# CRITERIA FOR EVALUATING THE CAPABILITIES OF GROUPS OF SIMILAR NON-LETHAL WEAPONS

## КРИТЕРИИ ЗА ОЦЕНЯВАНЕ ПОТЕНЦИАЛНИТЕ ВЪЗМОЖНОСТИ НА ГРУПИ ОТ СХОДНИ НЕЛЕТАЛНИ ОРЪЖИЯ

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***Abstract:*** *Investigation and assessment of non-lethal weapons (NLWs) require development of specific methods and tools different than those applied to conventional weapons, due to reversibility and limited duration of the NLWs' effects. The capabilities evaluation aims to establish to what extent the NLWs are able to meet the requirements of an operational task. The paper describes the criteria currently applied for assessing the NLWs capabilities and proposes an approach based on selection of criteria and variation of their relative weights depending on studied NLWs and operational tasks specific. The application of this approach is illustrated by a comparative evaluation of a group of non-lethal hand grenades with different effects.*

*Keywords*: NON-LETHAL WEAPON (NLW), CAPABILITIES ASSESSMENT, CRITERIA

## *Introduction*

According to the most contemporary definition the non-lethal weapons are "… explicitly designed and primarily employed to incapacitate targeted personnel or materiel immediately, while minimizing fatalities, permanent injury to personnel, and undesired damage to property in the targeted area or environment. Non-lethal weapons are intended to have reversible effects on personnel or materiel".[1] These special features require development of new methods and tools of study, since the methods applied to conventional weapons are considered inapplicable to NLWs. The most recent and comprehensive studies in this field are accomplished by the working groups on the NLWs capabilities assessment [2] and the effectiveness [3, 4] at the NATO Research & Technology Organization.

## *Existing Approaches for the NLWs Capabilities Assessment*

In most of available publications the abilities of a NLW to achieve the desired outcome of an operation are described as "effectiveness" and its evaluations are performed using various approaches and criteria.

Differentiation between terms "capabilities" and "effectiveness" of the NLWs is introduced in the NATO working groups reports [2, 3, 4] where the capabilities of a NLW are defined as its potential to successfully execute certain operational task, while the effectiveness is the extent at which a NLW achieves the goal of the task, i.e. the ratio between performance and the desired result, along the operational phases and taking into account the effects of the weapon on all groups of subjects involved in situation.

Evaluating the NLWs capabilities and effectiveness is based on operational scenarios, which allows determination of the desired outcome and formulating requirements for assessing the suitability of a NLW depending on the degree at which it meets the requirements.

The report of the NATO Working group on the NLWs capabilities based assessment [2] is an impressive study including 160 NLWs of all types and covering the whole range of missions in which different types of forces (military, police, anti-terrorist, etc.) are engaged. Thirty seven scenarios with over 50 operational tasks are developed, requirements for each task are formulated and NLWs applicable to the tasks are discussed and evaluated. The methodology of [2] represents "a process of analysis consisting of four steps: (1) operational requirements analysis; (2) capabilities analysis; (3) analysis of gaps (incompatibilities); (4) analysis of possible solutions". The Working group proposes 10 evaluation criteria and specifies their importance using 10-degree scale:

Context:
- Territory (air, land, water)
- Space (open, confined, building, underwater)

Target characteristics:
- Targets number (one, a few, group, crowd)
- Targeting (individual, group)
- Mobility (static, moving)
- Physical characteristics (protected, unprotected)

Characteristics of the contact with the target:
- Range (distance to the target)
- Coverage. i.e. area of the effect (point, area)

Effectiveness characteristics:
- Onset of the effect
- Duration of the effect.

These criteria with constant importance are applied in [2] to all scenarios and NLWs. The relative weight of a criterion represents the ratio between the criterion importance and the sum of importance of all criteria. The evaluation of a NLW for each criterion is the proportion between the NLW performance and the operational requirement (the rate to which the NLW meets the requirement) multiplied to the criterion relative weight. The total evaluation of the NLW for a scenario/operational task is the sum of evaluations for all criteria.

