the other hand, the A-35 gun is designed to work with the WG-35 fire control vehicle, from where it is remotely controlled by the operator or fully automatically by the WG-35 vehicle's fire control system.

Both gun variants are equipped with a double-sided ammunition feed system, which allows the simultaneous use of sub-calibre frangible armour piercing ammunition (high initial speed), with high fire power, and ammunition with programmable air-burst ammunition, which significantly increases the field of fire and facilitates the destruction or damage of small air targets, including fast-moving UAVs.

The effectiveness of both POPRAD systems and 35 mm guns in engaging UAVs can be additionally increased by integrating a target detection and tracking radar and non-kinetic anti-UAV devices such as jamming devices for RF and GNSS communications.

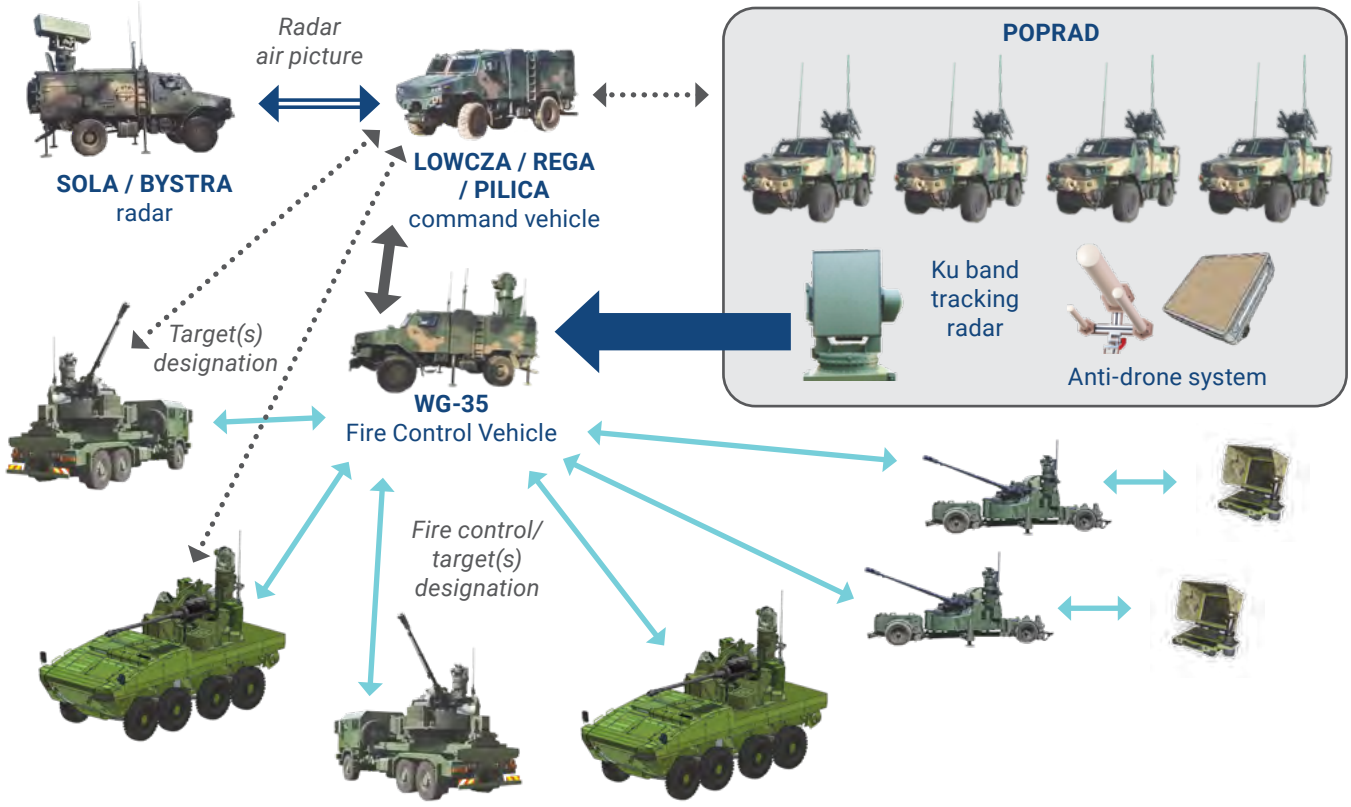
The OSU-35 Naval Armament System with a 35 mm calibre gun is designed to engage air targets at low altitudes and short distances. The system is an effective means of defence against unmanned aerial vehicles. It can also be used to engage targets on the sea surface. Due to its open architecture modularity and scalability the system can be integrated on various types of ships.

VSHORAD – Modular Very Short Range Air Defence System

The VSHORAD – Modular Very Short Range Air Defence System, which is the lowest layer of air defence, should provide military formations and specific infrastructure elements with direct protection against classical air targets, including unmanned aerial vehicles operating at low altitudes. The dynamically changing picture of air threats requires appropriate countermeasures, which will be based on modular and scalable systems, allowing for the design of anti-aircraft systems that are configured so as to meet the requirements of contemporary and future battlefield. Work on surveillance, engagement and control components for VSHORAD systems has been carried out in Poland for many years, and the developed military equipment are technologically mature solutions that are largely manufactured and operated by the Polish Armed Forces.

The issue of the sovereignty of the use of weapons and their further development should not be overlooked either. When purchasing equipment, the Polish Army should be able to maintain true independence and full control over the equipment used, including access to source codes and software documentation, which will enable future modifications and modernization of the acquired equipment (throughout the product life cycle). Relatively easy and quick access to servicing is also important. The Polish armaments industry is able to provide a repair and spare parts warehouse not only on site, but also in areas where the Polish Armed Forces conduct their military missions.

A VSHORAD class system, consisting of several batteries connected to each other via a telecommunications network, similarly to short and medium range systems (SHORAD and MRAD) – should be structured as network-centric system, in order to ensure its users the possibility of sharing available resources and provide a set of functionalities enabling selected elements to control and effectively manage operational activities in real time. The network solution should ensure the flexibility of choosing a means to engage the threat, reduce the system's susceptibility to neutralization by the enemy, and open architecture should allow for the system's future development and adaptation to current threats and requirements. The VSHORAD system should simultaneously enable interoperability with short and medium range air and missile defence systems and be able to cooperate with similar systems of NATO Member States, ensuring data transfer in accordance with relevant protocols and standards. At the same time, it is important



Proposed battery composition: *4 to 8* ***35 mm gun systems*** *and 4* ***POPRAD systems***

that the VSHORAD system battery is able to work autonomously and provide the possibility of producing the air situation picture locally based on information provided by its own radars.

