10.12753/2284-9378-19-06

AIR DEFENCE RESPONSE IN THE LAND FORCES OPERATIONS IN THE CONTEXT OF THE TECHNICAL UPGRADE OF GIS IN THE MODERN BATTLE SPACE

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The complexity of the contemporary operational environment specific to military actions is one of the major challenges of the decision-making factor. This fact is mainly determined by the mutations that occur in the field of military technologies with direct implications on the multidimensionality of the modern battlefield. In this context, the aerial area of responsibility corresponding to an area of operations represents the acting dimension of the missile and antiaircraft artillery structures of the land forces. Due to the speed, range and capabilities of the modern aircraft's munitions, air defence response in the land forces operations is on the list of priorities for solving the issue of air threat and aggression. The solution of such a problem consists in the joint approach of four courses of action: knowing the air defence artillery and missiles equipment, preparing and executing air defence fire, planning and applying the specialized tactics and general tactics elements. In this article we shall mainly refer to the issues related to the two dimensions of the air defence response: the operational environment and the air operational framework, in the context of GIS (Geographical Information Systems). The physical peculiarities of the land and aerial area of responsibility are directly conditioned by the technical and tactical capabilities of the aircraft, which implies a series of conceptual transformations based on the technical upgrading of the modern battle space.

Keywords: air threat and air aggression; air defense response; GIS; thematic maps; operational planning.

GIS Technological Dimension of the Modern Battle Space

The impressive development of the technological – industrial sector characteristic to modern societies has led to important changes in all the fields of activity. From a military point of view, this fact draws attention on the need to reconsider the power factors and their behavior in a possible confrontation between two or more adversaries. The multidimensionality of the modern battle space requires that a military structure should be able to respond to the new types of threats. Transposing the information about the battle space, respectively about the capabilities of their own forces and of the opponent in the digital environment is accessing a new dimension of the military confrontation. In this context we can talk about re-defining the operational environment, in technological coordinates – a situation specific to the 21st century. The main argument for making this statement is that the physical space: land, air and sea, has undergone major transformations from an information point of view due to the development of the geographical information systems (GIS). Although GIS technologies have emerged as a peaceful solution to the complex operations of geographical space analysis to support the military and civilian fields, they have definitely transformed the characteristics of any possible modern military conflict. At this point, it is unthinkable to plan and carry out any military actions without GIS technologies. The processing and the analysis of the spatial data from conventional sources (maps, plans, etc.) or other sources involving advanced technologies (aerial and satellite imaging, remote sensing, GPS) are based on GIS systems and they facilitate the immediate and efficient use of the terrain resources and beyond. In military acceptance, GIS systems integrate databases containing real-time, computerized coordinates for locating all the operational and logistic facilities to support military actions. The fundamental value of such databases in GIS format consists in their applicability in a different range of types of exploration of the confrontation space, on geographical and analytical criteria. The analytical aspect of GIS is given by the informational combination of the states of a military structure with the information

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support generated by the space operators that act on the spatial databases to generate a great variety of real geographical information. A GIS data model is fundamental for any military action because it the attributes associated with these elements (for example for a road or highway: length, width, number of lanes, construction material, technical facilities, etc.).