## *A New Approach for Evaluating the Capabilities of Groups of Similar NLWs*

On the base of [2] two methodologies are developed by the author – an Improved methodology for assessing the NLWs capabilities and a Methodology for assessing the capabilities of groups of similar NLWs, which are described in [5, 6]. The first one is intended for assessing the whole range of NLWs and can be applied to compare the capabilities of different types of NLWs, the second - for evaluating groups of NLWs with similar effects and/or equal way of delivery to the target. In terms of practice the first one is suitable to select the most appropriate types of NLWs for the given scenario and the second – to choose the most appropriate NLW of the selected type.

The methodologies are based on the general approach, scenarios, criteria and operational requirements of [2]. The Improved methodology is applied to two groups of NLWs - with chemical and with kinetic effect (hand grenades developed at IMSETHAC-BAS, hand grenades and launched munitions of leading world producers) for 5 operational tasks where these types of NLWs have best capabilities to achieve the operational goal. The results of this investigation show that products using one and the same technology have identical performance for some criteria in all scenarios. For example, the rounds and hand grenades with chemical effect equally meet the requirements of criteria target number, targeting, mobility and physical characteristics, due to the inherent features of this type of products, i.e. their performance does not depend on the design and delivery system. Proceeding from the assumption that in such cases using all the 10 criteria is not necessary and the fixed importance of the criteria does not allow clear differentiation of the NLWs capabilities, an algorithm for investigating the capabilities of groups of similar NLWs is developed [5]. The main point of this approach is selection of evaluation criteria according to the type of studied NLWs and determination of criteria importance depending on the operational task. This method is applied in [5, 6] to groups of NLWs with identical effects and different delivery methods. The results analysis shows very high correlation between the evaluations obtained by this approach, the Improved methodology and the method of [2].

The relative weights of the criteria applied in [2] and the Improved methodology for assessing the NLWs capabilities are illustrated in Figure 1.

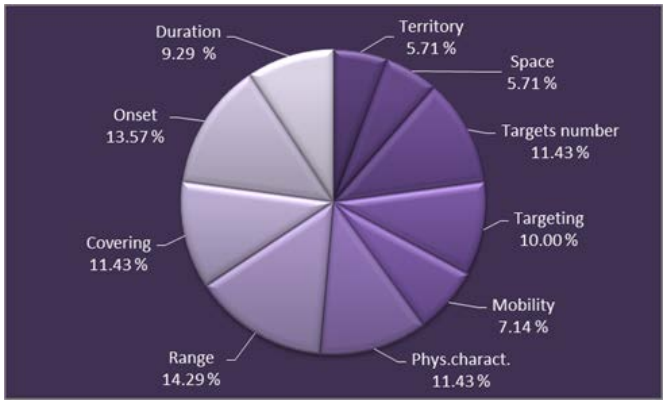


***Fig. 1**. Relative weights of the criteria applied in [2] and the Improved methodology for assessing the NLWs capabilities.*

An example with selected criteria and varying criteria importance, applied in the Methodology for assessing the capabilities of groups of similar NLWs is given in Figure 2.

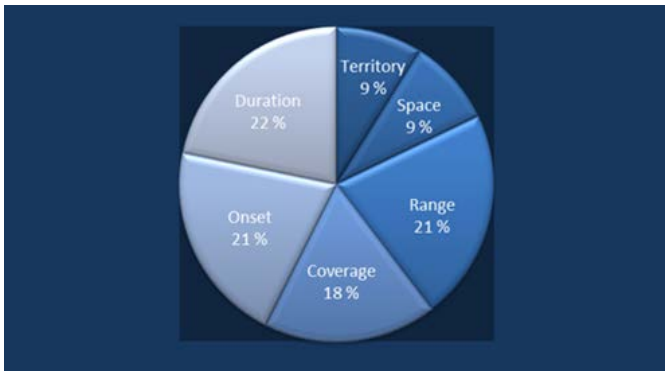


***Fig. 2**. An example with selected criteria and varying importance, respectively relative weights, of the criteria.*

It is clearly seen that elimination of some criteria leads to increasing the relative weights of the rest criteria.

## *Results from Application of the New Approach to a Group of Similar NLWs and Discussion*

This paper represents further efforts for verification the applicability of the proposed approach through evaluating a group of NLWs with identical way of delivery and different physical principles. For this purpose the capabilities of 7 types of hand grenades are studied: with teargas (CS), designated as *TGG*; "sting-ball" grenade (*SBG*); flash-bang grenade (*FBG*); smoke grenade (*SG*); flash-bang with tear gas (*FBTGG*); flash-bang sting-ball (*FBSBG*) and flash-bang smoke grenade (*FBSG*).

