RELATIONAL RISK ASSESSMENT IN THE DESIGN OF CURRENT MILITARY OPERATIONS

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Abstract: *The aim of this article is to analyze the risk assessment process of designing the current military operations from the perspective of the scientific argumentation of the Military Risk Assessment Matrix (MRAM) methodology. The use of this matrix is an efficient and expedient practice that is heavily used by the political and military decision makers, senior or junior leaders, throughout the all levels. In this respect, the matrix structure, the quantitative and qualitative classification of the data and, finally, the graphical representation of the results are not solely based on merely empirical arguments. On the contrary, their relevance is supported by a refined mathematical apparatus that explores and processes consistent data sets using the distributions of mathematical statistics.*

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Keywords: *management; risk; matrix; military; operations; complexity.*

The relational modeling of risks under the conditions of the systemic complexity

In accordance with the theory of complexity, the international system of relations and the war can be assimilated to complex systems characterized by uncertainty and behavior at the edge of equilibrium determined by the increased sensitivity to the variation of the initial conditions. The sudden change in the state of the system and the rapid transition to a new state are capable of triggering an apparent chaotic transition (in the sense of the non-linearity of evolution laws) towards a new apparently stable but unpredictable long-term state. The multitude of constituent parts and the quantitative and qualitative complexity of their interactions are likely to disrupt the researchers' effort to identify, as objectively as possible, the main risks that have a real potential to affect the evolution of relations between states and, implicitly, to trigger a military conflict in bilateral plan, state vs. state, but also internationally.

A viable methodology of deciding the magnitude of a risk and classifying it in a global hierarchy is to define the risk as a product between its likelihood of occurrence (its probability) and its impact on the system. Of course, for its success, it is important to use a common risk assessment scale. In this sense, we consider the risk as being the possibility of losing something valuable evaluated against the possibility of winning something valuable. Managing this uncertainty about the outcome of an action /state is the stake for the decision model based precisely on this risk assessment. For this reason, the risk calculation is based on multiplying the probability of producing an event with the impact of its occurrence. In most

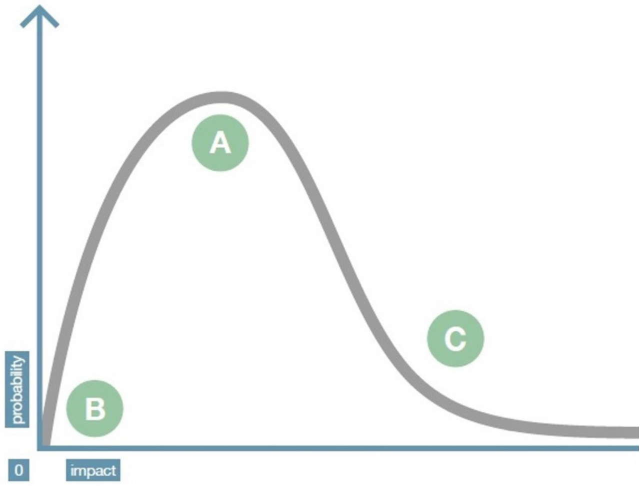

Figure no. 1. The probability density function of a risk based on its impact[1]

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[1] Source: Pamlin Dennis and Dr Armstrong Stuart, *Global Challenges 12 Risks that threaten human civilisation,* (Stockholm: Global Challenges Foundation, 2015), p. 31, accessed 07.12.2017, https://api.globalchallenges.org/static/wp-content/uploads/12-Risks-with-infinite-impact.pdf

cases, the impact is measured in economic terms, with the possibility of statistical representation, but more subjective representation such as the human suffering is possible.

Thus, the use of probability allows us the graphical representation of the impact function distribution, identifying three important areas, as it is represented in Figure no. 1.

In principle, the field of possible outcomes is superiorly bounded by the distribution curve but also in this case we can also distinguish three areas of interest: *area A* represents the most likely impact area, *area B* describes the correlation between the minimum impact and its probability that tends to zero and *area C* shows that despite the likelihood of occurrence is extremely low, however, the effects are extremely severe (infinite impact).

