Information-Reference System Creation Prerequisites for the Ground Forces Identification on the Battlefield According to NATO Standards

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Abstract

Fighting in modern military conflicts is primarily characterized by unpredictability and non-standard features of combat, rapid raids, opening fire from long distances on "closed targets", with limited time for decision-making and lack of situational awareness. This leads to the fact that under the influence of objective and subjective factors there is a high probability of getting under friendly fire. The war in eastern Ukraine, military conflicts in the former Soviet Union (Moldova, Georgia, Nagorno-Karabakh), the former Yugoslavia, etc., mostly took place in a limited area, and the weapons and military equipment used on both sides were usually produced in the same country and they not visually differ significantly. Therefore, the existing methods and means of recognition in this situation simply did not work. Analyzing the causes for falling under friendly fire, we note two main ones. The so-called "position error", which is associated with the quality of weapons (ability to fire accurately), imperfect ammunition (premature operation, the fire coming short of target) or an error in aiming at a target, and an "error of identification" when the fire is deliberately conducted on one's own troops, which have been mistaken for an enemy. All this stems from the inaccuracy or lack of information, gross errors of control, which are possible during the war. The inherent feature of mobile combat, with the rapidity of fire exchanges, which do not leave time for reflection, also plays an important role. The application of the relevant basic doctrine to prevent troops from falling under friendly fire during intense battle, at first glance, is quite simple and includes: 1

- Tracking from the control points the actions of friendly forces, constant monitoring over their movement and location;
- Determining the location of enemy positions by collecting information in real time;
- Division into "friendly" and "enemy" by means of surveillance and aiming systems or by other special systems;
- In case of receiving a positive identification - opening fire on the target.

Unfortunately, practice shows that this task is quite difficult, given the negative impact of a number of factors, namely:

- Modern offensive military operations are carried out at a fairly high pace and around the clock, with the movement of troops in unfamiliar terrain in conditions of limited visibility;
- Most combat clashes and fire exchanges occur rapidly, with shelling of quickly moving targets over long distances;
- Virtually unlimited combat range of the weapons significantly affects the ability of the shooter to destroy the target when determining a positive identification (despite the presence of thermal detection, especially in the desert or steppe zone);
- Error-free real-time determination of their own location, as well as friendly and enemy forces is determined not only by visibility conditions, but also depends on the orientation

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and the availability of sufficient time for commanders to form a clear idea of fire exchange with the enemy.

The task of recognizing the affiliation of forces on the battlefield or in the area of operations is solved by a combination of control procedures, situational intelligence, the use of technical means and effective training. As this task is complicated by increased distance, terrain complexity and reduced visibility, the main means of preventing misidentification and fratricide, especially at the level of military units and above, is the use of effective management measures. The purpose of combat identification is, based on a common doctrine, providing effective training and compliance with the rules of combat operations, improving situational intelligence, as well as methods, means and devices of recognition, in order to increase combat effectiveness and, consequently, reduce casualties of friendly troops. The purpose of target identification is to determine the nature of the object on the battlefield as allied, enemy, neutral or non-combat. Mutual identification of ground forces on the battlefield is carried out by establishing a stable relationship and the use of certain methods and methods of control, namely: control of forces and means in combat, automatic and manual request and response systems, personnel training, and battlefield management systems. Allied forces are identified and recognized by many means. The effectiveness of these tools directly depends on the training that commanders and fighters undergo before the operation. Such means include: identification of configurations of personnel and armaments, dynamics of actions; time parameters, sound characteristics, electronic radiation, infrared spectrum; signals, information about the deployment of troops; ground panels (pointers) of combat identification, etc.

Combat Identification (CID) devices of NATO member armies are used in accordance with established identification algorithms for the identification of Allied troops. These devices help identify friendly troops on the battlefield or in the combat zone to reduce the risk of striking coalition forces. CID devices can unmask formation positions, so they should used or activated for a limited or fixed period. Time limits for the use of these devices are set at the appropriate command level.

Among the numerous means of recognition, the following are considered the most effective:

- Battlefield Target Identification Devices (BTID);
- identification based on the means of automatic transmission of data about their troops (Radio Based Combat Identification - RBCI);
- Reverse Identification Friend or Foe (IFF) system;
- Recognition by means of radio tags (Radio Frequency Identification tags - RF tags).

Standards, methods and procedures for the use of means and devices of combat identification include: combat identification panel (Combat Identification Panel - CIP), identification thermal panel, thermal recognition beacon, emitters of the near infrared (IR) spectrum, reflective tape, or reflective near infrared spectrum, vehicle marking system. Thus, in the process of combat identification, a wide range of devices that work on different physical principles is used. This generates huge amounts of information that requires appropriate analysis in the implementation of combat identification. At the same time, in order to ensure the efficiency of the coalition forces' management, the time allowed for information processing and decision-making is extremely limited. This leads to information overload of the commander. In order to reduce this workload and increase combat effectiveness and, as a result, reduce the number of casualties of friendly troops, the objective of developing an Information and Reference System for the recognition of ground forces on the battlefield according to NATO standards is relevant. The aim of the article is to find the ways to increase efficiency of combat identification of ground forces on the battlefield according to NATO standards.

Keywords

NATO standards, target identification, combat identification, technical means, fire, ground forces, friendly troops, battlefield

1. Introduction friendly

The analysis of recent military conflicts and hostilities during joint forces operations shows that they are primarily characterized by unpredictability and non-standard features of combat, rapid raids,

opening fire from long distances on "closed targets", in limited situational awareness and time. Under the influence of objective and subjective factors, there is an acute danger of getting under friendly fire [2, 5-7, 10].

The analysis of hostilities during Operation Desert Storm provides an opportunity to assess the effectiveness of use of certain types of weapons and military equipment in the Persian Gulf. In the clashes (according to the information service of the Deputy Chief of Staff of the US army for operational issues), about 20 M2AZ "Bradley" machines were hit and 12 received varying degrees of damage. Of this number, 17 units of equipment were hit by friendly fire and 3 units were damaged. Of the nine destroyed M1A2 Abrams tanks, seven were shelled by friendly artillery.

The main reason for the erroneous firing on friendly troops was the inability of crews to identify targets over long distances. The gunners were forced to delay the opening of the fire, waiting until the combat vehicles approached the potential target at a distance that allows you to clearly see its outlines. The problem also was the inability to identify targets using optical systems. Thermal sights at a range of 4000 m and more on the screens had images in the form of "hot spots". Target identification was possible only at a distance of 1500 m-2000 m in clear weather, or 500 m-600 m in conditions of limited visibility.

Given that the main armament of the M2AZ Bradley and M1A2 Abrams tanks is capable of hitting targets beyond this distance, all this has significantly reduced the combat potential of tank and mechanized units.

It is no exaggeration to say that virtually all the US allies involved in combat operations have experienced the effects of strikes and shelling by friendly coalition forces. It should be noted that aircraft, anti-aircraft missile systems, tank units and manpower were hit.