The products are evaluated for 4 types of operational tasks: 1) Move individuals (moving individuals/groups out or to certain area); 2) Stop individuals (prevent or impede access to certain area, stopping or changing the movement direction); 3) Degrade individuals (selective reducing of one or some functions/responses of the object); 4) Disable individuals (general reducing the most or all functions/responses of the object). Evaluation is made separately for open areas and buildings.

Three combinations of criteria importance, respectively relative weights, are used for the products capabilities evaluation (Table 1). Varying values are given in bold, the rest are equal to those used for assessing different types of NLWs (in [2] and [6]).

***Table 1**. Importance and relative weights of applied criteria*

| ***Criteria*** | ***Variant 1*** | | ***Variant 2*** | | ***Variant 3*** | |
|---|---|---|---|---|---|---|
| | *impor-tance* | *relative weight* | *impor-tance* | *relative weight* | *impor-tance* | *relative weight* |
| ***Task 1*** | | | | | | |
| Territory | 4 | 0.09 | 4 | 0.09 | 4 | 0.08 |
| Space | 4 | 0.09 | 4 | 0.09 | 4 | 0.08 |
| Range | 10 | 0.22 | 10 | 0.23 | 10 | 0.21 |
| Coverage | 8 | 0.18 | **10** | **0.23** | **10** | **0.21** |
| Onset | 9.5 | 0.21 | 9.5 | 0.22 | 9.5 | 0.20 |
| Duration | **10** | **0.22** | 6.5 | 0.15 | **10** | **0.21** |
| ***Task 2*** | | | | | | |
| Territory | 4 | 0.09 | 4 | 0.09 | 4 | 0.09 |
| Space | 4 | 0.09 | 4 | 0.09 | 4 | 0.09 |
| Range | 10 | 0.23 | 10 | 0.22 | 10 | 0.24 |
| Coverage | **10** | **0.23** | 8 | 0.18 | 8 | 0.19 |
| Onset | 9.5 | 0.22 | 9.5 | 0.21 | **10** | **0.24** |
| Duration | 6.5 | 0.15 | **10** | **0.22** | 6.5 | 0.15 |
| ***Task 3*** | | | | | | |
| Territory | 4 | 0.08 | 4 | 0.09 | 4 | 0.10 |
| Space | 4 | 0.08 | 4 | 0.09 | 4 | 0.10 |
| Range | 10 | 0.21 | 10 | 0.24 | **8** | **0.20** |
| Coverage | **10** | **0.21** | 8 | 0.19 | 8 | 0.20 |
| Onset | 9.5 | 0.20 | **10** | **0.24** | **10** | **0.25** |
| Duration | **10** | **0.21** | 6.5 | 0.15 | 6.5 | 0.16 |
| ***Task 4*** | | | | | | |
| Territory | 4 | 0.08 | 4 | 0.09 | 4 | 0.09 |
| Space | 4 | 0.08 | 4 | 0.09 | 4 | 0.09 |
| Range | 10 | 0.21 | 10 | 0.22 | 10 | 0.22 |
| Coverage | **10** | **0.21** | **10** | **0.22** | 8 | 0.18 |
| Onset | 9.5 | 0.20 | **10** | **0.22** | 9.5 | 0.21 |
| Duration | **10** | **0.21** | 6.5 | 0.15 | **10** | **0.22** |

The selection of criteria is made according the type of studied NLWs. The four criteria concerning target characteristics (target number, targeting, mobility, physical characteristics) are eliminated, in view of the fact that all studied products have identical performance for these criteria (typical to all hand grenades and not depending on their design), i.e. these criteria can be considered of inessential significance for comparing the products of this kind.

The calculated results are given in Table 2 and Figure 3 and compared to results obtained by the methodology using 10 criteria with fixed importance (relative weights).

