

Improvement of Soldier Survivability by Signature Management

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Personal protection of a warrior has always been the focus of attention. Development of weapons and ammunition has been going on hand in hand with improvement of protection equipment. If in ancient world protection was offered by leather shields which saved human life against arrows, nowadays we enjoy ballistic helmets and vests saving human lives against small arms, grenade fragments and other types of modern ammunition. Such protection equipment makes us feel proud for our protection designers, but unfortunately cannot make us feel completely satisfied with the offered protection level.

The necessity to improve the soldier's survivability is caused in the first turn by the fact that the possibilities of ballistic protection are limited by the acceptable mass of protective equipment. Even well-physically-trained person is not able to wear protective clothing weighing 6 to 8 kilos for a long time. It's quite a load, especially if one bears in mind that the soldier wearing such clothing while performing his combat mission must also carry his weapons, surmount obstacles, shoot and run in cross-country. Besides, further improvement of ballistic protection can be achieved only by stronger and stronger efforts and expenses, and the results are less and less impressive.

At the same time the weapon threatening the modern warrior is constantly improving. While small arms improvement rate has also decelerated, high-explosive ammunition is rapidly developing. We've seen the use of volume effects ammunition against infantry in Afghanistan, and no body armor can protect against such threat. In many countries uncommon anti-personnel weapons are under development, including non-lethal ones.

The above facts show the urgency of finding the ways to protect the warrior against all modern threats. And such comprehensive way of protection does exist but is undeservingly little used, and this is personal signature management which offers concealment against all known and future surveillance and tracking equipment. The theoretical basis of such conclusion is the soldier disabling probability equation in the following form:

$$P_{disabl} = P_{det} \cdot P_{recogn} \cdot P_{hit}^i \cdot P_{guar.disabl}^i \quad (1)$$

where P_{det} is the probability of soldier detection;

P_{recogn} is the probability of detected soldier recognition, P_{hit}^i is the hit probability in i -zone of the soldier; $P_{guar.disabl}^i$ is the probability of guaranteed disabling of the soldier.

From equation (1) analysis it follows that P_{hit} completely depends on the enemy's capabilities. The values of probabilities can be affected by changing the soldier's equipment features.

It must note that while $P_{guar.disabl}^i$ is an attribute which is selective to different threats and is a conditional probability (i.e. depending on other multipliers), the detection probability is an unconditional probability and manifests itself to a greater extent, preventing from using the weapon.

Thus, the challenge of making the warrior more concealed in the modern warfare is critical and solvable.

To determine the methods and means of signature management and to develop particular technical solutions for signature reduction it's first necessary to consider the capabilities of detection devices.

In the optical wavelength range most widely used is visual surveillance and detection by such optical equipment as binoculars, field glasses and sights, often with image intensifiers.

Possibilities of optical concealment of the warrior are rather limited by a great variety of detection conditions and their versatility during day and night and during different seasons of the year. Backgrounds are also very different (Fig.1). The amount, direction and spectral composition of daylight and artificial light vary in a wide range. The capabilities of viewing devices also differ greatly. The conditions of optical contrast formation when using night vision devices with or without lighting require application of low-reflective materials in the warrior's uniform in the first case and of high-reflective materials in the second case which is mutually exclusive.