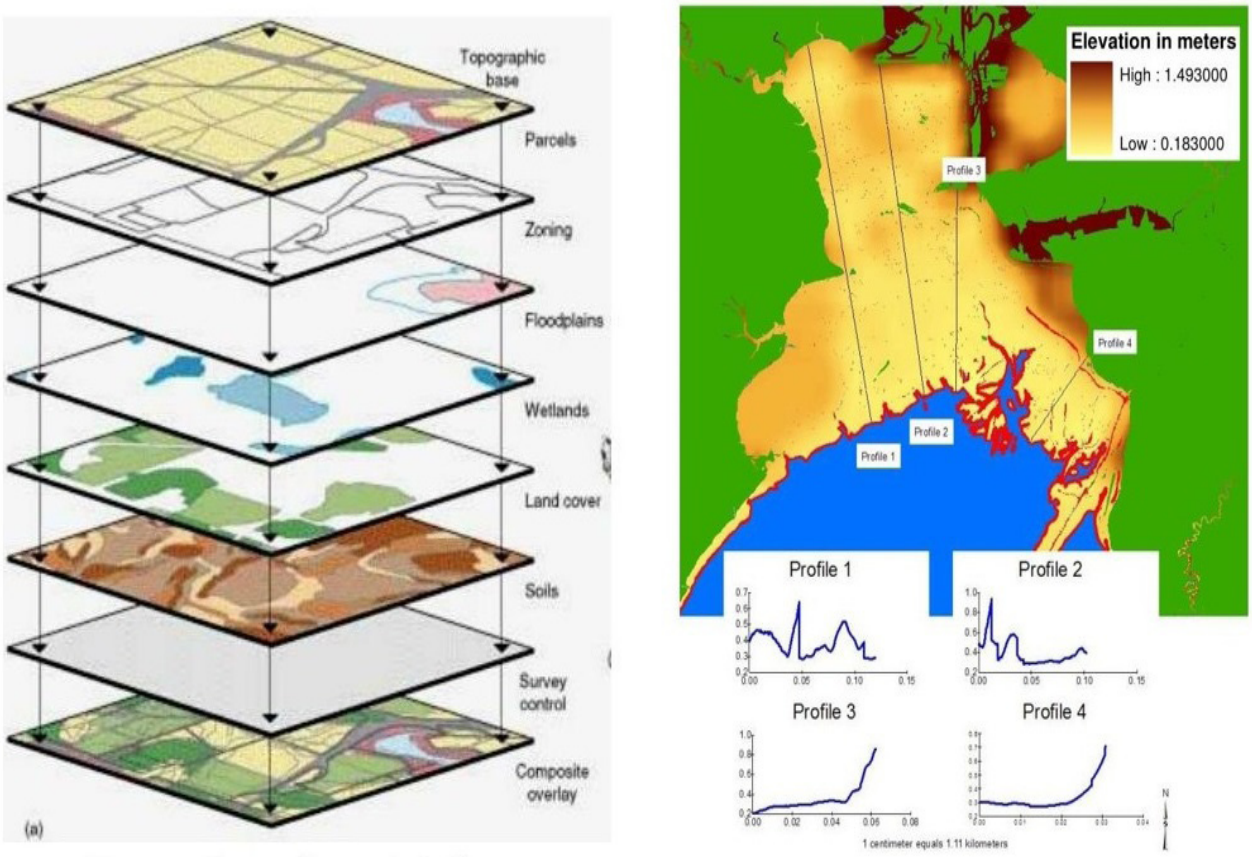

Figure 1 *Variant of representation of GIS spatial data through superposed thematic layers*

integrates graphical data (maps) with tabulated data (attributes or descriptive elements) resulting in *thematic maps*. Based on these thematic maps, a complex GIS can be used to simulate extremely complicated real-life situations and events. This fact requires that the GIS model is able to perfectly reproduce the events and the phenomena in reality, on which the military planning and the decision-making can be conducted.

Since it is based on the science of geography, the GIS integrates several types of data obtained by superposing the spatial locations on the attributes of the entities thus spatially positioned, obtaining "layers of information" in thematic views through the use of maps and 3D scenes. Having this capability, the GIS reveals a deeper understanding of the operational environment by storing data and integrating two types of information: the graphic information that indicates the spatial distribution of the studied elements and the database for storing