***Table 2**. Results from the capabilities evaluation using the approach with selected criteria and varying criteria importance*

| *Tasks, spaces and groups of criteria* | | | *Capabilities valuations* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TGG** | **SBG** | **FBG** | **SG** | **FBTGG** | **FBSBG** | **FBSG** |
| ***Task 1*** | **in buildings** | variant 1 | 0.91 | 0.56 | 0.66 | 0.65 | 0.84 | 0.70 | 0.65 |
| | | variant 2 | 0.99 | 0.62 | 0.75 | 0.73 | 0.90 | 0.79 | 0.72 |
| | | variant 3 | 0.95 | 0.57 | 0.70 | 0.68 | 0.87 | 0.73 | 0.67 |
| | | *IM** | *0.92* | *0.72* | *0.78* | *0.77* | *0.87* | *0.80* | *0.77* |
| | **in open areas** | variant 1 | 0.54 | 0.41 | 0.40 | 0.34 | 0.53 | 0.42 | 0.44 |
| | | variant 2 | 0.53 | 0.44 | 0.43 | 0.36 | 0.53 | 0.44 | 0.46 |
| | | variant 3 | 0.53 | 0.40 | 0.40 | 0.33 | 0.52 | 0.41 | 0.43 |
| | | *IM** | *0.68* | *0.62* | *0.62* | *0.57* | *0.68* | *0.63* | *0.64* |
| ***Task 2*** | **in buildings** | variant 1 | 0.89 | 0.55 | 0.71 | 0.63 | 0.80 | 0.72 | 0.62 |
| | | variant 2 | 0.82 | 0.50 | 0.62 | 0.54 | 0.75 | 0.63 | 0.56 |
| | | variant 3 | 0.84 | 0.54 | 0.67 | 0.58 | 0.77 | 0.68 | 0.61 |
| | | *IM** | *0.86* | *0.67* | *0.75* | *0.70* | *0.81* | *0.76* | *0.71* |
| | **in open areas** | variant 1 | 0.88 | 0.56 | 0.65 | 0.65 | 0.82 | 0.67 | 0.68 |
| | | variant 2 | 0.87 | 0.53 | 0.59 | 0.64 | 0.82 | 0.60 | 0.68 |
| | | variant 3 | 0.86 | 0.57 | 0.64 | 0.64 | 0.81 | 0.65 | 0.69 |
| | | *IM** | *0.86* | *0.68* | *0.73* | *0.73* | *0.83* | *0.73* | *0.76* |
| ***Task 3*** | **in buildings** | variant 1 | 0.86 | 0.51 | 0.66 | 0.58 | 0.78 | 0.66 | 0.58 |
| | | variant 2 | 0.84 | 0.54 | 0.67 | 0.58 | 0.77 | 0.68 | 0.61 |
| | | variant 3 | 0.85 | 0.51 | 0.64 | 0.56 | 0.77 | 0.65 | 0.58 |
| | | *IM** | *0.86* | *0.67* | *0.75* | *0.70* | *0.81* | *0.76* | *0.71* |
| | **in open areas** | variant 1 | 0.78 | 0.51 | 0.60 | 0.54 | 0.73 | 0.61 | 0.56 |
| | | variant 2 | 0.79 | 0.55 | 0.63 | 0.55 | 0.74 | 0.65 | 0.60 |
| | | variant 3 | 0.81 | 0.57 | 0.66 | 0.57 | 0.76 | 0.67 | 0.62 |
| | | *IM** | *0.82* | *0.68* | *0.73* | *0.68* | *0.79* | *0.74* | *0.71* |
| ***Task 4*** | **in buildings** | variant 1 | 0.82 | 0.50 | 0.62 | 0.54 | 0.75 | 0.74 | 0.56 |
| | | variant 2 | 0.89 | 0.55 | 0.71 | 0.63 | 0.80 | 0.79 | 0.62 |
| | | variant 3 | 0.82 | 0.50 | 0.62 | 0.54 | 0.75 | 0.74 | 0.56 |
| | | *IM** | *0.86* | *0.67* | *0.75* | *0.70* | *0.81* | *0.80* | *0.71* |
| | **in open areas** | variant 1 | 0.76 | 0.52 | 0.59 | 0.51 | 0.72 | 0.71 | 0.56 |
| | | variant 2 | 0.81 | 0.55 | 0.65 | 0.57 | 0.75 | 0.73 | 0.61 |
| | | variant 3 | 0.76 | 0.51 | 0.58 | 0.51 | 0.71 | 0.70 | 0.56 |
| | | *IM** | *0.82* | *0.68* | *0.73* | *0.68* | *0.79* | *0.78* | *0.71* |