For the complex systems, this *area C* is of interest because in this the evolution of risk exceeds the range of manageable uncertainty and penetrates into the seemingly chaotic behavioral area. It is therefore important to manage the risks in areas *A* and *B* as well as to identify (recognize) the transition conditions to the *area C* in order to act effectively in order to avoid this transition.

This is a simplified approach for an intuitive understanding of a much more complex field that is scientifically argued by complicated mathematical computations of probabilities and statistics. Rigorous risk modeling can be found in the financial, banking, insurance, and procurement markets. The sufficient amount of data with which these domains operate, makes it possible to structure and analyze them using statistic distribution functions and models from the probability theory. In practice, through regulatory measures, at the international and national level, are imposed Operational Risk (OR) models which are designed to regulate the exposure of the capital to risk. That is in order to reduce to acceptable limits the financial losses and, ultimately, to avoid the major financial crises.

One of the most sophisticated and used models is the AMA (Advanced Assessment Approaches) that allows banks to implement their own internal rules and procedures for managing financial capital OR using imposed indicators.

Thus, an important indicator is Capital Charge (CC), which sum Elapsed Loss (EL) and Unexpected Loss (UL):

$$CC_{AMA} = EL+UL \quad (1.1)$$

But the application of formula (1.1) is not simple just because of the difficulty of a reasonable estimate of the unexpected losses. For their modeling consistent data sets are needed for periods of at least 3 years, but also an appropriate mathematical model that shapes the distribution of two independent random variables: *frequency* of occurrence and *severity* of losses (see Figure no 2)

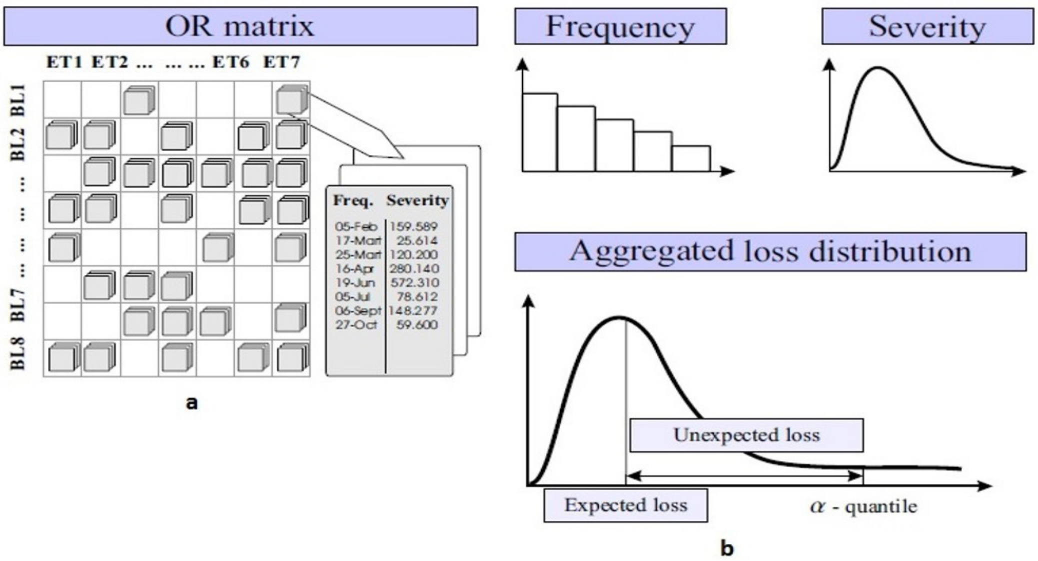

Figure no. 2. Loss Distribution Approach (LDA)[2]

[2] *Source*: Manic Ivana, *Mathematical Models for Estimation of Operational Risk and Risk Management*, master thesis, University of Mathematics Prirodno, Novi Sad, Serbia, 2007, p.30, accessed on 17.02 2018, http://people.dmi.uns.ac.rs/~natasa/ivana.pdf

In Figure 2a we can observe that the definition of a risk assessment matrix is based on the mathematical modeling of the statistical distributions of the two stochastic variables. In Figure no. 2b it can be noticed that the loss distribution function does not follow a normal Gaussian distribution due to the curve asymmetry in relation to the mean value (*m*). Of course, a particular importance in the study of the operational risk management is played by the determination of the inflection point's $m-\sigma$ and $m+\sigma$, where σ is the standard deviation. The tail of the curve, which tends to + ∞, approaching the X axis without touching it, captures the potential of the unanticipated risk of evolving into the uncontrollable area of *infinite impact*.