The war in eastern Ukraine, military conflicts in the former Soviet Union (Moldova, Georgia, Nagorno-Karabakh), the former Yugoslavia and others took place mostly in a limited spaces. The weapons and combat equipment used on both sides were usually manufactured in the same country and did not visually differ significantly. Therefore, the existing methods and means of recognition in this situation simply did not work. Analyzing the causes for falling under friendly fire, we note two main ones. The so-called "position error", which is associated with the quality of weapons (ability to fire accurately), imperfect ammunition (premature operation, the fire coming short of target) or an error in aiming at a target and an "error of identification" when the fire is deliberately conducted on one's own troops, which have been mistaken for an enemy. All this stems from the inaccuracy or lack of information, gross errors of control, which are possible during the war. The inherent feature of mobile combat, with the rapidity of fire exchanges, which do not leave time for reflection, also plays an important role. The application of the relevant basic doctrine to prevent troops from falling under friendly fire during intense battle, at first glance, is quite simple and includes:

- Tracking from the control points the actions of our forces, constant monitoring over their movement and location;
- Determining the location of enemy positions by collecting information in real time;
- Division into "friendly" and "enemy" by means of surveillance and aiming systems or by other special systems;
- In case of receiving a positive identification - opening fire on the target.

Unfortunately, practice shows that this task is quite difficult, given the negative impact of several factors, namely:

- Modern offensive military operations are carried out at a fairly high pace and around the clock, with the movement of troops in unfamiliar terrain in conditions of limited visibility;
- Most combat clashes and fire exchanges occur rapidly, with shelling of quickly moving targets over long distances;
- Virtually unlimited combat range of the weapons significantly affects the ability of the shooter to destroy the target when determining a positive identification (despite the presence of thermal detection, especially in the desert or steppe zone);
- Error-free real-time determination of their own location, as well as friendly and enemy forces is determined not only by visibility conditions, but also depends on the orientation and the availability of sufficient time for commanders to form a clear idea of fire exchange with the enemy.

These causes are easy to eliminate as technology improves. However, relying only on high-precision weapons, electronics, lasers, and thermal imaging devices is not justified. Changing labels or applicators also does not guarantee complete success. The task of recognizing the affiliation of forces on the battlefield or in the area of operations is solved by a combination of control procedures, situational intelligence, the use of technical means and effective training. As this task is complicated by increasing distance, terrain complexity and reduced visibility, the main means of preventing misidentification and fratricide, especially at the level of military units and above, is the use of effective management measures. The purpose of combat identification is, based on a common doctrine, the effective training and compliance with the rules of combat operations, providing the improvement of situational intelligence, as well as methods, means and devices of recognition, in order to increase combat effectiveness and, consequently, reduce casualties. The purpose of target identification is to determine the nature of the object on the battlefield as allied, enemy, neutral or non-combatant.

2. The recognition of friendly armed groups

Mutual identification of ground forces on the battlefield is carried out by establishing a stable relationship and the use of specific methods of control [3, 13, 16-23, 25-28, 33], namely:

1. Management of forces and means in combat space. Combat space is the environment, as well as certain factors and conditions that must considered succeeding in combat, maintaining defensive positions and performing objectives.

The meaning of the term includes: land, sea, air and space in the area of joint operations of the coalition forces and in areas of special consideration; allied forces and enemy forces stationed there; buildings; weather conditions on the ground and space; existing health threats; the nature of the area; electromagnetic spectrum, as well as the information environment.

Operational management measures are carried out using dividing lines, which include:

- The front edge of friendly troops (line of contact);
- Line of coordination of fire support;
- The boundary of coordination of used airspace;
- The boundary of control;
- Lines of definition of sectors and zones.

2. Automatic and manual query/response systems. These types of systems require the presence of a requester (the person or entity sending the request), as well as the respondent (the person (s), or the entity whose response will indicate affiliation with a coalition or unknown force). Query and response systems use verbal and nonverbal methods.

The nonverbal method is based on the use of colored smoke, lights, pyrotechnics, fluorescent panels and combat identification pointers, or other signals; electronic means, including radio communication on certain frequencies; optical means, such as lasers.

The verbal method is based on the use of security and guards. A voice request is most often used to detect an enemy approaching a unit's position. The voice request contains a password, which is usually changed at a specified time, at least once a day or depending on the specific situation.

This password is common to military formations of specific states or special groups in the areas of hostilities. The circumstances under which the guard must open fire on persons or groups of persons who have not responded to the password are determined directly by the senior commander (chief).

3. Personnel training. Successful use of recognition tools is achieved by appropriate training of users and operators. Recognition training plays a key role in the process of improving combat identification. NATO countries use different training systems, methods and standards of personnel training, but they all agree that such a training is of paramount importance for effective military operations [1, 15]. An important means of identification is the mutual exchange of data between joint units, about the characteristics of combat vehicles, equipment and fighters.

Since the specific states use different methods of identification and recognition, the exchange of operational information should take place during the formation of combat units and during the operation. Training should take place in compliance with the minimum requirements of the standard of combat identification, which is appropriate for these exercises and determined by the commander of the appropriate level.

4. Combat space management systems. Situational intelligence or situational awareness is a key element in the effective use of troops (forces) on the battlefield. To avoid fratricide, knowledge of the location and actions of coalition forces is important. Various methods are used to gather the necessary information about the battlefield, from the manual method to the automated and networked computer system. It is necessary to consider the time intervals between receiving information, processing it and providing the response.

Creating a true network of situational intelligence systems reduces the risks of information loss. Any changes to existing fire control or maneuvering measures involving automated systems must take into account immediately. Thus, there is an objective of creating a "friend-enemy" recognition system (general military system of recognition). The "friend-enemy" recognition system is a "hardware and software complex of automated differentiation of friendly troops from enemy troops".

3. Results and discussion

3.1. Identification of signs and signals

Allied forces are identified and recognized by many means. The effectiveness of these directly depends on the training that commanders and fighters undergo before the operation. Such tools include:

The identification of configurations of personnel and weapons. Identification of configurations are determined through the silhouette (contour), color, marking and general visual perception of the elements, which are compared with known characteristics.

The dynamics of actions. Determining the direction and mode of movement, speed of movement, weapons used, and type of formation contribute to the recognition of coalition forces. Identification or recognition of these characteristics requires knowledge of the current tactical situation and the plan of movement of coalition forces.

Time parameters. The relevance of the available information provides an adequate assessment of the risk associated with making decisions that may affect Allied forces; updating the information ensures its accuracy, but information about the location of troops should considered in conjunction with other indicators. The information on whether troops have crossed a certain line at a certain time helps to identify this.

Sound characteristics. Clear sound characteristics of a particular type of weapon and equipment can help in the process of recognition and identification.

Electronic radiation. Electronic systems are able in some cases to recognize or identify the radiation of allied electronic means (especially radar) [8, 9, 11, 14, 24, 30].

Infrared spectrum. In the process of recognition and identification, means using near, medium or far range of infrared (IR) radiation can be used [12]. Image intensifiers (such as night vision goggles) use near radiation and only work in the dark. Thermal imaging devices use medium and far infrared radiation and can work both at day and night. The list of such devices that use the IR spectrum is discussed in the paper below.