Without going into the technical specifications of GIS, the graphic information can be of two types: *raster* and *vector*. The military significance of the two types of information results from their content. *The raster graphics* is a way of representing images in software applications in the form of pixel matrix, while *the vector graphics* is a method of representing images using classical geometric symbols (points, segments, polygons), expressed by mathematical equations, thus obtaining the georeference of the analyzed object or subject. Therefore, an entity or an object (represented by an image or a vector) is represented in a unique position in the GIS corresponding to the geographical position in the real world. An example in this regard may be the planning and execution of a march of a mechanized brigade, a situation in which the air defense artillery and missile formations fight the aerial enemy. In GIS and by means of the GPS navigation system (Global Positioning System), the most favorable

route according to the road map is evaluated[2]. In this way, the georeferenced position, namely the exact location of the vehicle at a given moment, is obtained in the vector form. Route planning is actually a thematic map obtained from a spatial inquiry combined with an inquiry of the database associated with the roads in the electronic map so that a series of conditions are met. In addition, depending on the situation, a series of additional data/tasks can be identified and planned, such as: the firing areas for different variants of response to the land or air attacks; marking the contaminated areas; sources of water, electricity, etc.

Based on GIS, the multi-spectral imaging can provide topographic and hydrographic data which are fundamental to the military actions that would be otherwise inaccessible by using conventional methods. Moving imaging (video) and MTI (moving target indicator) technologies have added a new dimension of spatial data, one in which movement and position change can be instantly recorded[3]. The development of the thematic maps in GIS technology integrates the activity of the different types of sensors into the IT and thus facilitates the work of the military analyst to overcome certain problems generated by bad weather, poor lighting conditions or targets identified in the tactical field. The information integration of the sensors allows us, in GIS technology, to obtain a clear image of the target, both in daylight by means of the optical-electronic sensors, and during the night or under bad weather conditions by means of the synthetic aperture radar systems (SAR). As a purpose, GIS in the military context develops more than a description of the spatial relationships between objects or entities located in space (proximity, interconnection, continuity, incidence, etc.). The system helps us to understand situations; it facilitates analysis and decision making. The thematic maps contain: the complex of graphical data in digital maps and the information about the enemy in tabulated data on attributes or descriptive elements, resulting in a realistic interpretation of the situation and of the most likely course of action of the enemy. Identifying the adversary's probable actions based on the GIS reference data, by correlating the terrain features, the weather condition, the economic and social potential of the area of responsibility, the situation of the friendly forces, etc. brings the operational planning process into a new reality of the modern battle space[4].

Air Defense Response of the Land Forces in the Context of GIS Technological Upgrade

The complexity of the contemporary operational environment specific to the land forces operations is one of the major challenges of the decision-making factor. Due to the speed, range, and capabilities of the modern aircraft's munitions, the formations specific to the land forces are vulnerable targets facing a hypothetical air enemy that can act by surprise at low and very low altitudes. In identifying the most probable course of action of the air enemy and achieving an effective air defense response, a decisive part is played by the actions of the air defense artillery and missiles structures, planned and designed on situation awareness and after the information preparation of the battlefield[5].

The information preparation of the battlefield in terms of air defense requires a specific approach of the enemy's air actions. The specificity of such air actions consists in the fact that the aircraft have the possibility to act at low and very low altitudes which implies using the terrain to establish the avenues of approaching the objective, the stationary firing positions or the organization of the helicopter ambushes. Defining the air environment for the land forces operations involves evaluating the typology of the aircraft: fixed or rotary-wing aircraft, ground-based air defence systems, unmanned aerial vehicles, cruise missiles and some ballistic missile or anti-missile systems.[6] The assessment of the terrain to identify the most likely air enemy course of action contains a series of elements, such as: the protection against the air defenCe systems, the existence of the linear planimetric features, roads, railways and rivers, which provide assistance in navigation at high speeds and low altitudes, masking possibilities against ground observation or radar detection, direct access to the target area and terrain obstacles for the flight[7]. Therefore, the reference layers generated in the GIS are essential in the elaboration of the probable enemy courses of action. This involves accessing "the electronic terrain" and the meaningful data on channeling the enemy forces such as "drawing" the avenues of approach for the helicopters or fighter-bombers to hit a target. Due to the electronically stored data and the possibilities of the vector graphics of the terrain, including buildings and vegetation, repetitive simulations for the flight of an aircraft at

different altitudes can be performed using graphic representations as in Figure 2.