Therefore, the risk distribution, which we note *Gij*, represents an aggregation of the distributions of the two independent variables, the *frequency* and *severity* of the risk, being a function of the distribution of the independent random variable *Lij*, which is the total cumulative loss, also known as the Loss Distribution Approach (LDA).

$$G_{ij}= P(L_{ij} \leq x)= \begin{cases} \sum_{n=1}^{\infty} p_{ij}(n) F_{ij}^{n}(x), & x > 0 \\ p_{ij}(0), & x = 0 \end{cases} \quad (1.2)$$

where:

G_{ij} – the distribution of the variable *Lij* which represents the cumulative distribution function of the distributions of the two variables *Xij*, the severity of the losses, and *Nij*, the frequency.

Fij(x)=P(Xij≤x)

and is the distribution function of the variable *Xij*, the severity of the losses

$p_{ij}(x)$ – is the probability function for the *Nij* variable, where

$$p_{ij}(x) = P(N_{ij} = x) \quad 1.4$$

In this context, the total loss CC (capital charge) is a sum of expected losses (ELij) and unexpected loss (UL_{ij}):

$$CC_{ij} = EL_{ij} + UL_{ij} \quad 1.5$$

The calculation of the expected component *ELij* can be considered, by simplification, as the mean value of the independent random variable *Lij*, which represents the total loss, and thus we have:

$$EL_{ij} = E(L_{ij}) = \int_{0}^{\infty} x * dG_{ij}(x) \quad 1.6$$

Of course, in the case of an asymmetric distribution instead of the *mean*, the *median* value can be considered, this being recommended in cases of an *asymmetry (skewness)* $A \neq 0$ or a tilt index $T > 3$ (*flattening* or *kurtosis*). The *skewness* index *A* represents *the third central moment* of the distribution and shows the asymmetry of the data compared to the *mean*, while the *kurtosis* index *T* represents the fourth *central moment* and measures the distance from the *mean*, namely the *tail* of the curve. Thus, for a random variable *X*, the two coefficients can be defined according to the mean *m* and the standard deviation σ as follows:

$$A = \frac{E((X-m)^3)}{\sigma^3} \quad (1.7)$$

$$T = \frac{E((X-m)^4)}{\sigma^4} \quad (1.8)$$

In the case of a normal distribution, the asymmetry index is $A = 0$ and a positive value indicates a right-hand concentration of the probability distribution. Since for the normal distribution the flattening index is $T = 3$, a higher value indicates a consistent distance from the mean, in our case from the manageable area of the risk, therefore the unanticipated component will disrupt uncontrollably to the infinite impact area (*figure no. 3*).

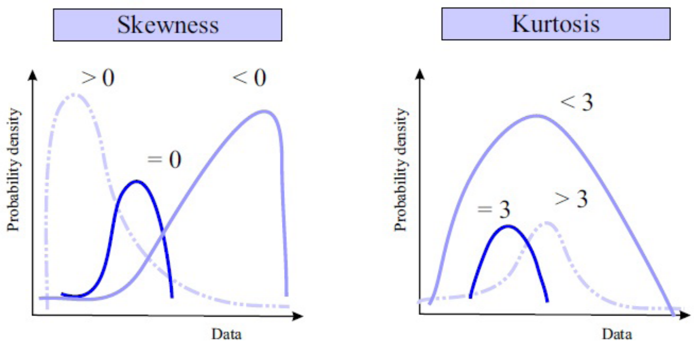

Figure no. 3. Skewness A and kurtosis T coefficients[3]

For frequency, the most used distributions are *Poisson* and *Binomial*, both being discrete

[3] Source: Manic Ivana, *Mathematical Models for Estimation of Operational Risk and Risk Management*, master thesis, University of Mathematics Prirodno, Novi Sad, Serbia, 2007, p.36, accessed on 17.02 2018, http://people.dmi.uns.ac.rs/~natasa/ivana.pdf

parameter distributions that describe properly the number of occurrences of a random event within a predetermined time interval. Parameters of these distributions represent *intensity rates* and are calculated by *mean (m)* and *variance (σ – standard deviation)* of the distributions. If the frequency of loss is considered in a *continuous* (non-discreet) approach, then the frequency distribution modeling can be done through a *Poisson process*.