Signals. Predetermined signals are used to recognize allied forces, namely, any type of signal according to an established plan or key, or a correct request and response.

Information about the deployment of troops. Information on the location of friendly forces or individual units, with a clear definition of the terrain and the intended boundaries of the area of operations for each unit of the coalition forces, allows to avoid the damage by friendly fire. Measures to coordinate fire support (for example, the line of coordination of fire support) as well as the establishment of artificial ground landmarks may use to identify ground units. Ground forces units are responsible for the visual display of these artificial landmarks, which will used by air units after coordination of time and place with the air command.

The recognition of the unit by the specific position and route can carried out based on correspondence with known data or correspondence of its radar data with:

- The position specified in the report on the situation (situation report - SITREP);

- The reported position of the unit recognized as allied or hostile;
- Knowledge of tactical demarcation lines and positions of allies and the enemy.

Ground panels (pointers) of combat identification. Fluorescent panels can used subject to limitations due to the terrain or the possibility of being detected by the enemy. Where such pointers are used, they shall installed in such a way as to ensure maximum visibility for coalition assault air forces (crews) or for moving ground forces.

3.2. Restrictions on the use of signals

Certain limitations in the use of recognition and identification signals are related to the human factor and the technical capabilities of the recognition means. Such restrictions include:

- Lack of information from the coalition troops about the current response to the request;
- Failure of the signaling equipment;
- Lack of proper level of technical maintenance of recognition means;
- Inability to give a correct answer to a visual, oral or electronic request (should not be considered as evidence of detection of the enemy);
- The possibility of disinformation, when the contents of the signals become known to the enemy (the responses from such devices and signals should be considered as an information, but not as a proof of the presence of coalition forces);
- Low efficiency of some methods both during the day and at night, and in conditions of poor visibility.

It is important to understand the limitations of recognition devices and provide alternative ways to overcome these limitations.

3.3. Additional information on recognition and identification procedures

In addition to the above, the following procedures and recommendations are used in the process of identifying coalition forces:

- In order to reduce the risk of disclosure, requests and responses should change periodically and communicated only as necessary. Updated requests, answers and their analogues, as a rule, are sent on a daily basis;
- Requests and responses should not be used outside the front line of the combat area, except in special circumstances (communication with the airborne landing site);
- In the event of an actual or potential security breach, alternative queries and responses as well as identification configurations should be used;
- The commander determines the use and configuration of specific identification means or devices in the prescribed manner, or in the form of special instructions in the separate order. Constant review of the conditions of use and configuration of these tools is a necessary condition to ensure their compliance, reducing the risk of disclosure and compromisation.
- The use of passive or active identification devices operating in the infrared spectrum should considered in the light of the enemy's reconnaissance capabilities. Such devices, if detected, may make it easier for the enemy to detect coalition forces if they use similar infrared systems;
- For safe use, identification devices must remain hidden from the enemy for as long as possible.
- The placement of additional armor, missile launch systems or individual equipment on the outside of the combat vehicle may change its distinctive features and eliminate the effect of all identification devices. Unit commanders should take this into account and, if necessary, provide additional instructions;
- The use of signal smoke and fire of those colors which are not defined for identification of coalition forces and do not correspond to the given purpose should be avoided;
- Intelligence forces must constantly monitor the possibility of the enemy using combat identification devices of coalition forces. Information on the use of such devices by the enemy will allow the timely disclosure of enemy's intention and the nature of his further actions.

The exchange of information on identification and recognition. Effective identification of coalition forces operating on the battlefield must base on accurate knowledge of the military uniforms, armaments and combat vehicles used by these forces. Such awareness is achieved through continuous training at all levels in all NATO countries. Improvement of training is carried out before the start of joint operations for a more detailed study of the signs of coalition forces and the enemy, which are found on the battlefield. Commanders of all units are fully responsible for the proper training of personnel to recognize the coalition forces and enemy forces on the battlefield.

To ensure that identification issues are considered when formulating an order, such a sub-item should be included in a separate section, for example, entitled “Instructions for the Coordination of Combat Identification Measures”.

3.4. Standard methods of identification and recognition

The need to develop an information and reference system for the recognition of ground forces on the battlefield according to NATO standards is due to:

- The significant amount of information that must be analyzed by the commander when deciding on the identification and recognition of targets;
- The availability of certain standards, methods and procedures, as well as digital means and devices of combat identification, which are used in the recognition of targets.

3.4.1. General provisions and restrictions

Combat Identification (CID) devices of NATO member armies are used in accordance with established recognition algorithms for the identification of Allied troops. These devices help identify their troops on the battlefield or in the area of hostilities to reduce the risk of striking coalition troops. CID devices can unmask formation positions, so they should use or activated for a limited or fixed period. Time limits for the use of these devices are set at the appropriate command level.

Among the digital means of recognition, the following are considered the most effective:

- Battlefield Target Identification Devices (BTID);
- Identification based on the means of automatic transmission of data about friendly troops (Radio Based Combat Identification - RBCI);
- Reverse Identification Friend or Foe (IFF);
- Recognition by means of radio tags (Radio Frequency Identification tags - RF tags).

3.4.2. Standards, methods and procedures for the use of means and devices of combat identification

3.4.2.1. Combat Identification Panel (CIP)

CIP is a device of using IR radiation in medium and long range, which is attached to machines, weapons and structures and forms a contrasting cold spot in the target signature, which can be detected by thermal imaging sensors. Based on this contrast, sensor operators (such as a gunner) can determine whether an object belongs to its own or someone else's troops. The lack of a specific contrast does not identify the object as enemy but informs that the object does not belong to friendly force.

The device is a solid surface measuring 0.6 x 0.8 m, which acts as a thermal mirror, reflecting the contrasting cold temperature of the atmosphere. CIP can have a form of a flat panel or a group of narrow louver panels. CIP panels are made of durable material; on the one hand, they emit almost no heat and are designed so that they can be turned over and masked. The CIP will clearly define the "cold zones" only if the correct reflection angle is used and the necessary surface is created that would be recognized

by the sensors. For the best definition of "cold zones", the panels that are attached to combat vehicles, as well as other equipment and surfaces, should be placed at an angle of 20-30 degrees.

To ensure the camouflage, the color of the CIP must match the color of the surface to which the panel will attached. For the best visibility of the vehicle from any angle, it is necessary to place on it from 4 to 10 panels. Each panel should be located in such a way as to ensure the reflection of colder radiation from the sky and create the necessary surface, which would maximally recognized by thermal imaging sensors (Fig. 1).

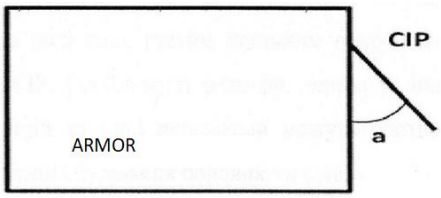


Figure 1: Angle of attachment of the combat identification panel (CIP).