Proposed by PIT-RADWAR, the implementation concepts of the VSHORAD system, which fulfils the tasks of the lowest air defence layer, are based on the POPRAD missile systems, as well as on the SOLA and BYSTRA radars, which have already been purchased by the Polish Armed Forces for inclusion in the country's air defence system, as well as on the automatic 35 mm gun system (towed and mobile version) with the programmable air-burst ammunition system and on the WD-35 and WG-35 command and fire control vehicles.

Currently, due to the intensive development of UAV systems that can possibly be used not only for engaging military targets but also for civilian objects of strategic importance, it becomes important to develop non-kinetic anti-UAV means. Such means include electromagnetic and laser beam weapons that do not pose a significant risk of damage or death.

The system can be equipped with both kinetic effectors (missiles, programmable air-burst ammunition system with projectile velocity measurement, sub-calibre and full-calibre projectiles) and non-kinetic neutralization means, which significantly increases the effectiveness of engaging the entire spectrum of air threats, including intensively developed UAV systems.

The kinetic effectors include: the 35 mm automatic gun system, which can be integrated on various carrier platforms, and the POPRAD Mobile Anti-Aircraft Missile System.

The POPRAD Mobile Anti-Aircraft Missile System is designed to engage air targets at short distances and low altitudes. It is equipped with a tracking and aiming head with integrated missile launchers, its own fire control system and communication and data transmission system enabling the operator to aim, track and engage targets not only individually but also to work in a group, while assigning targets from the command level. These features ensure high effectiveness of POPRAD when engaging the targets.

The 35 mm gun developed by PIT-RADWAR, equipped with a remote-controlled optoelectronic fire control system and integrated with command and fire control systems, is characterized by high fire accuracy and efficiency. The gun system is equipped with a double-sided ammunition feed system using belt feeders, enabling the simultaneous use of two different types of ammunition, e.g. programmable and sub-calibre ones. A feed source is switched over dynamically in less than 1 second. With this solution, the operator is able to quickly react to the changing situation on the battlefield and increase the effectiveness in engaging various types of targets, both by the gun itself and by a battery comprising several guns.

Non-kinetic anti-UAV means include electromagnetic jamming devices for RF and GNSS communications of UAV systems, which can be integrated both with POPRAD systems and with 35 mm gun systems.

The command and control functions of the VSHORAD battery and the targets allocation for POPRAD systems and 35 mm guns can be performed by the WD-35 command vehicle and the WG-35 fire control vehicle. Based on information received from the superior command system or local radar in the battery, the fire control vehicle ensures the interception of the assigned target and the setting up of the aiming channel. The designated target can be sent to the POPRAD systems, as well as to 35 mm guns, which, use their own fire control systems equipped with optoelectronic tracking heads, engage the designated target. It is also possible to automatically control the 35 mm guns from the WG-35 fire control system, ensuring the concentration of fire from many artillery sources simultaneously on a selected target.

Early detection, classification, identification and assignment of targets can be performed by radars manufactured by PIT-RADWAR: SOLA (operating in the S band) and BYSTRA (operating in the C band). Both radars provide automatic detection and tracking of airborne objects of various classes, including small UAVs, helicopters in hover and mortar shells, at such ranges that enable cooperation with the VSHORAD system effectors. With the capabilities of the multifunctional BYSTRA radar with an active antenna with electronic beam steering, the radar can be used also in SHORAD class anti-aircraft defence systems.

It is possible to retrofit individual system components with target pre-detection and tracking radar with the parameters required for a fire control system and intended for the detection of UAVs, with the possibility of using it also for engaging classic means of air attack.

Designed for use in anti-drone systems, a small detection and tracking radar can also be installed in the POPRAD systems and on each of the 35 mm guns, thereby extending their capabilities with non-kinetic neutralization of UAVs.

Target tracking at the battery level would be provided by the Ku-band radar (RSKu), which would be integrated in the Fire Control Vehicle (WG-35) of the battery system.

The tracking radar, supplementing the optoelectronic systems, among others, used for artillery fire control, including 35 mm guns and GROM/ PIORUN missiles, will allow the fire control system capabilities to be enhanced thus enabling targets to be engaged effectively even in harsh environment conditions, when the operation of optoelectronic sensors is not optimal.

All elements of the system, especially weapons, are adapted to work with the IKZ-50P short-range interrogator (mode 5), which is the last element of identification prior to the use of weapons.

The VSHORAD system configuration concepts assume the use of nationally developed communication and data transmission systems, radar stations, missile and artillery systems, IFF devices, which are largely in current production, as well as in the use by the Polish Armed Forces. They form complementary and coherent configurations that can be flexibly implemented in various variants on various carrier platforms.

Air defence system integrated with radar and command and control systems

The system concept is a development of the solutions developed and tested as part of the project of the Anti-Aircraft Battery with 35 mm gun systems. The system is used to engage such threats as: small air objects, including UAVs, fighters, helicopters, unguided and guided air-to-ground missiles, as well as unarmoured and lightly armoured ground and sea surface targets.

In this configuration, it is possible to integrate a 35 mm gun turret with an optoelectronic head, as well as a fire control system (as a counterpart of the WG-35 fire control vehicle) on a heavy-duty vehicle. This solution will combine fire capabilities with the mobility of a wheeled vehicle and will enable additional ammunition to be transported. With the ability to engage ground targets, the mobile 35 mm automatic gun could also serve as an escort unit in convoys.

The 35 mm automatic gun system (AG-35) can also be installed on a tracked armoured vehicle. The 35 mm artillery system could then be used as a cover for motorized infantry units equipped with tracked vehicles of the same type. It is also possible to successfully mount a head on such a vehicle to connect a tracking radar with optoelectronic observation and aiming systems.

Early detection of threats is ensured by the cooperation of the battery system with radar stations. It is also possible to use SOLA or BYSTRA radar on the same vehicle as weapons would be mounted. In addition, using the capabilities of a heavy armoured vehicle, such a system can be retrofitted with very short-range anti-aircraft missile launchers, e.g. by using the optoelectronic tracking head as is used in the POPRAD system to obtain an integrated artillery and missile air defence system.

Making the mobile anti-aircraft system platform uniform with the vehicles used by mechanized or motorized units would facilitate the operation of such system.

Turret system on self-propelled platforms

The comprehensive, modular turret system on self-propelled platforms can be used both to engage air targets, including unmanned aerial vehicle, and unarmoured and lightly armoured land and surface targets, using various types of ammunition.

Appropriate design solutions make it possible to integrate the turret system with a wheeled or tracked vehicle of suitable load capacity. The implementation of a 35 mm automatic gun will ensure high mobility of the system, which will significantly increase the protection capabilities of military units being on the move, including armoured and mechanized troops.

