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An operations research approach for combat readiness assessment in the military system

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Abstract
Combat Readiness (CR) is the preparedness of combat systems to accomplish some organized or assigned tasks. Measures of both concrete and abstract aspects of combat command are used to evaluate the battle preparedness of military forces. The mathematical model and equations for calculating combat readiness have been evaluated, and they show that many methods have been employed to operationalize their respective notions. The goal of this work is to evaluate the effectiveness of previously constructed models using Mankilik's Lambda technique (1999). The simulation model was utilized to assess performance, and the results produced indicated good promise for assisting military commanders or decision makers in making quality decisions.

Keywords: Combat readiness, psychological readiness, morale, fitness assessments, peace-support operations, λ-factor, lambda simulation

1. Introduction
The phrase "combat" or "engagement" is used to describe the many tools and armaments used to support, undermine, or pursue a cause or goal. Combat readiness is described by [27] (Prokhorov, 1970) as the level of readiness of each branch of the armed forces (troops) to carry out the combat missions delegated to it. However, battle readiness is described in the discipline of psycho-sociology as a psychological quality in terms of a soldier's decision or level of commitment to, and persistence in enacting, a certain course of action [7] (Gal, 1986). The combat readiness evaluation was created as a comprehensive fitness test with the goal of simulating for military personnel the physical demands of a battle environment [13] (Moore, 2022). Military personnel must continuously maintain battle preparedness and make sure they are competent of carrying out military activities when necessary. Maintaining their battle preparedness is essential if they are to continue serving and defending the country [9] (Fook *et. al.*, 2014). "Hardiness" is the name of one of the psychological concepts that explains how a personality can resist the impact of diverse stimuli [2, 5, 8, 10, 11], (Bartone, 2006; Florian *et al.*, 1995; Kobasa, 1979; Maddi, 2002; Maddi & Khoshaba, 1994).

Literature Review
Psychological Readiness: Using the techniques of semantic differential, peer review, and factor analysis, [18] (Prykhodko *et al.*, 2021) constructed a model. The model can be used to predict military personnel's behavior under risky circumstances, train them professionally and psychologically, and select them psychologically. It can also be used to develop post-deployment psychological support strategies. In order to quantitatively and qualitatively define the characteristics of the researched notion of "psychological readiness of military personnel to take risks" as its representation in an expert's mind, the semantic differential approach [15, 23] (Osgood, 1952; Stoklasa *et al.*, 2019) was utilized. According to the researchers' findings, a soldier's psychological readiness for risk in a combat deployment is formed mostly by their sense of patriotism [3, 14] (Delahaij *et al.*, 2006; Myrseth *et al.*, 2018). Hardiness serves as the foundation for military personnel's psychological readiness to take action and overcome challenges in risky situations (uncertainty, immediate danger to one's health or life, absence of specific guarantees of success) [18] (Prykhodko *et al.*, 2021).

Measuring Combat Readiness
Multiple regression analysis, mathematical modeling, and simulation were used by [9]**.**

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(Fook *et al*., 2014) to analyze the capability component, which reflects the organization's assets and resources, the morale component, which reflects human needs, and the quality of life component, which reflects the soldiers' level of satisfaction with their lives. Each of the variables and factors in the model has parameters that are significantly identified by the outcomes [1]. (Andrews and Shambo, 1980) emphasized that the material and morale characteristics of a military force can be used to sum up the capability of a military organization. As an alternative, [26] (Voith 2001) defined functionality as the level of readiness of a unit to carry out the task for which it is organized or constructed. Research has also shown that ability, particularly in military organizations, not just infrastructure capabilities but also army morale when carrying out a military operation [7] (Gal, 1986). Based on these academic studies, it is clear that the armed force's performance is still not fully evaluated because soldiers' morale and other intangible components of combat strength are not taken into account.

Fitness Assessments
[13] (Moore, 2022) such fitness evaluations fall short of keeping up with the physical demands of military operations. It would be more accurate to determine if soldiers are prepared for the demands of battle if a fitness test that is more specifically geared toward warfare was developed. According to [19, 25] (Rayson *et al*., 2000; Van *et al*., 2000), the creation of more combat-specific fitness tests would improve the accuracy of determining whether soldiers are prepared for the demands of battle [22, 20]. (Sharp, 2017; Rohde, 2015) details the creation of multiple test batteries intended to evaluate all facets of "combat fitness." The US Army created the "Occupational Physical Assessment Test" (OPAT) as a pre-employment fitness test to evaluate the military-specific fitness standards of prospective soldiers before they join. This test is followed by the "criterion measure task simulations" (CMTS) assessment at the conclusion of basic training. The goal of developing a complex combat-specific fitness evaluation to evaluate the probable fitness components needed in a wartime operational situation was stated in [13] (Moore, 2022). The results may have implications for the use and dependability of the combat readiness assessment. Comparison to the validity of earlier military fitness tests using various protocols.