The design of the CIP should characterized by strength, uniformity of form and ease of installation, as the loss of such a panel leads to the uncertainty about identification. Strength is the most important factor in the use of CIP. The same placement improves the quality of identification, and the same shape facilitates maintenance and transportation of panels. Easy installation also reduces maintenance costs.

The efficiency of CIP depends on the properties of thermal sensors and the size (area of the irradiated surface) of the panel. At more than 2500 m, the efficiency of CIP decreases, especially during the movement of the machine. The use of CIP at distances greater than 1500 m is complicated by the fact that the sighting grids of thermal imagers can obscure cold areas of the image. Even at distances less than 1500 m, the identification of CIP may be hard during the direct aiming at the target. By switching the thermal imager modes from “white-hot” to “black-hot, it is possible to increase the probability of effective identification of CIP. The cold contrast CIP image in the vehicle's hot mode is much clearer when using the black-hot mode. Quickly and accurately detected CIP allows combat crews to avoid inflicting fire damage on their troops (forces), so preparation for the use of CIP should be included in the list of mandatory training of personnel on the use of thermal identification devices, which are carried out after arrival at the theater of operations to ensure maximum efficiency of the CIP.

The use of combat identification panels (CIP) should not be the only means of recognizing targets, as they may damage, lost during transport or their efficiency may reduce due to dust (dirt), etc. In addition, non-combat forces on the battlefield do not use such recognition devices. CIP should considered only as one of the means that contributes to the reliable identification of the object.

Image contrast may reduce due to high cloud cover, poor visibility on the battlefield, thick foliage, or accumulated dust (dirt) on the surface of the CIP. Terrain features, trees and other vegetation, natural shelters of fire positions and other obstacles can distort the reflection and complicate the recognition of any weapon. Using specific CIP configurations for a long time is dangerous. The enemy can easily and quickly reproduce such configurations. CIPs can used by the enemy to mislead, as they can imitated, purposefully or involuntarily. Therefore, the decision to open fire should made based on thermal or visual recognition of the object using all the functions and processes of recognition.

In the case of purposeful imitation, the enemy may intentionally copy the panels to impair the efficiency of their use. The countermeasures are to switch off the panels of friendly troops.

The simplicity of the CIP design makes them relatively easy to maintain. In order to ensure the reflective properties of CIP, they must kept clean. CIP must replace if vegetation, strong wind or other factors on the battlefield have caused damage or loss of the panel.

3.4.2.2. Thermal identification panel

Thermal identification panel (TIP) is a flexible thermal panel that uses the middle and far part of the infrared spectrum, which is recognized by TI sensors. TIP is usually used to identify objects in the ground from the air-ground (Fig. 2).

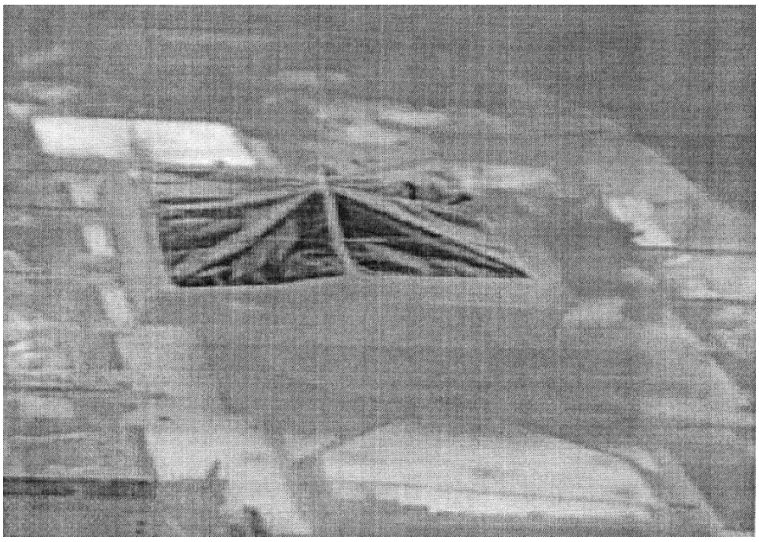


Figure 2: The image of the thermal identification panel in the thermal imager.

Through the TI-sensor, the panel is displayed as a contrasting cold area against the background of thermal radiation of the target. Some TIP variants have daytime visible markers (bright orange) on the reverse side. Some orange markers look like TIP, but they do not have thermal properties. Thermal Identification Panel (TIP) is a fabric thermal panel, usually 1.3 x 1.3 m in size, covered on at least one side with a heat-reflecting material. In order to ensure double recognition, some TIP variants on the reverse side have an orange color of the international standard; others - camouflage color (Fig. 3).

Figure 3: Samples of identification thermal panels.

Smaller TIPs may used for soldiers operating on foot. This type of TIP is a board measuring 30 x 30 cm, which can be attached to the equipment of a soldier (for example, on a backpack or other equipment) or for the whole groups to be installed on the ground. TIP can fixed by the rings attached to them. In order to effectively identify ground objects from the air, the TIP can be placed in the middle of the air-ground direction to achieve optimal angular reflection of the object. The TIP variant for infantrymen should be as rigid as possible and fastened at an angle for optimal reflection. On aircraft equipped with thermal imagers, TIP is displayed as a clear cold area against the background of the hot zone of the target, visible at 3 - 5 km, depending on environmental conditions and surface openness.

The guidelines for prevention of degradation, misleading, maintenance and inspection that are given for CIP apply equally to TIP, which can be used during the day or night and in all climatic conditions. This tool is also used as the simplest CID device for machines not equipped with CIP.

3.4.2.3. Thermal identification beacon

The thermal recognition beacon is an active flickering beacon that operates in the middle and far infrared range. The thermal beacon provides vehicle recognition by constantly adding a shimmering warm or cold spot to the vehicle's thermal signature. These beacons are generally unaffected by weather conditions, are relatively easy to install, and require minimal training to perform recognition. The thermal beacon contains an emitter platform, which has a radiating thermal element and a parabolic reflector; the reflector rotates around the element and focuses the energy of the radiation into a concentrated and directed in one direction beam, which flickers in the TI-sensor during viewing (Fig. 4). The thermal identification beacon is mounted and actuated on the main combat vehicle. Image changes caused by the installation of a thermal beacon are insignificant - the beacon does not change the image characteristics of the vehicle either visually or in the infrared spectrum. Therefore, the beacon does not interfere with other recognition processes and does not cause a significant increase of unmasking of the host machine. The thermal beacon operates from the power supply of the combat vehicle; a mounting kit that ensures its mounting on a variety of vehicles and is installed by the crew of the vehicle produces the heat for the element of the rotating beacon.

Figure 4: A sample of thermal identification beacon

The prevailing visibility conditions and the efficiency of the TI sensor limit the range of the thermal beacon. The test results showed that the recognition distance is 1500-4000 m.