*IM* - values calculated by the Improved methodology*

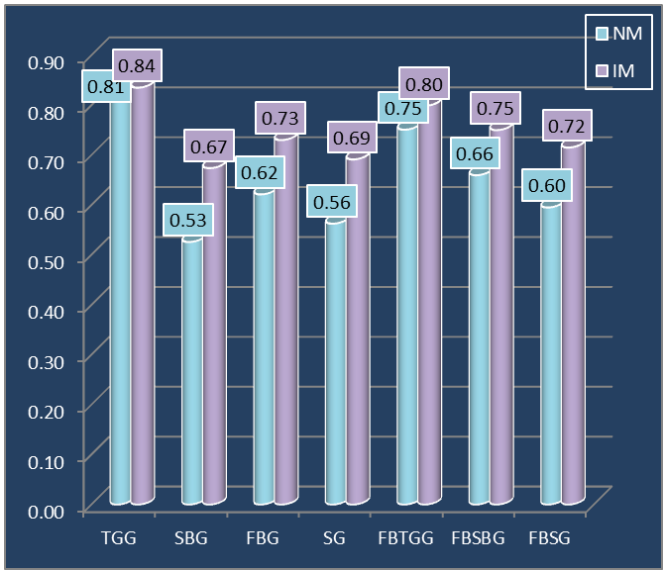


***Fig. 3****. Capabilities evaluations obtained by applying the approach with selected criteria and varying criteria importance (NM) and the approach with fixed criteria (IM) - average values from all operational tasks.*

Additional differentiation of the products capabilities is obtained through variation of the criteria importance in accordance to the specific of the concrete operational situation which leads to redistribution of the criteria relative weights. Thus the evaluations

From Table 3 is seen that for all operational tasks, with the exception of task 2 for *TGG* in buildings and open areas and task 1 in buildings for *TGG* and *FBTGG*, the results calculated by the new methodology are lower compared to these by the methodology using 10 criteria. As a result the average evaluations from all tasks by the new approach are with 9 to 14 % lower (Fig. 3). Notwithstanding, the differences between evaluations of the NLWs with best capabilities (teargas grenade and flash-bang grenade with teargas) calculated by the two methodologies are comparatively small – 3 % and 5 %. The differences between the evaluations of the highest *(TGG)* and lowest *(SBG)* scored products is 17 % by the approach with 10 criteria and 28 % by the approach using selected criteria with varying importance.

Such a differentiation, which is the purpose of the proposed methodology, is achieved mainly by reducing the criteria number. In the case with the group of hand grenades, for the criteria target number, mobility and physical characteristics, all products fully meet the requirements and have maximum evaluations of 1.00, for criterion targeting all evaluations are 0.5. When they are eliminated, the relative weights of the criteria, for which the products have worse presentation, increase and the total evaluation of products capabilities decrease. Within this group of NLWs biggest "contribution" for decreased evaluations has the criterion range (considered as most important characteristic of NLWs) – the weak point of hand thrown grenades compared to launched non-lethal munitions and other long-range NLWs.

of NLWs which have good performance for the criteria with high importance grow up while these of NLWs with inadequate performance become smaller, giving the opportunity of selecting the most appropriate NLW for the task.

Finally, eliminating the criteria which are not significant for the similar products comparison has one more positive effect – considerable reduction of the calculations number. The capabilities evaluating can be easily made using Microsoft Excel without necessity of special software.

## *Conclusions*

The following conclusions can be drawn on the base of the comparative analysis of obtained results and taking into account observations from preceding studies:

1. The proposed approach for evaluating the capabilities of groups of similar non-lethal weapons, using selected criteria depending on the type of studied NLWs and varying criteria importance depending on the operational task specific, has the following advantages compared to existing approach using ten criteria with constant importance:
   - More rapid differentiation between the capabilities of similar products (having identical physical principle of operation and/or delivery method);
   - More realistic assessment with the view to selection of most appropriate NLWs for concrete operative situations.
   - Simplified calculation procedure which makes it easy for application without special software.
2. The proposed approach for evaluation of similar NLWs using selected criteria with varying importance can be applied for evaluation of existing NLWs, as well as in the process of development (design and testing) of new NLWs with the purpose to achieve an optimum combination of characteristics providing maximum capabilities.

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