The VSHORAD battery module weapons can be supplemented with a tracking radar, optoelectronic head and early detection radar, located on the same vehicle,

to provide data to the integrated fire control system. Such a system can be equipped with two 35 mm guns with programmable air-burst ammunition and sub-calibre ammunition. The anti-aircraft guided missiles Piorun or Piorun 2 can supplement the system armament by creating an integrated artillery and missile component of the VSHORAD system. There are also possible other system configurations as required, including retrofitting it with elements of non-kinetic neutralization of unmanned aerial vehicle . Effectors, tracking radar and optoelectronic head can be placed on one vehicle. Then, command and fire control vehicles, using data provided by SOLA / BYSTRA radars, can be used to initially assign a target for such a system.

PIT-RADWAR's broad experience in the field of advanced driving systems – both in weapons and optoelectronic tracking and aiming heads, allows it to effectively implement solutions enabling effective fire on the move. Similar solutions have been used in the proven, tested and deployed 35 mm Naval Armament System (OSU-35) on the ORP KASZUB.

Naval Armament System

The naval armament system with a 35mm gun (OSU-35) is a modern direct defence system of naval ships. The naval gun system (OSU-35) uses solutions based on analyzes and research work in the field of the latest technologies. The OSU-35 consists of: unmanned turret with stabilized 35 mm gun, with two storages of programmable air-burst and sub-calibre ammunition, 100 projectiles each, fire control system with the main operator post, tracking optoelectronic head equipped with the IFF system and reserve fire control station.

An important feature of the OSU-35 is the line-of-sight stabilization system for the sensors of the integrated head and the sight line of the gun barrel. Stabilization enables accurate firing in an extremely variable marine environment. The stabilization systems for all axes of the gun and head include driving systems using electric motor sets that are controlled by specialized computers. The drive controllers, using an appropriately selected set of gyroscopes, record with high frequency the measurements of the angular position of the gun barrel and the line of sight of optoelectronic sensors relative to the global reference system associated with the Earth. The controllers use algorithms developed and tested by PIT-RADWAR, in order to minimize the impact of sea and ship movement on the angular position of the barrel and the optoelectronic tracking head's line of sight. The latest solutions in the fields of gyroscopic systems, power electronics, power supply and control systems were used to design the stabilization system. These solutions made it possible to compensate for the impact of motion of the platform, on which the gun is mounted, on the fire control process, ensuring high efficiency of the gun even at sea state higher than force of 5 on the Beaufort Scale.

The naval gun system is modular and scalable, which allows for its development and adaptation to changing needs and requirements. The system has an open architecture in hardware and software layers. Due to this approach, the system can be used both on smaller units, as an autonomous ship defence system, and in more complex configurations, in which the gun is a part of the ship's combat control system.

Experience acquired during the work on the development of the OSU-35 system allowed us to improve

the solutions that will be used in the next version of the OSU-35K system, intended for project 258 for mine destroyers (Kormoran II) currently under construction. The OSU-35K turret is smaller, lighter and has improved ergonomics. The optoelectronic head and the fire control system with the operator's station were also modified and modernized.

In order to increase its capacity and efficiency, the naval system can be expanded with such components as the BYSTRA-M radar station, tracking radar, as well as an integrated optoelectronic head system with missile launchers.

The presented solutions, showing PIT-RADWAR's potential in the development of recognition, control and management means for VSHORAD class systems, do not exhaust the catalogue of possible configurations. The target solutions will result from the user's requirements, while taking the user's current and future operational needs into account. It is worth noting that the acquired competence allows PIT-RADWAR to offer not only ready-made solutions that are effective in the fight against the enemy, as well as service and support throughout the product life cycle, but also, in response to the growing needs of the Polish Armed Forces, it enables further development and modifications of the offered products.

BYSTRA Redeployable Radar

BYSTRA (ZDPSR) Redeployable Radar – the country's first radar with the active antenna (AESA) – is designed for detecting and indicating targets in short-range anti-aircraft artillery and missile systems. The basic functional parameters of the radar result from the operational needs of the anti-aircraft protection of a tactical battle group. In addition to typical air threats, such as combat aircraft or helicopters, the BYSTRA radar has the ability to detect and track missiles, unmanned aerial vehicles (UAVs) and mortar grenades. In order to meet a wide range of tactical and technical requirements, the device is designed as a multi-functional radar with exceptionally versatile capabilities and software-defined applications.

The radar can operate in several operating modes adapted to combat tasks being carried out. In each of the modes, a circular search is performed by rotating the antenna and scanning the airspace with a software-defined transmit-receive pattern. The scanning profile can be established in a wide range of elevation angles. This enables the operator to effectively use the radar's potential and select a search program taking into account the specific conditions of the workplace and the performed function (detection and tracking) or operational task. The radar's resources and working principles reduce the probability of its detection by the opponent's electronic reconnaissance and technical means that ensure high immunity to passive or intentional interference. These are, among others: the ability to quickly adapt the carrier frequency, phase and frequency encoding of pulses, interference bearing and spatial filtering.

The radar components with a power generator is installed on a single off-road wheeled vehicle with an armoured cabin. Thanks to the short deployment and retraction times, the ability to quickly change the workplace was achieved. The system also includes a radar decoy installed on a trailer, which can be used for either protection against the attack of anti-radiation missiles or simulation of the radar operation. The versatile (radio and cable) communication and data transmission system enables the operator to simultaneously cooperate with various automated air defence command systems of the Army, the Navy and the Air Force.

The BYSTRA radar designed at PIT-RADWAR uses numerous innovative technologies, resulting in exceptional parameters being obtained such as : effective detection and tracking distances of various classes of objects, interference filtration, dynamics of receiving channels and the ability to detect weak echoes (e.g. coming from unmanned aerial vehicles, mortar shells or missiles), high measurement accuracy of object coordinates, high resolution and increased reliability.

These innovations among others, include:

- active antenna with electronically scanned beam (AESA), with liquid-cooled solid-state distributed amplifier, characterized by a low thermal signature and increased resistance to critical failures,
- digital beam forming, reducing the influence of passive and active interference through their spatial filtration,
- digital synthesis, coding and matched filtering of signals, allowing various waveforms to be used, including frequency or phase modulated pulses,
- coordinate estimation, characterized by high accuracy of angular coordinate measurements, with limited influence of multipath propagation for low-flying objects,
- tracking subsystem based on a multiple-hypothesis (MHT) algorithm, characterized by high resistance of track initiation and tracking interference,
- dedicated subsystem for the detection of hovering helicopters, supporting several classes of helicopters,
- fusion of data from main radar, helicopter detection and IFF identification subsystems that supports classification and identification of targets,
- software-implemented radar resource management functions allowing automatic systems to be used for adapting space coverage, detection and classification of objects, interference filtration to the current situation,
- radar decoy allowing the operator to simulate radar operation, as well as to confuse missiles guided by the signal emitted by the radar.

The system was designed to be scalable, both in terms of hardware and application software. This approach was used to increase the system susceptibility to possible future upgrades and to ensure the possibility of implementing new proven technologies.