The thermal identification beacon is not a full-fledged CID device. It serves as an aid to strengthen or accelerate existing recognition procedures. The very presence of a beacon is often the first sign that the object of recognition is indeed the vehicle of friendly troops. However, the absence of a beacon signature does not mean that it is an enemy vehicle. The use of a thermal identification beacon is appropriate for non-military vehicles to assist convoys or other persons involved. In addition, the beacon can used as an aid to movement control, in particular for convoys.

In situations that allow the use of active devices and in conditions of limited visibility, the thermal beacon can used as a replacement or addition to the CIP. Thick fog, dust, foliage, smoke-forming substances on the battlefield can reduce the efficiency of TI sensors. Tests have shown that the thermal beacon has a higher level of penetration through the smoke means of rapid dissipation (e.g. smoke screen) than the residual thermal signatures. Strong winds, which can lead to rapid cooling of the element, can reduce the range and efficiency of the detection process. The thermal identification beacon

is an active CID device that is equally easily detected by the TI sensor of both friendly forces and the forces of the enemy. The expediency of using the device should assessed considering the possibility of detection and equipping the enemy with recognizable thermal devices. The instructions on the thermal identification beacon must specify the conditions and methods of its use. Among these, it is possible to use partial masking of the device from the enemy to reduce the likelihood of detection.

The device has no encryption protection. Capturing a beacon can lead to both simple inconveniences and a serious risk to friendly forces, depending on the number of captured devices. The simulation of a thermal beacon in any quantity requires modern engineering and production facilities.

3.4.2.4. Near-infrared (IR) emitters

Electronic or chemical near-infrared emitters work with the active energy of near-infrared radiation, which can only see with image intensifying sensors (II-sensors), and therefore are effective only at night. Near-range infrared emitters can be pulsed, fixed, and directional or non-directional. A pulsed emitter is usually called a stroboscope. Examples of near-IR emitters are disposable chemical emitters (e.g., fluorescent illuminators or infrared markers), the Phoenix beacon, and BUDD flashlights (Fig. 5).

Figure 5: Phoenix beacon and BUDD flashlight

a) Near-range infrared emitters, stroboscopes. Near-infrared emitters are compact devices powered by a 9-volt or AA battery. The flashlight and its power supply can placed on the palm. The pulse emitted is like the strobe pulse. The size of the flashlight makes it convenient for use in stationary facilities, vehicle identification and for use by personnel operating on foot.

In the directional use, the pulse is best seen when the beam is directed directly at the II sensor. Non-directional uses can provided with a screen that makes them directional and protects against radiation detection with the help of the II-sensor. Screens can also applied to directional strobes, which makes their radiation more accurate. The protective screen can be made of tin cans or tape.

b) Chemical IR markers in the near range. These markers are like traditional fluorescent chemical emitters. Chemical IR markers emit stable (constant) infrared light. They can used like IR strobes, except that their range is limited, and uncontrollability is possible only in the absence of physical blocking. The average duration of the chemical IR marker work in the near range is 3 hours.

Near-range infrared emitters can used to mark stationary ground forces and vehicles. They are effectively used for marking or signaling between two ground, or ground and air positions. They can be used in stripes to identify units, as well as to mark obstacles or places of breakthrough, or to use an on / off signal to notify the completion of a task (for example, crossing the control line).

Near-range infrared emitters are also used to indicate areas of loading (landing) on board, launch or landing. When performing air-to-ground identification, the IR emitter can used to mark the platforms of friendly forces, infantry, fire prevention zones, targets, landmarks for the use of means of destruction and boundaries of damage zones, sectors.

The directional nature of the emitter signal limits the likelihood of unmasking during enemy surveillance, but this in turn limits the reliability of target identification. Flashlight radiation can also be mistaken for a muzzle flame.

In order to reduce the probability of error, the conditions of use of IR emitters should considered depending on the current tactical activities, and they should not be the only source for recognizing friendly forces or targets. The frequency of the strobe should be coordinated and serve as a control to increase safety. The performance of the short-range IR emitter is limited by the battery life.

II-sensors, unlike thermal imagers, are relatively inexpensive and available in large quantities. It can assumed, in the absence of reliable intelligence, that the enemy troops are equipped with II-sensors and have the same ability to detect IR emitters as coalition troops. Therefore, the use of sensors should monitored and limited for as short a time as possible, for example when troops have crossed the border.

II flashlights should considered if the battlefield has forests, fog or smoke. Like car headlights in fog, a circle of reflected infrared light is formed around the light source of the emitter.

3.4.2.5. Reflective paint or tape of the near IR spectrum

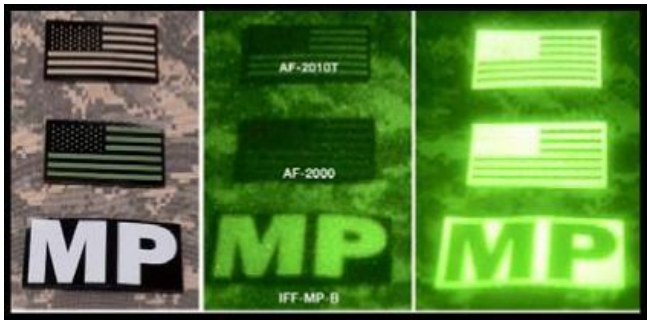
Infrared reflective paint or tape can used both passively and through active infrared illumination to identify vehicles on land. Various symbols or signs can be painted or temporarily applied with tapes on the sides of the vehicle. Color (tape) inscriptions are visible through II-sensors. Due to the difference between the color of the vehicle and the reflective tape (paint) applied to it, the symbols or signs also contribute to visual identification. An example of the above is the use on tanks of the symbol applied above the caterpillars - at a horizontal angle of near infrared radiation. As a rule, the tape scheme uses tapes 45-50 cm long and 7.5 cm wide, which ensures their visibility within 500 m. It should note that the rectangles on both sides of the tank tower are hook and loop fasteners, to which CIP can attached (Fig. 6).

Figure 6: Example of infrared paint usage

Applying reflective tape or paint directly to the combat vehicle gives a more lasting effect but limits the commander's ability to use them selectively. To reduce the likelihood of their disclosure by the enemy, it is necessary for periodically change the color (tape) schemes. The appropriate commander carries out the coordination of symbols and characteristic marks.

3.4.2.6. Reflective material of the near-IR spectrum

The reflective material of the near-infrared spectrum is a passive device, designed to identify combat vehicles and individual fighters. This material is used to recognize friendly forces with the help of visual aids and passive use of the II-sensor. It is best seen with an active short-range infrared radiation source, where the material glows, which facilitates identification through the II sensor. This material can attached to machines, military uniforms and equipment. For greater efficiency, it can installed in different places so that the backlight facilitates identification in any direction (Fig. 7).



a b c

Figure 7: Infrared flags and stripes visible (from left to right): a) with the naked eye; b) through a passive II-sensor; c) through the II-sensor with active infrared illumination of the near range.

The reflective material of the near-infrared spectrum is usually used for overlays and markers of various sizes, unique drawings (figures), which are installed directly on vehicles, military equipment, equipment, certain types of military uniforms, or for the temporary use on hooks and loops.