In order to explain the situation regarding the

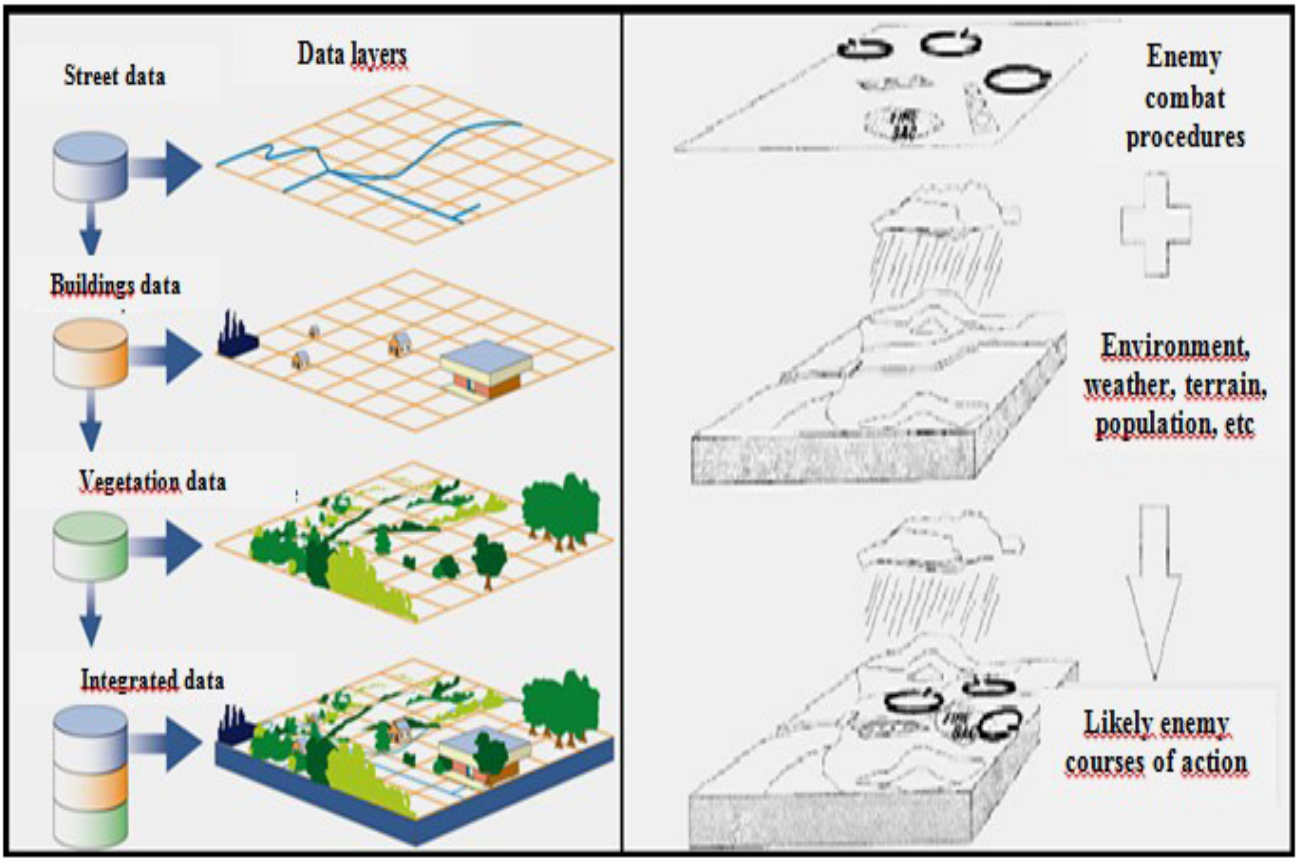

Figure 2 *Variant of superposing the reference layers in GIS spatial data to develop the likely enemy courses of action*[8]