It is impossible to provide concealment in all these

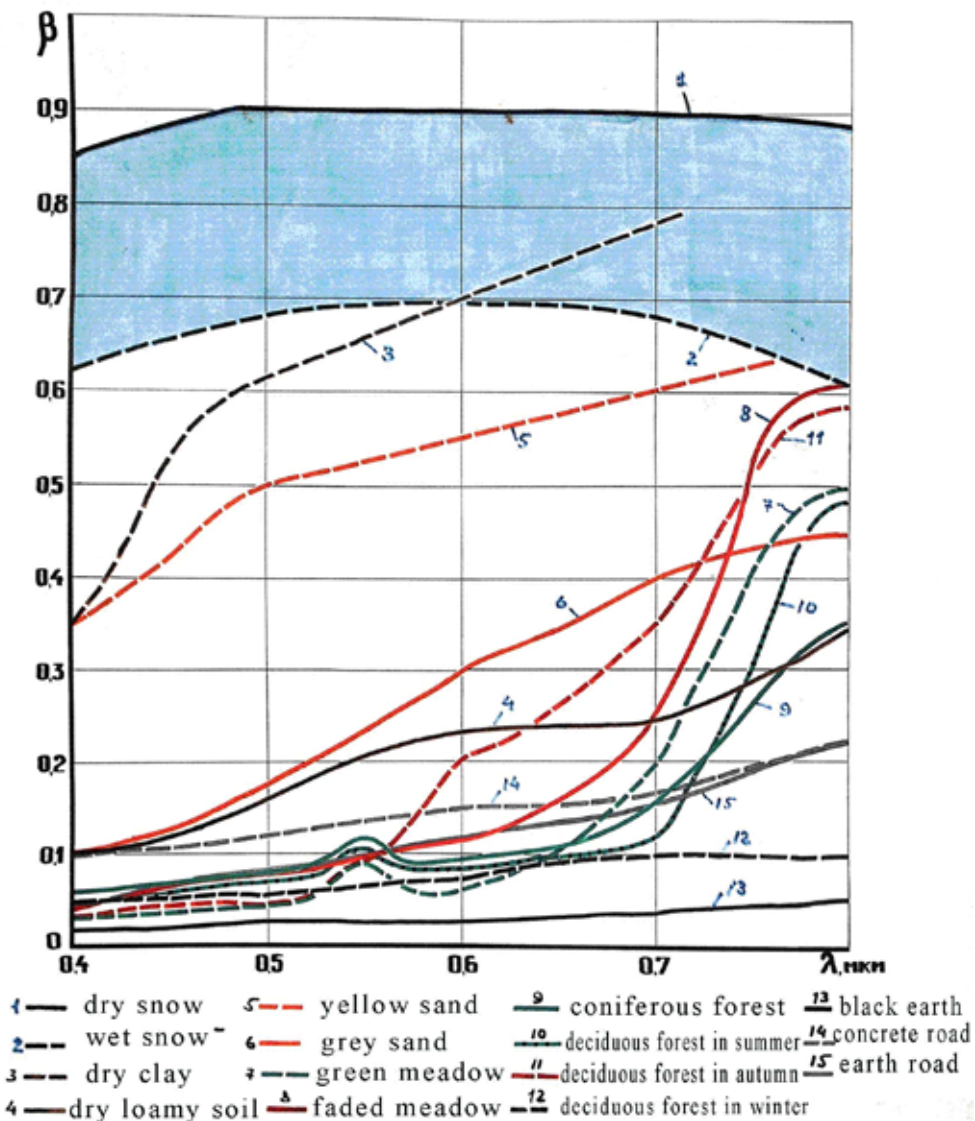


Fig.1 Background spectral characteristics

conditions with the same materials. Data on signature reduction materials should be checked experimentally for the whole range of optical surveillance conditions. Spots typical for body armor camouflage painting, with linear size of less than 30-50mm, are not visible from more than 30 meters and, subsequently, lose their camouflage effect. The color pattern of camouflage painting often includes also different shades of red and blue which are not typical for nature and do not conceal but rather discover the soldier.

To reduce optical signature of the warrior's personal equipment (not only body armor) it is necessary to use camouflage spots of such sizes which are optically resolvable at the most probable distances of small arms fire, i.e. 300-500 meters. It is recommended to use combinations of spots with brightness coefficients of 5-10%

and 25-30%. The color pattern should contain the colors typical for the particular geographical zone and season. Spectral characteristics of color spots shall be normalizable characteristics of camouflage materials.

The spectral characteristics of green spots shall feature increased reflectivity at the wavelength of 550 nanometers, matching the natural vegetation because of chlorophyll. For winter patterns it's preferable to use the materials and paints with reflectivity matching that of snow in UV region. Most white-color textiles and films do not meet this requirement and when viewed through filters can be seen as dark against white snow. Besides, the spot pattern is also necessary for winter camouflage. The idea of monotonous snow surface on the battlefield is erroneous.

It's important that with the advent of thermal imagers and radars optical surveillance lost its unique role. Optical surveillance cannot be used or is very difficult to use at night, in fog, from behind the smoke screens, in low forest. But thermal systems can detect warriors in all these conditions with high probability. Experimentally we have confirmed the possibility of detecting a warrior in standard uniform in summer via a thermal sight at the ranges of up to 4 km. It's very important that neither the night-time nor aerosols can conceal a person from thermal detection which makes the issue of soldier's thermal signature management even more critical.

Radar surveillance of warriors is not used so widely. Just some cases of using AN/TPS-15 radar in the role of rifle sight are known. However, radar surveillance of combat units is an important method of target designation for mortar and artillery batteries.

"NII STALI" JSC has designed a range of personal equipment for optical, thermal and radar signature management.

Fig.2a shows a general view of an armor vest with metal ballistic panels; the vest reduces the radar reflection of the soldier in centimeter wavelength range by one order. Fig.2b presents a general view of a polymer ballistic helmet with low radar reflection and concealing the thermal image of the soldier's face. Signature reduction is gained with the help of special materials, and the weight increase is only 30-60 grams.



Fig.2 Body armor with reduced radar reflection
a - armor vest
b - ballistic helmet



Fig.3 Warrior wearing a camouflage cape and a ballistic helmet made by "NII STALI" JSC

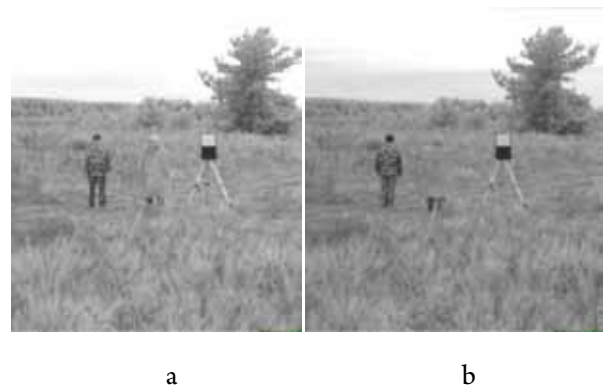


Fig.4 Thermal image of warriors, one of whom is wearing a standard Army camouflage uniform (left) and the other - a camouflage cape made by "NII STALI" JSC (right)
a - front view
b - back view

For combined reduction of optical, thermal and radar signature "NII STALI" JSC has designed a camouflage cape (see Fig.3). Fig.4 presents a close-distance thermal image of soldiers wearing a standard camouflage uniform and a camouflage cape made by "NII STALI" JSC. The new soldier's signature reduction means impede the use of any type of weapons by the enemy and in combination with body armor can greatly improve survivability of warriors, even against such types of weapons which cannot be stopped by ballistic protection.