When using material to identify individual servicemen, we should check for infrared tapes and stripes, which should be placed on the outside of the uniform, helmets and equipment in designated areas specified by current orders or standard operation procedure (SOP). When using this material on vehicles, make sure that the markers are placed on the external fixed elements of the machine so that the normal mode of operation and movement of the vehicle does not lead to displacement or loss of reflective markers (Fig. 8). The appropriate commander carries out approval of drawings (figures).

Figure 8: Reflective material of the near-IR spectrum.

Some countries use this material in the stripes of the national flag as a means of distinction, thus reducing the possibility of its forgery (Fig. 9).

Figure 9: Examples of infrared stripes / markers and national flags.

According to information about tests of such infrared stripes in the Armed Forces of the Russian Federation, the Ministry of Defense of Ukraine plans to use them to identify its soldiers with the use of night vision devices. Stripes are placed on field kits of the all-season set of combat clothing. Due to the peculiarities of the design, they give infrared illumination in the lens, which allows distinguishing friendly servicemen from enemy soldiers. The stripe is made in the shape of a rectangle and is placed on the sleeve pockets. Fastening is carried out by means of a Velcro, for ensuring its fast removal and installation on the form. The material reflects only the infrared part of the spectrum, which allows you to observe a bright point. Moreover, such stripe is not visible - the human eye does not perceive this spectrum of radiation (Fig. 10).

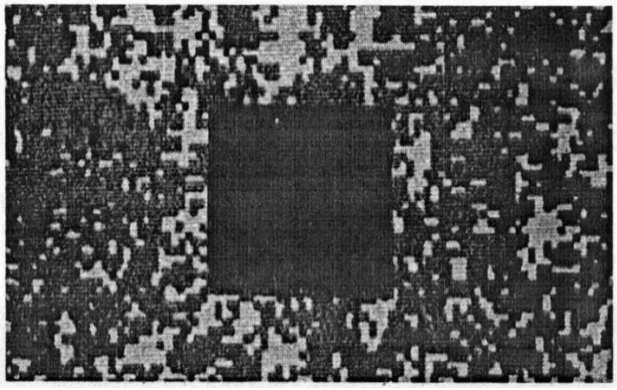


Figure 10: The general view of the infrared stripe on combat clothing

However, the Russian terrestrial signaling device, which belongs to the first generation of such devices and was developed in the 80s of last century, gives a blurry image. For the system to work, you need to have modern night vision devices of the second and third generation. The project of creating a research and production cluster is planned for implemented by the Russian company Concern “Radio electronic Technologies”. The internal electronic component of the applicator will programmed depending on the task. It is planned that such a recognition system will be integrated into the combat equipment of soldiers "Ratnyk" and "Barmytsya" [4].

Such applicators have become a mandatory attribute of combat equipment not only in combat units of the US and Russian armies, but in the armies of many countries around the world.

3.4.2.7. Vehicle marking system

Vehicle marking system consists of a standardized system of combinations of numbers or symbols that provide a visual distinction of machines in the unit. The markers are of standard size and can mounted on the CIP or on similar surfaces. To ensure visibility, the markers must have a color that contrasts with the color of the base. This marking system is usually coordinated during the operation or combat management activities in a separate theater of operations (Fig. 11).

Figure 11: The use of “ACUIRtabs” on vehicles

3.4.2.8. Military doctrine of combat recognition in the armies of NATO member countries

According to military doctrine, the solution of combat recognition tasks in the armies of NATO member states provides (Fig. 12):

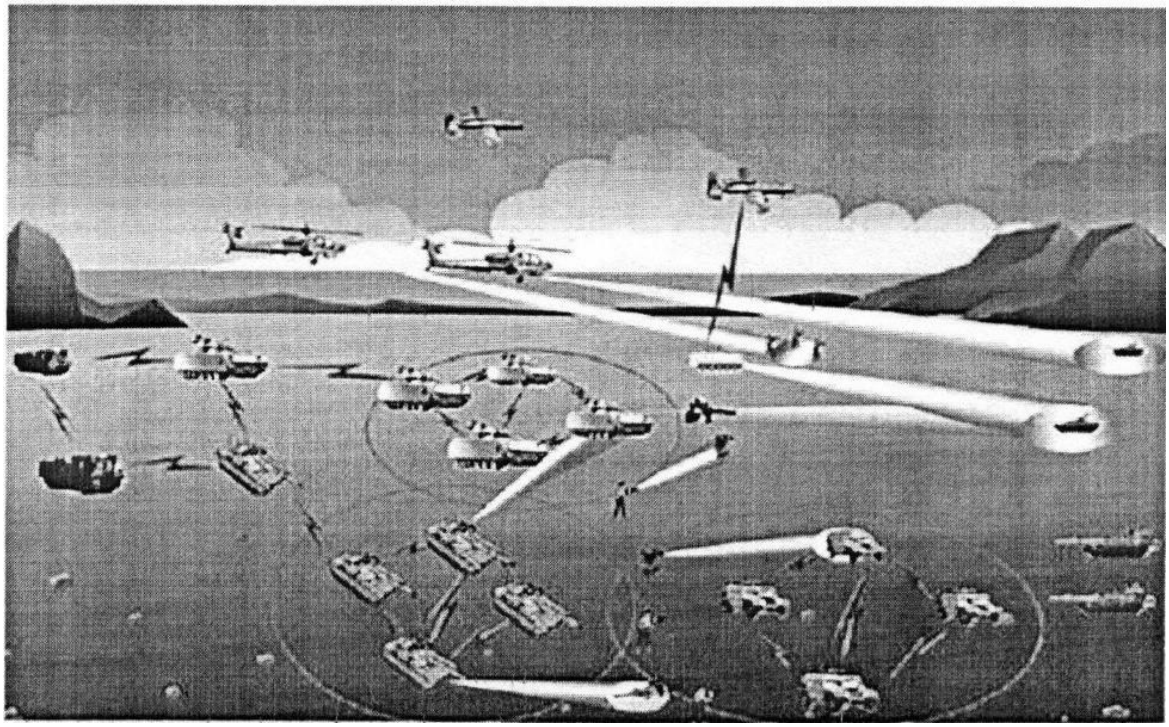


Figure 12: The use of systems depending on the conditions of the combat situation.

- Recognition of interacting allied combat forces and timely detection of the enemy;
- The use of sensors on combat vehicles in order to determine the location, signs of covert actions of the enemy;
- Providing NATO member countries with modern, reliable and interoperable means of recognition, organization of communication networks between all coalition forces;
- Defining the policy, structure of the concept and procedure of recognition, which will reduce the vulnerability and increase the effectiveness of the interaction of coalition forces, standardization of recognition information using tactical radio lines and general decision-making algorithms;
- Recognition of soldiers during operations on foot and on equipment in combat conditions.

Allies, namely the United States, the United Kingdom, Germany, France and Italy, have developed and approved a single NATO Standard, STANAG 4579. "Target recognition equipment on the battlefield" and a number of other normative documents (STANAG 4162, 4193) with appendices "A", "B", "C", "D", "E", according to which the methods of implementation of the system are specified depending on combat conditions (Fig. 13) [29].