possibilities to informatively integrate the data stored in the GIS regarding the flight path of an aircraft aiming to attack a specific objective of the land forces, we have considered the projection of its trajectory in two plans: vertical and horizontal. Solving such a problem consists in the joint approach of four courses of action of the air defense artillery and missiles structures of the land forces: knowing the air defence artillery and missiles equipment, preparing and executing air defense fire, applying the specialized tactics and general tactics elements.

In terms of the air defense operational framework, knowing the air defense artillery and missiles equipment implies the possible use of their maximum combative potential according to the environmental characteristics, which is achieved by superposing the reference layers in GIS. This implies the possibility of sequentially planning the air enemy fight and avoiding the technological collapse due to the particularities of the confrontation environment. Another aspect of conducting the air defense response under the influence of the incompatibilities of the confrontation environment with the possibilities of the combat equipment is given by the topographic and geodesic survey of the combat systems, respectively of the air defense cannons such as the air defense weapon systems OERLIKON and KUB. The topographic survey in fighting the air threats is necessary for combining the air defense effort of all the components in achieving the algorithm on important sequences as follows: airspace reconnaissance (in visible, infrared and electromagnetic spectrum), searching and classification of the aerial target, tracking the aerial target, establishing its belonging (electronic/safe and procedural control), engagement and destruction of the hostile aircraft (executing air defense fire), assessment of the firing effects, ceasing or resuming sequences depending on the situation.

Another aspect of the air defense response covered by the specialized structures of the land forces in the GIS context is given by the preparation and execution of the air defense fire. In the literature in the field, two stages of preparation of the air defense fire are known: *the preliminary preparation* and *the immediate preparation*. Due to the high speeds of the aircraft and the very low and high altitudes for attacking ground targets, the air defense artillery systems fight the air enemy within a time frame counted in seconds and tens of seconds. Maneuvering in land forces operations generates periodic change of the firing positions, which implies changing the current location data for the air defence firings. In other words, activating the GIS database for the air defense firing positions substantially reduces the assessment time and the advantage over the complexity of the current air situation. Due to the possibilities of interpreting the terrain in GIS format, it is possible to obtain the essential elements for planning the maneuvers of the air defense artillery structures, this being possible based on the thematic maps. The thematic maps for the air defense structures automatically generate the most optimal solutions for the positions of the air defense artillery systems that take into account the following: the freedom of movement in the tactical space, size of sight angles (visibility) and the maneuver of air defended objective, as in Figure 3.

Another aspect regarding the conduct of the air defense response is supported by the application of the specialized tactics and general tactics elements. The specialized tactics refers to the achievement of the air defense combat formation according to the probability of the air enemy's actions, during the important moments of the fight and depending on the evolution of the tactical situation of the air defended objective. The specialized tactics issues include the maneuver of the forces and assets in the tactical field, namely the measures that are undertaken to achieve the air defense response sequences. Mainly, the visualization of the airspace of responsibility is maintained by applying the protection measures against jamming, respectively maintaining the functionality of the centralized notification network for aerial image awareness in order to make immediate decisions. The elements of general tactics support the accomplishment of the maneuver of forces and weapon systems in the development of the operation and constitute the final end for obtaining or maintaining the local or general air superiority in an area of operations. The GIS facilities in this case contribute to optimizing the planning and conducting of combat actions by the land forces structures through spatial integration