The main application of BYSTRA radars acquired by the Polish Armed Forces is to support air defence components of the Army and the Navy. Additionally, the tactical and technical parameters of the radar, technology scalability and the ability of developing its software-defined functions makes it possible to adapt the BYSTRA radar to be integrated on ships as a multifunctional ship defence radar (e.g. in the MIECZNIK and CZAPLA programmes) or on the towers in coastal surveillance posts of the Navy (as a successor to the NUR-23 radars).

In particular, due to its detection ranges, high accuracy of coordinate measurements, including those for low-flying targets, the BYSTRA radar can also be used as a multifunctional fire control radar in ZROP-KZ NAREW.

In addition to the basic function of indicating targets for ground-based anti-aircraft systems, the BYSTRA radar is capable of detecting and tracking mortar grenades and determining the coordinates of their launch and impact points. During the field tests, the radar's ability to detect and track e.g. howitzers shells and artillery rockets was also confirmed. Therefore, one of the next possible applications of the BYSTRA radar, after extending the existing functions of the ballistic calculator and artillery threats' database and integrating with the artillery fire control system ZZKO TOPAZ, is the use of the radar for detecting and indicating targets for field artillery including self-propelled RAK mortars.

The results of the BYSTRA research and development project can be used in three types of armed forces: the Army (air defence and field artillery forces), the Air Force (air defence) and in the Navy (air defence, ship defence, coastal surveillance of sea and air space).

On a national scale, the ZDPSR BYSTRA project is a breakthrough in terms of the applied technical innovations and technologies. It resulted also in new R&D expertise and experience and developed new production capabilities.

IFF System

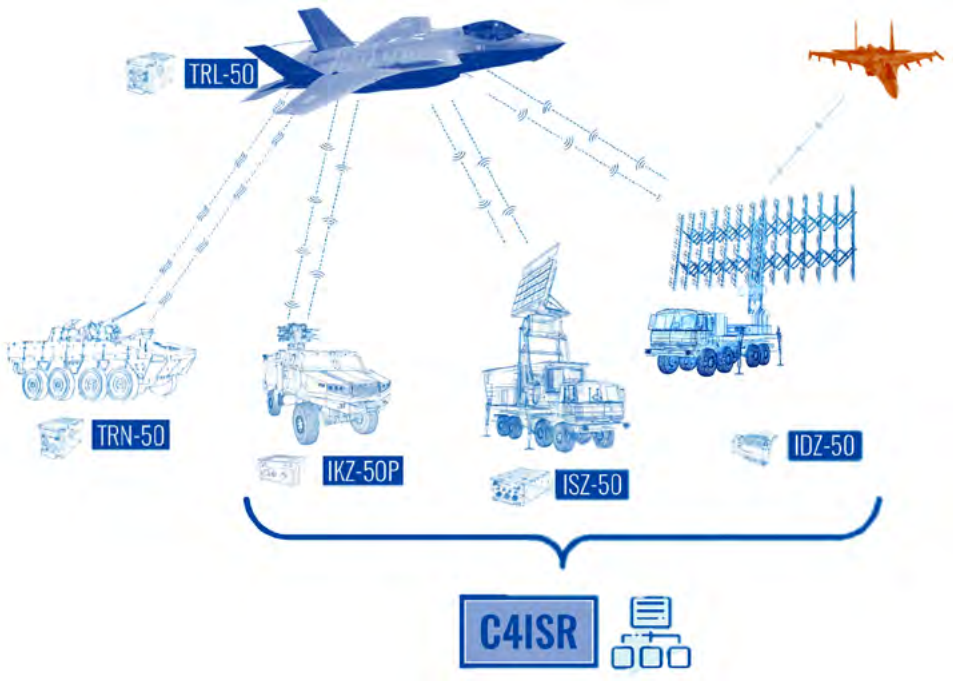
The Identification Friend or Foe (IFF) system is inextricably linked with target detection by radar. Until recently, Mark XII was the official standard of IFF adopted by the NATO. The newest version of the IFF system that introduces Mode 5, Mark XIIA, came into service and became a NATO standard on July 1, 2020. Mode 5 ensures immunity to interference and prevents the enemy's attempts to "impersonate" friendly objects. Mode S, currently used for civilian applications, allows more data to be transmitted than by using modes 3A and C. PIT-RADWAR has developed the IFF Mark XIIA system devices based on its own proprietary technologies and experience in developing of IFF Mark XIIA system devices, which are owned by only six other NATO Member States. The devices operate with crypto computers available in the NATO and comply with the NATO standard STANAG 4193.

The safety of own forces (airborne, naval and land units) depends on the effectiveness of the IFF system. Nowadays, where armed conflicts of an asymmetric nature dominate, a significant percentage of losses on the battlefield is caused by friendly fire, i.e., fire directed by mistake at own or allied units. The use of a reliable IFF system eliminates such losses.

The IFF system uses active interrogation (fixed carrier frequency of 1030 MHz) and active response (fixed carrier frequency of 1090 MHz). This requires two types of devices: interrogators and transponders (response devices). The interrogator typically sends interrogation signals to the object detected by the primary radar. The transponder on board an aircraft receives interrogation signals and sends response signals, which, when received by the interrogator, are shown on the operator's display. The received signal, properly decrypted, ensures a positive verification of the interrogated object. If a correct response is not received, the system immediately notifies the units capable of neutralizing the "negatively verified" object.

In the case of identifying "own" (coalition) aircraft, the key issue is the credibility level of such identification. The use of strongly encrypted communications (Mode 5 in place of the withdrawn Mode 4) allows allied aircraft to be fully, reliably and unambiguously identified and prevents "impersonation" by intruders.

IFF interrogators and transponders have been manufactured by PIT-RADWAR since the 1990s. Intensive work carried out by the Company quickly resulted in a number of proprietary solutions that have been deployed into the Polish Armed Forces after Poland had joined the NATO. The IFF Mark XIIA system devices developed by PIT-RADWAR use advanced interrogation and response encryption techniques.



The family of IFF Mark XIIA system interrogators manufactured by PIT-RADWAR includes three devices:

- short-range interrogators (IKZ-50P) – designed to operate with short-range or very-short-range radar stations, or for autonomous operation as the last identification stage prior to the use of weapons. Signing of the contract for the supply of up to 124 IKZ-50P interrogators, allows the interrogators to be installed in the POPRAD and PILICA systems (the IKZ-50P has already been integrated with the ELTA EL/M 2106NG radar used in the PILICA system);
- medium-range interrogators (ISZ-50) – installed in radar stations operated by the Polish Armed Forces (ODRA, SOLA, BYSTRA), in NUR-15C radar stations used by the Naval Missile Unit for guiding the NSM anti-ship missiles, and in the modernized NUR-15M stations; also intended for installation in the NUR-15M, NUR-21M, SAJNA radars, OSA missile systems, etc.;
- long-range interrogators (IDZ-50) – intended for installation in the NUR-12, P-18PL and WARTA radar stations.