Peace-Support Operations
The researcher used a method of factor analysis that prevents the development of arte factors, according to the [21] (Schepers, 1992) study. 2007's Piet and Karel There are many different building components that make up confidence, social trust, and morale. As a result, this mental state is thought of as a multidimensional construct. An essential requirement for efficacy and efficiency during deployment for peacesupport activities is this multidimensional construct. According to the paradigm of [4] (Feigl, 1970), behavioral indicators for peace-support activities were employed to connect the theoretical notion with empirical variables [24] (Swart *et al*., 1999). High face and content validities were established as a result of this [16].

(Piet and Karel, 2007) study was to explore the concept of "combat readiness" through the conceptualization and measurement of Combat Readiness within the South African military context with specific emphasis on peace-support operations. The theoretical model was also presented to experts in the field of peace-support operations. It was decided to create a psychological model of battle preparation. The Peace-Support Operations Questionnaire (PSOQ), which has 242 elements, was created based on this paradigm. Therefore, additional research into the combat preparedness sector appears to be essential for the SANDF to operate at its best during peace-support missions.

Methodology
The Lambda (λ) Method
The Lambda (λ) method is an extension of the C-rating technique developed by [6] (Frank *et al*. 1968), in summarizing the C-rating technique, remarked that the C-rating techniques was developed within a purely naval – environment. The C-rating technique identified and reported combat readiness rating (C-rating) for naval ships under 4 major resources areas, namely, supply, equipment and training. Four grades were identified, namely;
C-1 Fully Ready
C-2 Substantially Ready
C-3 Marginally Ready
C-4 Not Ready

The Conceptual Framework of the Lambda (λ) Method
The Lambda (λ) method for combat readiness assessment for naval fleet is largely based on the Prevailing Static Condition (PSC) of sub-resources which is called the Φ - state of sub-resources and the criticality position of sub-resources (CPSr) with respect to a specific task which is called the λ factor (Lambda factor) [12]. See Mankilik (1999)

The Φ - State
In the analysis of the Φ - state, the possible prescribed performance standard (PPS) that a subresource can assume the prevailing condition to be Excellent, Good, Fair or Poor. Then, at any given time, each sub resources can be in one and only of the states, namely, Excellent, Good, Fair or poor to mean it is in Φ_0, Φ_1, Φ_2, Φ_3, respectively.

Table 1: Analysis of the Φ - state (Mankilik, 1999)

PPS	Φ - STATE
Excellent	Φ_0
Good	Φ_1
Fair	Φ_2
Poor	Φ_3

Considering the i-th sub resources in F_h, this resource may be reflected on all or just some of the ships. Ships of the same type will normally carry the same type of sub resources. The matrix representation of the Φ_1 – state of the resources for F_h is given below:

Table 2: The matrix representation of the Φ_1 Source: Mankilik Ph.D. Thesis 1999

$S_i L_1$	S_1	S_2	...	S_M
L_1	$\Phi_{(1.1)}$	$\Phi_{(1.2)}$	...	$\Phi_{(1.M)}$
L_1	$\Phi_{(2.1)}$	$\Phi_{(2.2)}$	...	$\Phi_{(2.M)}$
. . .	. . .	. . .	. . .	. . .
L_N	$\Phi_{(N.1)}$	$\Phi_{(N.2)}$	...	$\Phi_{(N.M)}$

The structure is a matrix of type (N.M). $\Phi(i.j)$ is the entry i.e. Φ-state of the i-th sub-resource in the j-th ship. This means we are examining some characteristics of interest of the i-th. Sub-resources with respect to the j-th ship.

Result

The body of literatures on the measure of combat readiness indicates that there are different models and approaches used to measure combat readiness. The reviewed mathematical model and formulae used for measuring combat readiness indicate different approaches have been used to operationalize their respective concepts for the measure of combat readiness. Different constructs and various domains and sub-domains are being used for different models for measuring combat readiness. It is also used to determine the gap of knowledge and to identify the best approach to bridge the gap in the current measure of combat readiness in military forces. The result obtained showed good promise to help military commanders or decision makers take quality decision and the simulation model was used in evaluating performance.

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