Means of target recognition on the battlefield must provide [31]:

- Work in the modes of request-response of targets in the millimeter wavelength range of 33-40 GHz;
- Operation in fog, rain, dust and wooded areas, real-time target recognition; data exchange and digital data transmission network;
- Flexibility coupled with the platform (carrier), the structure of which does not require significant modifications and additional devices for installation on the platform (carrier);
- Minimum weight and dimensions.

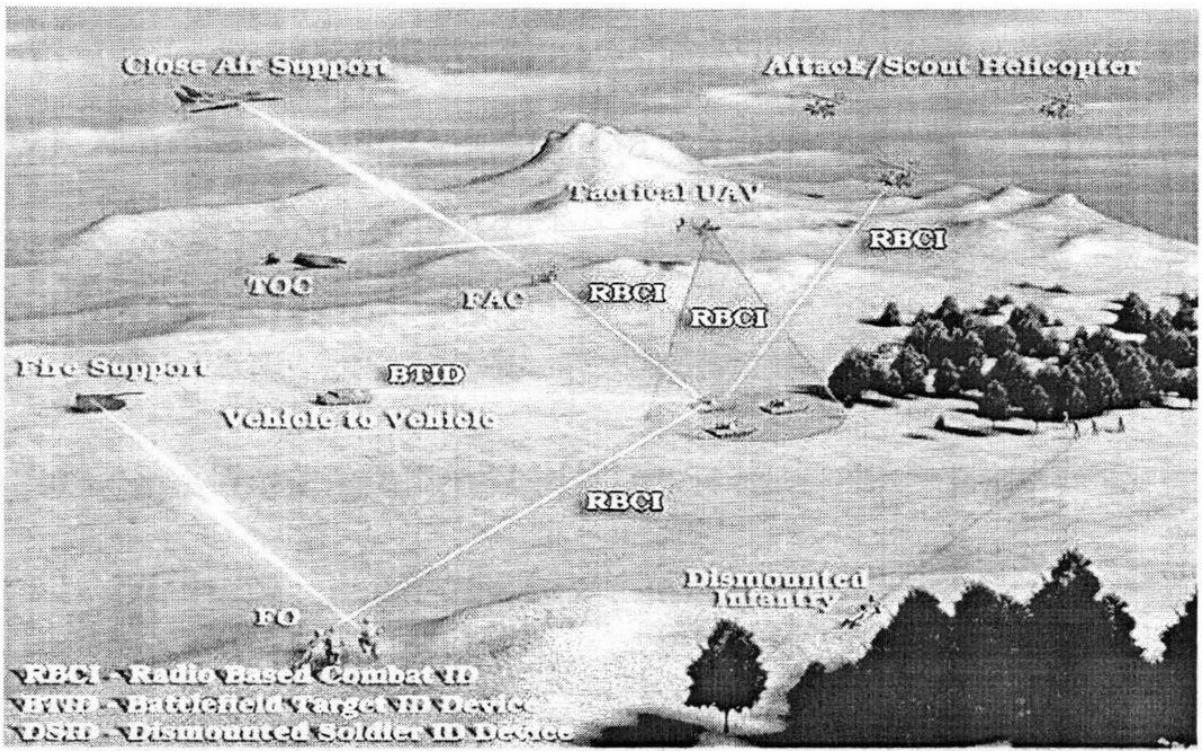


Figure 13: The concept of the method of system implementation.

Based on the above requirements, a single recognition device (Combat identification for the Dismounted Soldier) was developed. The device is a laser requester recognition system, which includes a compact, safe for human vision semiconductor diode laser emitter with a capacity of 25 watts, a set of laser receivers and an electronic processor (Fig. 14).

Figure 14: Practical operation of the system "DCID".

This device is mounted on the weapons of the soldier. The ballistic helmet houses a respondent that includes a set of four laser receivers with a VHF transmitter, which transmits a response upon request confirming that the soldier belongs to his troops. A standard commercial battery powers the system.

The availability the wide range of devices used in the identification of targets requires justification of the range of their tactical application depending on different environmental conditions.

3.4.2.9. Methods of application of DCID devices

The Fig. 15 presents the variants of implementation of the identification system.