A miniaturized version of the IFF Mark XIIA interrogator, the IKZ-50M (portable, battery-powered mobile version), intended for use, e.g., with MANPAD launchers, such as GROM and PIORUN and ready to operate in Mode 5 (after connecting a compatible crypto computer) is under development.

The above devices are designed to operate with short-, medium- and long-range air defence systems. The ISZ-50 and IDZ-50 interrogators support identification in Modes 1, 2, 3/A, C, S and encrypted Mode 5 (up to Level 2), while the IKZ-50P supports Mode 5. The devices use the latest digital technologies that ensure immediate and reliable identification, high reliability and interoperability. Security in Mode 5 is ensured through the use of crypto computers compliant with the DoD AIMS 04-900A Option B standard. Modular design and software upgradeability enable the functionality of all devices to be expanded along with the evolution of IFF and SSR (Secondary Surveillance Radar) standards.

PIT-RADWAR has also developed prototypes of airborne, ground vehicle and shipborne transponders. They are developed under the KWISA-2 development project.

Designed for installation on air and sea platforms, the TRL-50 transponder is a response device of the IFF Mark XIIA system that also functions as an interrogating device in the Reverse IFF (RIFF) system. RIFF is an innovative air-ground identification system that allows ground objects to be identified from the air, which dramatically reduces the risk of friendly fire. For the proper functioning of the RIFF system, it is necessary to equip ground (and sea) platforms with appropriate response devices. This role is fulfilled by the TRN-50 transponder, designed for installation on ground and sea platforms. In conjunction with the TRL-50 transponder or other devices supporting the RIFF system, the TRN-50 can identify own platforms on the battlefield, thus reducing the risk of friendly fire. The protected area is defined in the identification process, which allows to protect not only the vehicle itself, but also the accompanying infantry or stationary group against friendly fire.

The IFF Mark XIIA system will be of key importance in the near future, especially in asymmetric conflicts, such as in Iraq, Afghanistan or Ukraine, where no designated front line exists and where both own and allied troops change positions frequently.

Like any electronic system, IFF Mark XIIA may be subject to remote functionality modification (manipulation) through methods known to its manufacturer. It is, therefore, very important to use solutions with known and verified software developed by the domestic industry.

At the same time, the development of national crypto computers would ensure the full sovereignty of combat identification by the Polish Armed Forces, regardless of the international situation.

Key features common to the IFF systems offered by PIT-RADWAR:

- full compliance with IFF Mark XIIA and ICAO (Annex 10) standards,
- easy integration with cooperating systems,
- very high reliability,
- extensive self-test capabilities,
- built-in advanced functions for cooperation with the antenna system (including antenna side lobe suppression),
- design based on large-scale integrated circuits, ASICs, microwave integrated circuits, microprocessors, etc.,
- small size and high resistance to environmental factors,
- low power consumption.

VSHORAD Battery Command Post

The C2 class solutions as proposed by PIT-RADWAR enable fire of missile and artillery systems to be effectively controlled through, among others, advanced processing of radar information coming from radars (e.g. NUR-21M, SOLA, BYSTRA), as well as from superior command systems such as SAMOC or LOWCZA (designed to control the battle from the battalion commander level). C2 Component, developed as software to be used in the command posts of VSHORAD batteries, responsible for the battery fire control, is called the Fire Control Module (FCM).

The FCM software is a standardised product, implemented in order to be used in very short range Anti-Aircraft Missile and Artillery Systems. It is intended for use in the automated elements of these systems equipped with various types of effectors. The idea of common software for many applications is of great importance both for training the crews of Anti-Aircraft Missile and Artillery Systems (PZRA) (standardisation of workstations and user interfaces), as well as for the software development organization in the future (synchronous development of systems based on one common software version).

The FCM software consists of two main software modules.

The first of them is responsible for the implementation of the **fire control process**: it distributes targets among effectors (aiming channels), collects status data and organizes cooperation with anti-aircraft effectors, including support of reporting on firing results. As part of this module, mechanisms responsible for cooperation with the system environment – with the superior level and radars, and for the development of information on the air situation are implemented. An important element of this module is the user interface, which must present a very dynamic situation in a manner optimal to the operator's needs and capabilities. Mechanisms have also been developed to this purpose to support the risk assessment and task allocation. Such mechanisms automatically recommend the optimal allocation of target engagement means.

The second software module is responsible for the implementation of **activity support processes**. It, among others, provides support for planning operations through the automated processing of combat orders and the preparation of reports compliant with NATO standards that are exchanged, for example, by e-mail. On the basis of the received tasks, the operator plans a manoeuvre and the grouping of batteries using advanced mechanisms based on digital mapping products and photos, e.g. from aerial reconnaissance. The results of the operator's work are the optimal arrangement of the group's elements and marked background elements tactical for the activities carried out (e.g. cover objects, responsibility sectors, radar coverage).

The system can work in an integrated distributed simulation environment based on international standards for the exchange of simulation information, which allows the staff to actively participate in multi-level exercises, e.g. as part of coalition/allied activities.

The software has an open and modular architecture. Thanks to the mechanisms used, it allows the user to easily expand and adapt the software functionality to the configuration of workstations in the target system.

The offered solution is network-centric within the battery and interoperable – it allows the user to maintain full cooperation, by using the interfaces of the LINK-11 and LINK-16 standards, with the master object, with adjacent anti-aircraft missile and artillery and anti-aircraft missile systems and with radars operating in the network.

The diagram on page 19 shows the universal structure of the very short range Anti-Aircraft Missile and Artillery System. The battery command post cooperates with anti-aircraft effectors through wide area network IP-WAN called PZRA-WAN, implemented as a radio network (based on software-defined radio stations) – OP RP (Polish Air Defence) or wired (fibre optic) network. The cooperation between the C2 component and anti-aircraft effector is accomplished through a standardized "effector interface", which is identical for all types of effectors. The diagram assumes that up to eight effectors are supported.

The anti-aircraft effector is a component that represents one aiming channel. It is equipped with a fire control sensor (usually an optoelectronic head) and one or more means of destruction (GROM / PIORUN missiles or 23 mm/ 35 mm guns).

The following can be used as such effectors:

- Fire Control Vehicle (WG-35) equipped with an optoelectronic head, IFF interrogator, GPS receiver and operator's terminal coupled with a maximum of eight 35 mm guns,
- Autonomous 35 mm gun system equipped with an optoelectronic head, IFF interrogator, GPS receiver and operator's terminal,
- Fire unit of the PILICA system equipped with 23 mm gun and two GROM launchers, optoelectronic head, IFF interrogator, GPS receiver and operator's terminal,
- POPRAD Mobile Anti-Aircraft Missile System,
- Air defence terminal (e.g. Rega-4) supporting independent MANPADS equipped with GROM launchers.