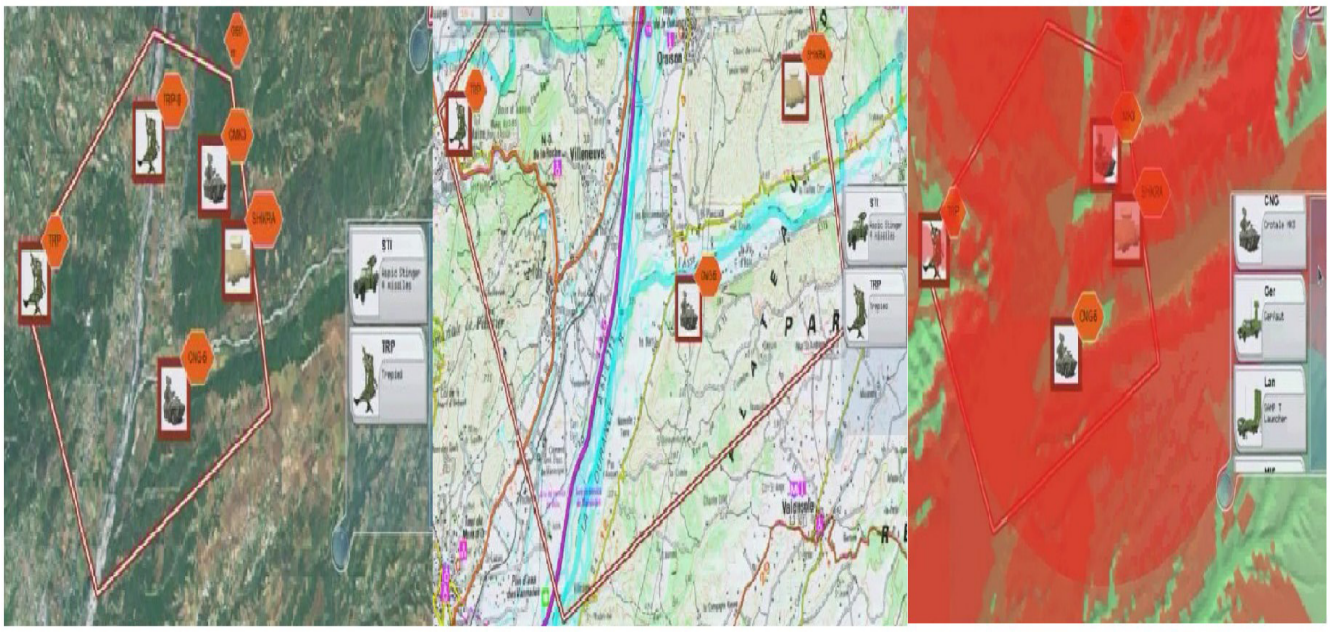

Figure 3 *Variant of thematic maps in GIS space data for conducting air defence response while maneuvering in land forces operations*

of all the reference layers based on the thematic maps. It should be mentioned that according to the thematic maps made during the information preparation of the battlefield, certain projections are obtained on the probable course of the military confrontation, respectively a forecast on the best variants of achieving success.

Due to the above-mentioned GIS facilities, the conduct of the air defence response in the land forces is only one component of a complex situation generated by the multitude of actors involved in a potential crisis or military conflict. The final result of the informational preparation of the battlefield in terms of air defense consists in obtaining the air threat and aggression plans for the objectives defended against them according to the operation (NAI situation - named area of interest). Based on these overlays, the models of air defense response are developed, respectively the tactical moments when the air defence effort is concentrated. (TAI – target area of interest).

In the case of planning and conducting a joint operation, the information about the facilities of the operations area proportionally increase due to the number of users, and of actors involved in solving the crisis or the military conflict. The thematic maps are the result of applying the data obtained by means of sensors placed on the ground but also of designing capabilities during the combat, such as designing the logistical supply routes. Another aspect is related to the informational support provided to the land forces structures by the GIS, in the stages prior to the development of a crisis or military conflict situation. This is due to the "activation" of some indicators or to recording those values of certain data that are directly related to the forms of manifestation of a possible hybrid war. The argument in this case is given by the fact that, based on the thematic maps, not only the objectives with military potential are kept under observation, but also other elements of interest such as those specific to the field of critical infrastructures (for example in the case of cyber attacks)[9]. Obtaining the technological results of the GIS applications in the area of civil activities such as the GPS for planning a march and other aspects tackled from an air defense perspective has highlighted the benefits of these applications. The results of the GIS in