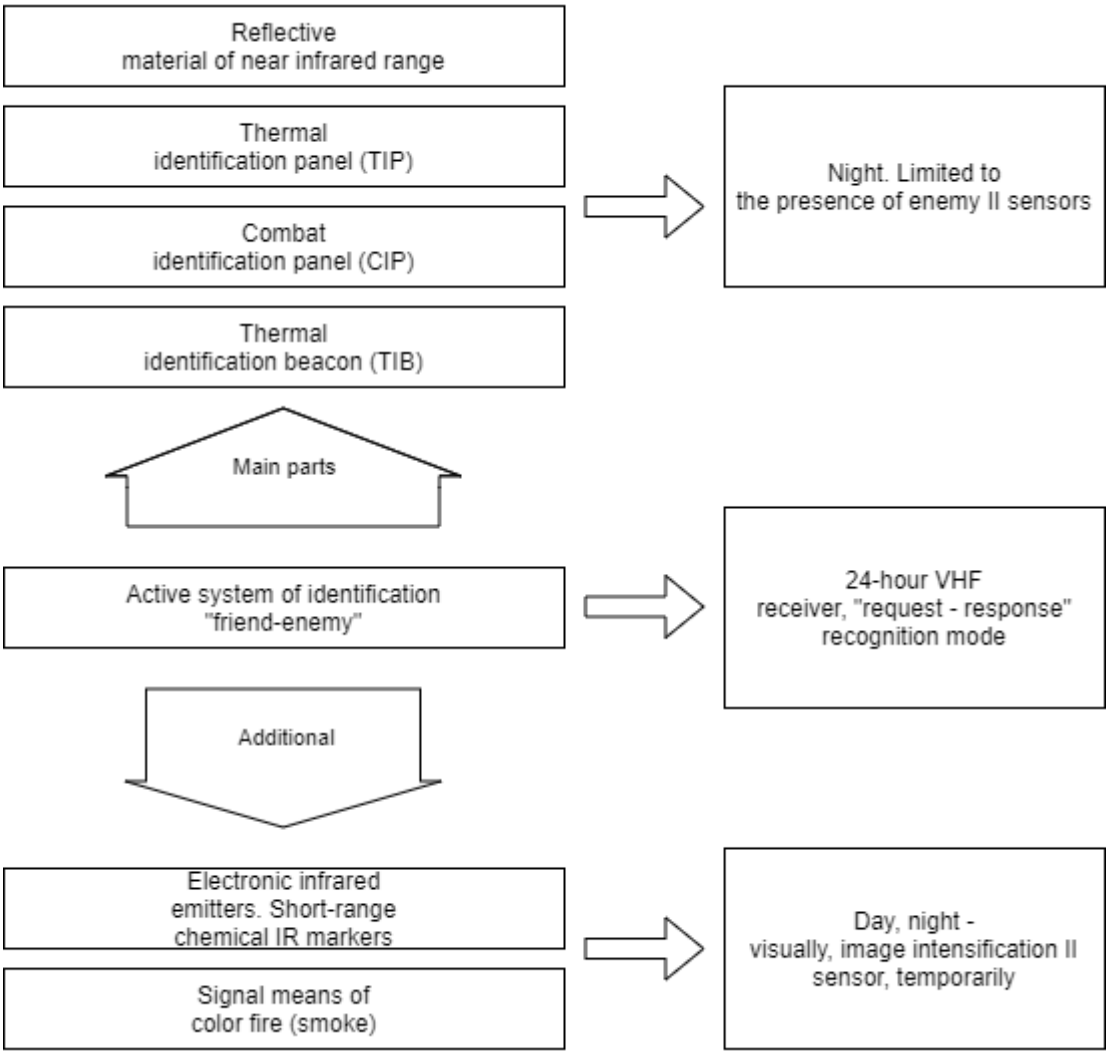


Figure 15: Variants of implementation of the identification system

The mentioned above technical standards, including STANAG 2129 "Ground Recognition on the Battlefield and in the Operation Area", allow NATO countries to develop interoperable target recognition equipment and compatible software. To improve the quality of decision-making, recognition information is accumulated in a single NATO identification system - "CIN" [29].

Variants of the spectrum of tactical application of the CID devices described above are given in Table. 1. The technical standards mentioned above, including STANAG 2129 "Ground Recognition on the Battlefield and in the Operation Area", allow NATO countries to develop interoperable target recognition equipment and compatible software. To improve the quality of decision-making, recognition information is accumulated in a single NATO identification system - "CIN" [29].

Variants of the spectrum of tactical usage of the CID devices described above are given in Table. 1.

Table 1

Methods of tactical use of CID devices

Factor	Situation	Usage
Combat mission	Attack, or pass through the battle formations of friendly troops with access to the enemy.	CIP: mounted on the front, sides and rear. TIP: turn on if necessary to identify ground targets from the air. TIB: turn on; protect the front arc with a screen.

Factor	Situation	Usage
	Defense, retreat through the battle formations of friendly troops	CIP: is attached to the sides and around the positions of friendly troops. TIP: used for identifying ground targets from the air. TIB: turn on, protect the front arc with a screen
Enemy troops	Rare use of short-range IR sensors	Near-infrared emitters are used with caution
	Widespread use of short-range IR sensors	Near-infrared emitters are not used
	Rare use of thermal sensors	CIP: fixed only on the back. Remove or turn the panel on the front and sides and around the locations of enemy troops TIP: used for the necessary identification of ground targets from the air. TIB: used only for specific tasks (e.g., convoy training, identification of ground targets from the air); if necessary, the front and / or side arch is protected by a screen.
Friendly troops	Most use thermal sensors	CIP / TIB: Not used or used with caution. TIP: used for the purpose of identifying ground targets from the air
	Ability to install mid-range and long-range IR CID devices	CIP / TIP / TIB: not used.
	Joint / Multinational Forces	The appropriate commander in accordance with orders or SOP. Sets the minimum standards for CID devices. The use of CID devices should be coordinated. It is recommended to conduct training exercises on the use of CID devices
Weather (warm / hot)	Clear, dry	CIP / TIR / TIB and short-range IR emitters: high efficiency
	Clear, wet	CIP, TIP and TIB: high efficiency (use of white-hot thermopolarity)
	Cloudy, humid, damp	TIB: works effectively. CIR and TIP: significant reduction in performance. Near-infrared emitters: possible halo effect
Weather (cool)	Clear, dry	CIP / TIP / TIB and short-range IR emitter: high efficiency.
	Clear, wet	CIP, TIP and TIB: high efficiency. Near-infrared emitters: possible halo effect
	Cloudy, damp, humid	CIP, TIP and TIB: high efficiency Near-infrared emitters: possible halo effect
	Damp, windy	TIB: efficiency may reduced due to wind, it is recommended to use wind cover. CIP and TIP: high efficiency. Near-infrared emitters: possible halo effect
Day time	Day	It is recommended to use TIB, CIP, TIP and vehicle marking
	Night	It is recommended to use TIB, CIP, TIP and passive and active devices in the near IR range

CID devices provide various methods of recognition, which together with direct vision sensors guarantee high reliability of the results of identification of friendly forces.

4. The analysis of time spent on the process of applying standard methods of identification and recognition

In the process of combat identification, a wide range of devices that work on different physical principles is used. This generates huge amounts of information that requires the appropriate analysis in the implementation of combat identification. At the same time, in order to ensure the efficiency of the coalition forces' management, the time allowed for information processing and decision-making is extremely limited. This leads to information overload of the commander. In order to reduce this workload and increase combat effectiveness and, as a result, reduce the number of casualties of friendly troops, it is important to develop an information and reference system for recognizing ground forces on the battlefield according to NATO standards.

5. Conclusions

1. There is a substantial danger of falling under the friendly fire, when coalition forces under the influence of multiple objective and subjective factors do fighting.

2. The characteristic feature of mobile combat is the rapidity of fire contacts, which leaves no time for reflection.

3. The creation of a Combat Identification (CI) system is an important objective to prevent falling under the friendly fire.

4. The purpose of combat identification is to improve situational intelligence, as well as methods, means of recognition, based on a common doctrine, effective training and compliance with the rules of combat operations, in order to increase combat effectiveness and, consequently, reduce casualties of friendly troops.

5. The purpose of target identification is to determine the nature of the object on the battlefield as allied, hostile, neutral or non-combat.

6. CI functionality includes enemy identification (including platform type, class, nationality, alliance, and intent information), allied identification, neutral force identification, and interoperability to minimize the total number of casualties.

7. It can argued that the modernization of existing and creation of new identification systems is in the areas of:

- Radio identification methods;
- Use of shorter wavelengths;
- Use of requesting and non-requesting identification methods;
- Use of complex signals as request and response signals;
- Extensive use of geographic information systems.

8. According to military experts, only a comprehensive provision of such systems to tactical units will help reducing the level of combat losses from friendly fire.

9. Commanders of all units are fully responsible for the proper training of personnel for the recognition of coalition and enemy forces on the battlefield.

10. Combat Identification (CID) devices of NATO member armies are used in accordance with the Alliance's identification algorithms established by the standards.

11. These devices help identify their troops on the battlefield or in the area of hostilities to reduce the risk of striking coalition forces.

12. CID devices can unmask formation positions, so they should use or activated for a limited or fixed period. Time limits for the use of these devices are set at the appropriate command level.

13. The process of combat identification requires the analysis of a huge amount of information. At the same time, in order to ensure the efficiency of the management of the coalition troops, the time allowed for its processing and decision-making is extremely limited.

14. The information and reference system for the recognition of units of the Land Forces on the battlefield according to NATO standards will increase the efficiency of their combat identification, which determines the relevance of its development.

In the future, the authors plan to develop the structure and algorithm of the Information and Reference System for the recognition of units of the Land Forces on the battlefield according to NATO standards.

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