The universal structure of very short range Anti-Aircraft Missile and Artillery System

SENSORS

LINK-11B

LINK-16

LINK
protocols adapter

(radio/wired)
IP WAN NETWORK
OPL WAN
„OP-NET”

OP-NET
network
of **OP RP**
(Polish Air
Defence)
system

ODRA
remote radar

LOWCZA / REGA
/ SD PILICA
command vehicle

SOLA / BYSTRA
radar

WKO
Battery Command
Post

gun system

EFFECTORS

AG-35
mobile gun

(radio/wired)
IP WAN NETWORK
PZRA-WAN

AG-35
towed gun

WG-35
fire control vehicle

AG-35
mobile gun

POPRAD

Anti-arcraft
terminal

AG-35
mobile gun

AG-35
towed gun

AG-35
mobile gun

GROM

GROM

GROM

C4ISR
interface

Effector
interface

Sensor
interface

C2 Component of PZRA is equipped with WAN access node "OP-NET" (wide area network operating according to the principles specified for the OP-NET OP RP – Polish Air Defence system), which enables cooperation with the superior level object, with neighbouring C2 class system components (including PZRA) and with radars operating in the network. C2 PZRA provides cooperation with objects of the system environment mainly by using standardized interfaces Link 11B, LINK16/JREAP-C for fire control and air situation management and ASTERIX protocol for providing information on the air situation. Additionally, as part of the information exchange with the system's national elements (e.g. with the SAMOC system), a protocol was used to extend the possibilities and scope of the information exchanged.

The Battery Operation Centre with the FCM software, is implemented as a mobile element on the vehicle that is used to transport the remaining battery elements. OC equipment (computer, ICT, communication systems with cryptographic devices) will be placed in a body, which meets the requirements of relevant standards for information security and guidelines of the Ministry of National Defence so that the solution can be certified and the system accredited.

NET-CENTRICITY CONCEPT

The concept of Network Centric Warfare (NCW) introduces new possibilities of fighting battle, which will allow to translate information advantage into military advantage. The idea of network-centricity is to maximize the use of all available information in order to increase combat potential by distributing it to all recipients who need specific information. Systems with network-centric capabilities, in accordance with the NATO concept (Network Enabled Capability), provide opportunities to achieve new useful capabilities used in combat operations. These capabilities include having "appropriate" information, delivering it in the right form, at the right time and to the "right" participant in the right place, and the ability to use it. Network-centric actions therefore refer to the creation of such conditions as to ensure that each participant of combat operations has knowledge about the situation that concerns himself/herself, as well as about his/her environment interacting with him/her (the so-called common situational awareness) and preparation to meet the challenges of the battlefield. Therefore, the net-centricity describes a set of features and the ability to exchange information and use it in order to build common situational awareness resulting in gaining information advantage on the battlefield and achieving military advantage.

INTEROPERABILITY VERSUS INTEGRATION OF COMMAND AND CONTROL SYSTEMS

One of the key features of the command and control system at each level is its interoperability and the level of integration with other combat systems and components.

Interoperability means the ability to work together consistently, effectively and efficiently, in order to achieve tactical, operational and strategic goals (Department of Defence Dictionary of Military and Associated Terms, June 2020). Thus, interoperability manifests itself in a number of skills of systems and units to provide and receive services and to use them, in order to ensure effective interaction between them. Interoperability on the battlefield is therefore the goal which is to ensure the possibility of cooperation by using the same operating procedures and having the same data (information).

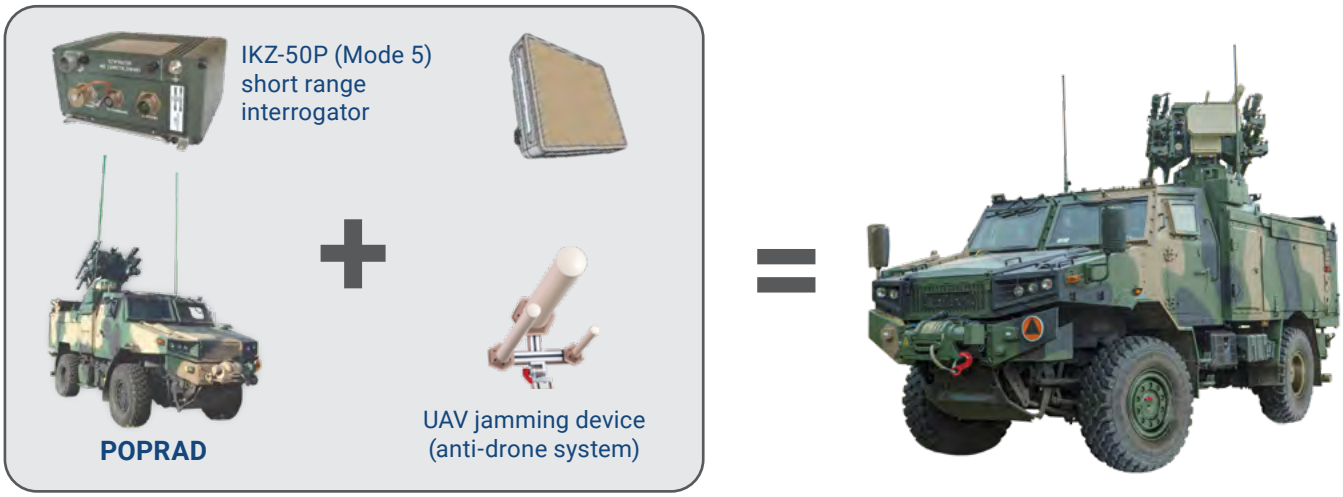
An important element of achieving interoperability is system integration, i.e. deliberate connection of components to build a system dedicated to specific tasks. This requires the integration of command and control systems into a coherent federation of systems (system of systems).

Integration, and hence interoperability, is achieved through the design of command and control (C2) system components and their interconnection.

Most of the automated command and control (C2) systems that were and are currently used by the Polish Armed Forces have been developed by PIT-RADWAR. The Company develops systems that are compliant with the requirements of the network-centric architecture and is a national leader in this field, appreciated also abroad. It has competence to implement and develop modern command and control systems for the needs of the Polish Armed Forces.

POPRAD Mobile Anti-Aircraft Missile System

The POPRAD Mobile Anti-Aircraft Missile System is a modern air defence system designed to detect, identify and engage air targets, including drones, at very short distances and low altitudes. It is mobile, hard to detect, and immune to interference. The system can work within the air defence system, as well as independently carry out air defence tasks.