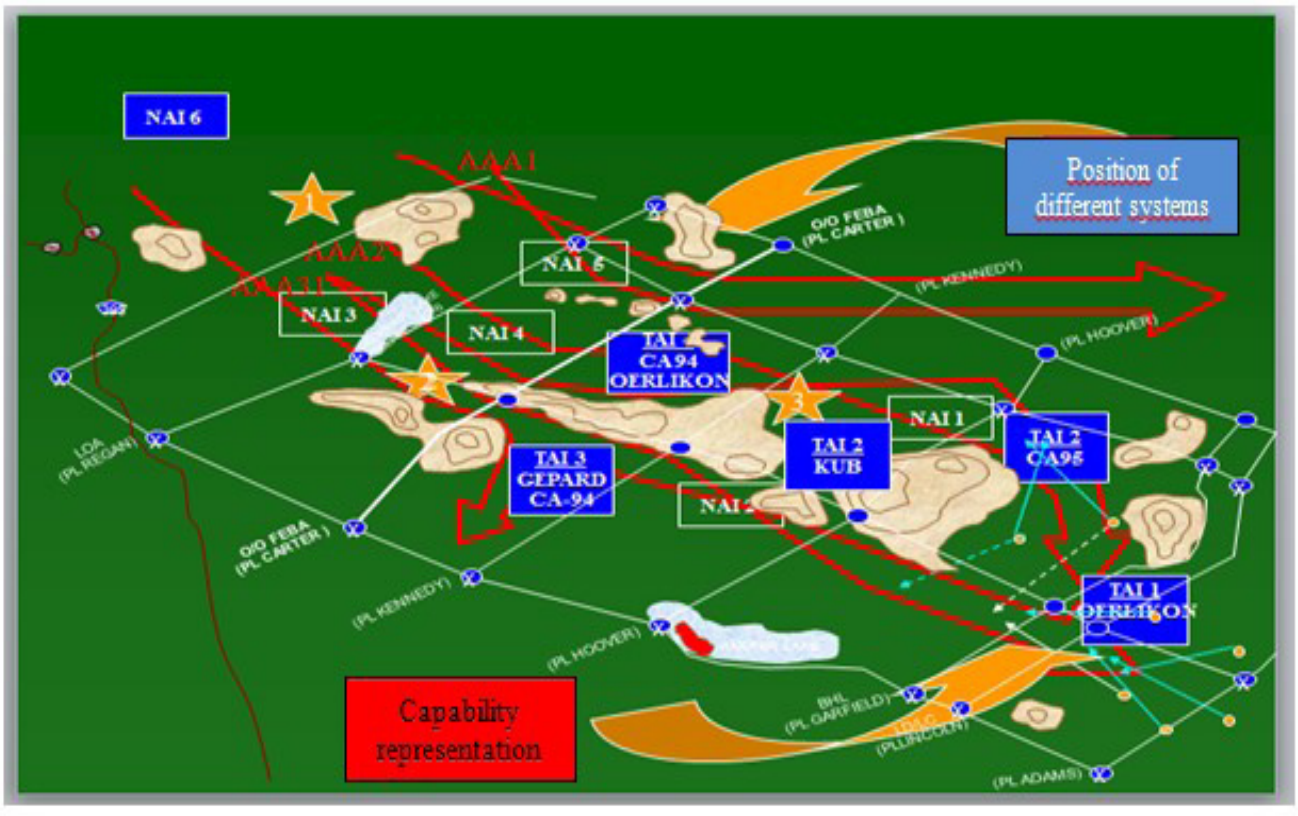

Figure 4 *Variant of integrative overlay obtained by superposing the air threat layer to the air defense response layer*

the field of operational planning, respectively of the information preparation of the battlefield, show that in the manner of processing these data, the probable courses of action of the enemy are obtained, and the concept can be taken to the civil domains, by making thematic maps with elements generating crisis situations. (NAI situation - named area of interest). This way we can talk about opening up new perspectives on the possibilities of understanding the concept of hybrid warfare, which could be a possible topic of a future article.