Regarding the statistical modeling of *loss severity data*, most cases involve positive asymmetry and high flattening coefficients. Thus, in this situation it is necessary to use distributions that have the most pronounced *tails*, as the losses can be sampled into three large categories: *small*, *medium* and *very large*. Typically, losses or impacts falling within the first two, *small* and *medium* are characterized by high frequency and reduced severity. Instead, the third category, *very large*, is generated by low frequency events but with a large impact, with potential of the infinite impact. This hypostasis is described by the distribution queue. In view of these considerations, the *LogNormal distribution* is used for the modeling of the *severity*, although models based on other distributions such as *LogLogistic*, *Weibull*, *Pareto* or *LogGamma* can be found in the literature. The choice of a particular distribution is determined by the specificity of the data used, taking into account quantitative considerations such as their number but above all qualitative ones, such as their homogeneity, degree of dispersion or their convergence.

Summarizing the statistical modeling of the two variables of risk, *frequency* and *severity*, we consider that the two are described by different distribution functions that are aggregated in a loss distribution (LDA – Loss Distribution Approach) that gives us an estimate of total losses.

Constraints and particularities of the risk assessment in military operations

The characteristics of military operations, which involve time constraints, limited or unrelated (as well as current) statistical data, uncertainty and rapid transition phases that are difficult to predict, all make it impossible to apply mathematical calculations to operational risk assessment.

However, we consider it extremely useful to present the mathematical modeling of the risks whereas we have the justification and the understanding of the structure of the risk assessment matrix according to *frequency* and *severity*. We can interpret correctly the graphical representations that shape the global risks in the works from the literature concerning the global strategy and security.

Therefore, unlike the mathematical modeling based on the *frequency* and *severity* of risks, the expedient modeling of risks in military terminology involves coding and representing the likelihood of occurrence (*probability*) and the *severity* of the risk impact in the form of a risk matrix that provides a homogeneous scale for a risk hierarchy: *Extremely High*, *High*. *Moderate* and *Low* (Figure no. 4).

In this methodology, the probability quantifies on 5 levels (*frequent*, *likely occasional*, *seldom* and *unlikely*) the possibility of occurrence of an event which constitutes a risk for the military operations. The assessment of the level is based mainly on the information held at the time of the analysis (mission, COA) but also on the experience of the commanders and their staff.

Risk Assessment Matrix						
Severity		Probability				
		Frequent A	Likely B	Occasional C	Seldom D	Unlikely E
Catastrophic	I	E	E	H	H	M
Critical	II	E	H	H	M	L
Marginal	II	H	M	M	L	L
Negligible	IV	M	L	L	L	L
E- Extremely High), H- High. M-Moderate and L- Low						

Figure no. 4. Risk Assessment Matrix[4]

[4] Source: *US Headquarters Department of the Army, FM 5-19 Composite Risk Management, august 2006*, p. 1-8, accessed on 22.02.2018, http://cdm16635.contentdm.oclc.org/cdm/ref/collection/p16635coll8/id/55440

In terms of severity, this is represented on four levels (*catastrophic*, *critical*, *marginal* and *negligible*) that expresses the impact that the production of a risk may have on the power of fighting, on the forces and finally on the success of achieving the objectives of the military operation

After the assignment of a quantified value for the probability and severity of each identified risk, using the risk matrix from the Figure no. 4 we can code each combination of *probability & severity* into a defined level of risk, standardized at the organization or community level:

- *Extremely High (E)* – represents the loss of ability to achieve the objectives of the operation in case of occurrence of the risk. This encodes the combinations of a *frequent* probability with a *catastrophic* impact (*AI* class risk) or *critical* (*AII* class risk), or a *likely* probability with a *catastrophic* impact (*BI* class risk). The decision to continue the action in this case must be evaluated against the value of the potential gain in case of success;
- *High (H)* – encodes a wider set of combinations of risk *frequency & severity*, indicating mainly severe degradation of capabilities and capacities to achieve the desired goals in case of the risk occurrence. As in the previous case, the decision to continue an action must be evaluated against the value of the potential gain in case of success;
- *Moderate (M)* – expresses the reduction of the capabilities of achieving the objectives according to the design of operation or the performance standards. It balances the entire spectrum of combinations of risk *frequency & severity*, starting from *frequent & negligible* (AIV class risk) to *unlikely & catastrophic* (*EI* class risk);
- *Low (L)* – Early losses in the event of these risks have a minor or negligible impact on the success of the operations, the probability of *critical* loss being *unlikely* (*EII* risk class), while *marginal* losses are *seldom* (*DIII* risk class) or *unlikely* (*EIII*). So the anticipated and associated losses to these risks have a minimal impact on the success of the operations.

This efficient methodology responds to the operational requirements and time constraints specific to the military operations. For the politico-strategic level a model is used that distinguishes among four levels of risk probability, having associated predetermined percentage ranges: *highly unlikely* (0-20%), *unlikely* (21-50%), *likely* (51-80%) and *very likely* (81-100%)[5].

The *Risk Judgment* phase, subsequent to *Problem Framing* and *Risk Assessment* ones, places the risks into a *Risk Evaluation* category. It has a particular importance as the decision-maker has to decide whether the risk is *acceptable* or *unacceptable*. An *acceptable* level indicates that the risks are rather low and do not require further reduction measures, while an unacceptable level means that the risk is too high for the operation to be continued without the risk reduction measures.

The last step of the risk management model is centered on the design, implementation and monitoring of risk decisions, in which sense the decision maker has the choice between:

- *accepting* the risk – it involves making the decision, being informed of its existence, continuing the activity without taking further measures to reduce it;
- *prevention* of the risk – it supposes the cancellation of the activity which will cause an unacceptable risk;
- risk *reduction* – it means the implementation of measures designed to reduce the likelihood or severity of the risk;
- *transferring* risk – it consists of initiating actions to change the place and time where/when the risk will occur, and as much as possible whom and how it will be affected.

CONCLUSIONS

Military operations are characterized by uncertainty, which determines the impossibility of a long-term predictability, but also the lack of consistent and timely data sets of information that could be statistically modeled. In this context, the use of the risk assessment matrix is the only viable risk management solution. It involves identifying them, assessing them according to the likelihood of their occurrence and severity, quantification of levels and the risk classification in pre-established categories, and ultimately analyzing whether they are acceptable or not. Based on this distinction the decision maker determines the appropriateness and scope of the measures to be taken in order to manage the risks.

[5] US Chairman of the Joint Chiefs of Staff Manual, „*Joint Risk Analysis – CJCSM 3105.01*", October 2016, p. C-4, accessed on 22.02.2018, http://www.jcs.mil/Portals/36/Documents/Library/Manuals/CJCSM%203105.01%C2%A0.pdf?ver=2017-02-15-105309-907

But matrix structuring, grading and graphical representation of data, as well as analysis of results has a rigorous mathematical justification based on the distributions of the probability functions from the mathematical statistics.

In the military environment for the *strategic* risk analysis (risks to national interests) and to those *strategic military* ones at the politico-military level, US experts use, according to JRAM Risk Analysis Methodology (Joint Risk Analysis Methodology), a process that has three main components (*Risk Appraisal*, *Risk Communication* and *Risk Management*) and is carried out in four distinct steps (*problem framing*, *risk assessment*, *risk judgment* and *risk management*) [6].

This methodology implies that it deliberately omitted the zero-risk risk categories, because even if a risk-free situation is desirable in developing a strategy or designing a structure of forces, costs would increase exponentially and unsustainably imbalance the trinomial *objective-means-resources* formula. Resources are finite, so commanders have to spend time and energy for an improved risk management.

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