Development concept of the POPRAD system in terms of retrofitting it with non-kinetic UAV neutralization means

The POPRAD Mobile Anti-Aircraft Missile System, being a part of the VERY SHORT RANGE AIR-DEFENCE (VSHORAD) systems, is designed to detect, identify and engage air targets at low and medium altitudes and short distances. It is capable of destroying airplanes, helicopters and unmanned aerial vehicles using short-range self-guided missiles – during the day and night. The automated process of aiming and tracking the target allows the system's reaction time to be minimized – from the moment the object is detected, the process of identification, fire opening and destroying the target can be carried out in just a dozen or so seconds. The effectiveness of the system is ensured by, among others, an integrated tracking and aiming head equipped with highly dynamic drives and high accuracy and an automatic target tracking system based on a video tracker system, cooperating with electro-optical sensors: infrared imaging camera, daylight camera and laser rangefinder.

The system's firing unit consists of 4 ready-to-use missiles mounted on the optoelectronic tracking head and 4 spare missiles, transported in transport boxes located on the system's platform. After leaving the launcher, the missiles guide themselves to the target using infrared seekers. Thanks to cooperation with the automated air defence control system and having an autonomous passive target detection and tracking system, capable of operating during the day and night, the POPRAD is difficult to detect and resistant to interference.

The main task of the POPRAD system is to protect troop columns, stopping places, command posts and groupings, as well as airports, ports, industrial plants, road and rail hubs, etc. against attacks by means of air attack. The combat properties of the system, especially such as high manoeuvrability, the ability to travel long distances and radio data transmission systems, are subordinated to its main application, i.e. operation in air defence systems of operational troops. At the same time, an advanced fire control system based on optoelectronic sensors enables the system to operate independently, which can, in this mode, aim, track and engage various types of air targets. Such activities are supported by a portable system of initial target designation whose key element is a light, day-night observation and pointing device. The POPRAD system operation can be controlled from the operator's station located in the vehicle's cabin or from a portable station outside the cabin with the operator's terminal connected to work remotely.

When operating within battery air defence systems, the POPRAD systems can cooperate with SOLA and BYSTRA radar stations via command components. With their modular and flexible architecture based on modern components, it will be possible to include the POPRAD systems in a network-centric battlefield command and control system. The integration of POPRAD missile systems, already in service with the Polish Armed Forces, with the VSHORAD system developed by PIT-RADWAR will be facilitated by the compatibility of communication and data transmission systems.

The system's modular structure also provides the possibility of introducing new solutions and further development of the system towards the direction determined by the forecast picture of threats and conditions of the battlefield. Taking these needs into account, the POPRAD can be retrofitted, for example, with elements of the non-kinetic UAV neutralization system. It can also be modernized so that it can work on the move. As part of further development of the system, it is planned to develop solutions enabling the use of missiles with a range of more than 12 km in the system.

Solutions resulting from the work carried out as part of the POPRAD project may also be used in the development of the naval version of the integrated optoelectronic head system with missile launchers and the associated fire control system, thus equipping the Naval Armament System with missile means of destruction.

Project "Anti-Aircraft Battery with 35 mm Guns"

The task of the very short-range air defence system (VSHORAD), which is the lowest layer of the anti-aircraft and anti-missile system, is to engage air targets at medium altitudes (up to 3.5 km) and short distances (up to 6 km), regardless of weather conditions and the time of day and night. These assumptions are consistent with the project "**Anti-aircraft battery with 35 mm guns** – artillery system with programmable air-burst ammunition system complementary to missile systems" developed and implemented by PIT-RADWAR.

AG-35

The new system provides multiple aiming channels by equipping each gun system with its own target detection and interception system and its own fire control system. At the same time, the applied design and software solutions ensure high firing precision and effectiveness. The fire control and command modules can be implemented as two separate stations on one carrier or separately – on two independent vehicles, depending on the need. The first solution, i.e. the modules are installed as two separate posts in one vehicle, allows costs and the number of the crew to be reduced. On the other hand, the second solution, i.e. the modules are installed in separate vehicles, allows the fire control vehicle to be located away from the entire group as such vehicle, due to built–in signal emitting devices, such as a laser rangefinder or interrogator, is at risk of being detected and attacked by the enemy. This increases the security of the command vehicle, which does not reveal its position.

The main task of the system is to engage, at a distance of up to 5500 m and at an altitude of up to 3500 m, air targets – including unmanned aerial vehicles (UAVs), fighters and helicopters, guided bombs, as well as unarmoured and lightly armoured ground and surface targets.

The 35 mm anti-aircraft battery consists of:

- WG-35 fire control vehicle,
- 35 mm automatic gun system (AG-35/ A-35),
- 35x228 mm programmable air-burst ammunition system (developed in cooperation with MESKO S.A.).

The computer and communication subsystems installed in the battery components have the task of optimizing the management of subordinate combat assets and cooperating with the superior command system. The means of communication of the WG-35 fire control vehicle enable the operator to control of up to eight effectors (A-35 or AG-35 guns, and the POPRAD systems, if necessary) by radio or wire. The design of the WG-35 vehicle allows a tracking radar to be installed, which would significantly increase the possibilities of fire control in particularly difficult weather conditions.

The project was aimed at developing, manufacturing and testing the components of modern artillery system with 35 mm guns, designed to engage wide range of means of air attack. The developed guns are an excellent replacement for the worn out 57 mm S-60 guns. The use of a fully automated towed platform for the effector resulted from the plans to replace, in the Navy, the towed 57 mm S-60 guns using the BLENDA fire control system, also developed by PIT-RADWAR. The modern solutions put into service and increasing effectiveness and efficiency would not require a change in logistics in terms of the movement of systems. The system development direction was also influenced by the NOTEC programme, whose aim was initially to obtain an artillery firing asset and then – after expanding the expectations of the Armed Forces – the entire battery system. The AG-35 gun was also integrated into the PILICA system, which was ordered a few years ago for the defence of air bases by the Armament Inspectorate. The gun proposed by PIT-RADWAR is fully compatible with this system, therefore it can realize the potential of using NATO 35 mm ammunition, in addition to the lighter 23 mm guns.

The battery can consist of two types of anti-aircraft guns:

- A-35 with programmable sight,
- AG-35 with optoelectronic tracking and aiming head.

AG-35 gun, firings on tactical lane

The A-35 gun is mainly designed to be connected to a fire control vehicle, from which it is remotely controlled by the operator.

The AG-35 gun is equipped with a small-size optoelectronic tracking head, which includes a set of optoelectronic sensors (daylight camera, infrared camera) and a laser rangefinder with high repetition rate. The head, cooperating with the ballistic computer and the video tracker system, enables the operator to automatically track the object designated from the command / fire control vehicle. Due to this feature, the AG-35 gun is an independent aiming channel in autonomous mode.

Advanced azimuth and elevation drive systems provide the devices with high dynamics and precise movement. This translates into a very high accuracy of the guns, which means that usually three to five shells are enough to hit and eliminate a target.