Instead of Conclusions

Engaging a hostile aircraft in the airspace of responsibility of the land forces is the deliberate act of the air defense artillery and missiles structures. Essentially, the fight with the air enemy is caused by solving the problem of the projectile or the missile meeting the aerial target. This implies the positioning in the tactical field of the air defense systems, respectively the cannons, so that the aerial target can be engaged at the maximum range. Planning the firing positions according to the enemy's probable course of action is made based on the cartographic projections or the modeling of the three-dimensional space (in x, y, z coordinates). From a technological point of view, the problem of the air defence artillery firing was solved by improving the calculation devices, in the case of the air defense artillery the mechanical adjuster, and respectively the firing calculators, and in the case of the air defense missile systems different methods of guiding. There is a change in the flight parameters of the aircraft due to the technological superiority and the possibility of using them in actions against the land forces, which has generated a new spectrum of threats and possibilities of aggression from the air. In another aspect of the military confrontation, the land forces are called upon to carry out increasingly complex missions, so that the concept of multidimensional actions has been developed.

The new combination of factors that define the operational environment specific to the actions of the land forces in the modern battle space requires maneuvers and the integration of the most advanced geographic information systems (GIS). In arguing the views formulated regarding the design and implementation of the air defense response of the land forces, we have highlighted the role of the *thematic maps*. Due to the specificity of the air defense combat in the three-dimensional space (projectile or missile trajectories) in addition to the longitude and latitude geographical coordinates, the computing devices also process the altitude coordinate. Therefore, the natural takeover of the possibilities of GIS applications through the vertical component, paved the way to a new dimension of military operations planning. By processing the variable "Z" in the GIS, the altitude component was processed and with it a series of attributes related to the land point identified through georeferencing. Taking into account that a ground map is a mathematical representation, by informational adjustment of the reference point in space, this is identified with additional information according to a chosen theme, which means that this map is practically a new means of transmitting knowledge about a certain situation (Figure 1. Alternative representation of the GIS spatial data of the superposed thematic layers).

Another observation related to conducting the air defence response by the land forces is the employment of the GIS technologies in an integrated aspect. This fact implies the shift from the use of the topographic maps to the use of the thematic maps, resulting in an important advantage through the upgraded decoding of the reality of the technological operational environment. The thematic maps take into account the spatial distribution of the qualitative variables related to the terrestrial surface, showing the distribution of the basic nominal data in different non-hierarchically classified, denominated and differential results. From a quantitative point of view, the thematic maps show the distances, the distribution of vegetation, the soil types, the precipitation types, etc. which are essential in decoding the respective battle space, in order to identify the most likely course of action. The quantitative thematic maps are more complex because they aim at locating ordinal data, intervals and reports. The analysis of the methods of executing air defense firings shows that the range of detecting an aerial target is the direct firing range processed in the computing device. As a result of the GIS possibilities applied to the air defense response systems, it turns out that their topographical survey represents the starting point for formulating a new concept of fighting the air enemy.

Upon covering the air defence response in the land forces operations in the context of the technical upgrade of the GIS technology of the modern battle space, we can assert that new perspectives are being opened for conceptualizing the employment of the air defense artillery structures. Depending on the source of the thematic maps and on the manner of their informational exploitation, we can anticipate the development of new concepts regarding the informational preparation of the operational environment, respectively of redesigning the operational framework specific to the land forces actions.

NOTES:

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