The AG-35 gun can operate in several modes: automatic, autonomous and remote autonomous. It is capable of fighting against air targets moving at speeds of up to 600 m/s at distances of up to 5500 m – depending on the target and ammunition used. The altitude of the targets to be engaged is 3500 m. The guns can work during the day and night, they can fire single and bursts. The gun's theoretical rate of fire is 550 rounds per minute.

The adopted design solutions ensure the high mobility of the gun and a very short deployment and retraction times (less than 2 minutes). Only two persons are needed for operation.

The double-sided ammunition feeding system allows the operator to quickly change the side from which the gun is fed. This enables the operator to quickly use one of the two different types of ammunition, located in the two magazines of the gun and appropriately selected for the target. The possibility of loading the gun with two different types of ammunition (with the indication of programmable air-burst and sub-calibre one) provides the ability to eliminate a very wide range of air, land and surface threats.

The sub-calibre ammunition will prove useful in combating such threats as classical means of air attack as well as unarmoured and lightly armoured ground and surface targets.

LOARA MOBILE ANTI-AIRCRAFT ARTILLERY SYSTEM

The LOARA integrated anti-aircraft artillery system was developed by PIT-RADWAR in the early 1990s and was designed to engage airborne targets (airplanes, helicopters and unmanned aerial vehicles) operating at very low, low and medium altitudes. It could also destroy lightly armoured land and surface targets.

LOARA is an autonomous firing unit, capable of performing tasks independently or within an anti-aircraft sub-unit.

The LOARA's armoured and rotating turret is equipped with sensors that enable the operator to detect and intercept air targets moving at speeds of up to 500 m/s. The three-coordinate observation radar working while the vehicle is on the move is responsible for the exact location of the tracked targets and their identification by using the IFF system.

LOARA is equipped with two 35 mm guns to ensure effective target engagement at distances of up to 5000 m.

The LOARA program was discontinued but many of the solutions developed for the needs of this system turned out to be a technological leap and were used – after appropriate adaptation and further development – in other projects, such as the anti-aircraft battery with 35 mm guns. The choice of 35 mm guns for the LOARA anti-aircraft system resulted from analyzes made not only in Poland, but also abroad.

At that time, work was done on the so-called "universal anti-aircraft calibre" and an artillery system was sought – optimal in terms of both combat capabilities and mass, mobility as well as, first and foremost, the possibility of integration with various carriers and modern battlefield systems.

The system development indicates high competence allowing for the efficient development of systems in various – required and expected configurations, using components selected appropriately to the needs of the demanding customer. It also shows how important the continuity of research and development is. It is not possible to develop new technologies in a short time for limited financial means and without a long-term programme and previous experience.

WG-35

WG-35 FIRE CONTROL VEHICLE

The WG-35 fire control vehicle uses the Zubr-P 4x4 armoured chassis manufactured by AMZ Kutno.

The WG-35 includes such functional systems as: optoelectronic head, command, fire control, automatic tracking, data transmission and communication with guns subsystems, as well as navigation and orientation subsystem. In addition, the vehicle is equipped with identification friend or foe (IFF) subsystem.

The above-mentioned data and communication subsystems include: the main management computer, VHF radio stations, broadband radio stations with preselectors, routers, data encryption devices, cable repeaters and recording systems.

Directly connected to the fire control vehicle, portable observation post (WPO) ensures that the head is automatically aimed at the object detected and selected by the operator. The portable observation post, among others, includes night vision binoculars, phonic communication modem, headphones and tripod with accessories.

Whereas, programmable air-burst ammunition is particularly effective in neutralizing so-called "soft" targets such as aircrafts, including UAVs.

The system with a programmable air-burst ammunition was developed by PIT-RADWAR in cooperation with MESKO. The projectile burst time is calculated on the basis of the parameters of the projectile and target and is programmed in the projectile when leaving the barrel. This mechanism significantly increases the field of fire and facilitates the destruction or damage of enemy air targets, especially small-sized, fast-moving UAVs.

The system effectiveness was confirmed by the tests of the programmable air-burst ammunition conducted by PIT-RADWAR as part of the programme "Anti-aircraft battery with 35 mm guns" in September 2019 at the Central Air Force Training Ground in Ustka. All targets determined for firing programmable air-burst ammunition in accordance with the testing programme were hit.

An important feature of the gun is its ability to operate stealthily. This is possible thanks to the use of passive optoelectronic sensors for intercepting and tracking targets.

The gun is rapidly and automatically linked to the system, after deployment, thanks to the navigation subsystem, which includes the inertial navigation system and GPS receiver. The subsystem precisely determines

35 mm automatic gun system on the Rosomak vehicle

OPERATING MODES OF THE AG-35 GUN:

- autonomous – target acquiring, aiming and tracking by its own optoelectronic head; the gun is controlled by the operator on the gun, using its own fire control system;
- autonomous remote - target acquiring, aiming and tracking by its own optoelectronic head; the gun is controlled by the operator from an external workstation (outside the gun), using a portable terminal;
- automatic – the target is acquired, aimed and tracked by the optoelectronic head of the fire control vehicle; no operator on the gun; the gun is controlled from the fire control vehicle; the trigger is fully automatic.

AG-35 and WG-35

the position of the gun and also carries out - with high accuracy – continuous measurements of azimuth, pitch and roll angles.

The gun also has its own communication and data transmission subsystem, which ensures close cooperation with the command systems and fire control vehicle, using wire, wireless transmission and remote control via optical fibre lines. In automatic mode, the gun is controlled remotely – from the operator's post in the WG-35 fire control vehicle. In autonomous mode, it can be controlled either by the operator on the effector or remotely by using a portable terminal, so that the operator does not need to be in a place directly exposed to enemy attack.

A modular design of the gun system makes it possible to integrate it on various types of platforms with the required load capacity: wheeled – both towed and self-propelled (including Jelcz or Rosomak vehicles) and tracked platforms.

At the same time, work on the OSU-35 mm naval gun system is carried out by a consortium led by the Military University of Technology with consortium members – the Naval Academy, Zakłady Mechaniczne Tarnow and PIT-RADWAR – the main integrator and contractor of the system. As a result, the Naval Armament System was developed and equipped with a gun as firing asset based on the same 35 mm automatic unit as land gun systems. Experience acquired in the course of work and tests was used to develop a new version of the system, designated OSU-35K – much lighter, miniaturized and optimized in terms of functionality, which could be the basis for the system land version.

A 35 mm anti-aircraft battery, supplemented by pre-detection radars such as SOŁA or BYSTRA, and a missile effector such as POPRAD, is essentially a complete very short range air-defence system (VSHORAD). The system is able to effectively engage enemy targets, and due to the diversification of weapons and the use of complementary radars, it significantly improves the battery performance, reduces its sensitivity to interference and increases combat capabilities in battle against various types of enemy equipment.

35 mm automatic gun system on Jelcz vehicle

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