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Lambda (λ) method simulation for navy system combat readiness assessment

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Abstract
National military organizations must evaluate both their operational preparedness and, increasingly, their combat system readiness. A framework for simulating the λ-method developed by (Mankilik, 1999) that finds the criticality elements of the sub-resources with regard to a defined task or goal is what the current research efforts are attempting to do. The simulation framework created has provided some understanding of the preparedness issue. In our test case, two Squadrons namely, Frigate Squadron and Fast Attack Craft (FAC) comprising of 8 ships and 5 ships respectively, were considered. Of the 44 platforms in the Nigerian Navy, 8 ships formed the frigate squadron, 5 ships formed the fast attack craft squadron. The result obtained showed good promise to help the decision. The results obtained showed great promise for assisting the decision-maker in making quality choices, and the simulation model that was used to assess performance in four areas-range, endurance, lethality, and survivability-could also be applied to other factors in the majority of a given theatre of operation.

Keywords: C-rating, simulation, combat readiness, assessment, λ-factor

1. Introduction

The Nigerian Navy (NN) was founded in 1956 to carry out Nigeria's constitutional obligation to ensure its maritime defense (Galdorisi, 2006) [2]. The NN carries out traditional naval duties in order to accomplish this mandate as well as activities that are occasionally given to it in order to further stated national interests (Galdorisi, 2006) [2]. It would seem, though, that the NN merely theoretically addresses the aforementioned problems. This opinion is based on the assumption that the NN's diminishing operational efficiency may indicate a disregard for established standards. The NN is rapidly nearing a state that might be referred to as "rush out," which is characterized by a lot of broken and outdated equipment (Shiyanbade, 1994) [3].The essential documents appropriately handle the subject of a ship's shelf life, planned maintenance schedule, readiness, availability, mean time between failures, mean time to repairs, and pre-joining training, which taken together should account for the effectiveness of the service (Nathman, 2016) [4].

The issues of readiness evaluation are quite critical, especially when it relates to military combat readiness (Mankilik, 1999) [1]. The necessity to evaluate a fighting unit's readiness for the mission and roles for which it was created may be as old as battles between peoples and nations. Numerous studies have examined readiness evaluation, particularly as it relates to military combat units from a logistics perspective (Bello, 2008) [9]. Others examined it from a maintenance and dependability standpoint, and some looked into it from a labor perspective (Mankilik, 1999) [1]. According to the US Army Field Manual 100-1, a soldier's mental state is just as important to a military force's readiness as their training and equipment (Akinyemi, 2003) [17]. In this research project, we are particularly interested in looking more closely at the numerous readiness evaluation techniques that have been documented.

1.1 Statement of the Problem

Every mission along this operational continuum requires a discrete set of capabilities drawn from particular tasks, and military planners have long battled to build a system that assures military capacity exists at each mission. Determining the fleet's preparedness or capability to complete the specified task or mission is the problem's stated objective. To create a general-purpose simulation model for readiness assessment, we would particularly like to provide a framework for scenario simulation (GPRASM).

1.2 Aim

The aim of this research is to simulate the Lambda (λ) approach for assessing battle preparedness (Mankilik, 1999) [1] and to produce a variety of scenarios that can assist a leader in achieving a more solid support system and increased system capability and availability.

1.3 Basic Concepts and Definitions:

1. λ-factor (Lambda factor) is the prevailing static condition (PSC) of subresource which we refer to as the ϕ state of subresource and the criticality status of the subresources with respect to a specific task.
2. Readiness is the preparedness to perform a task or embark on a mission.
3. Combat or engagement is the term used to define the various machinery and arsenal to defend, offend or prosecute a campaign or task.
4. Combat Readiness (CR) is the preparedness of combat system to accomplish some organized or assigned task.
5. Combat Readiness Ratings (CRR) are the various levels of preparedness employed or deployed by combat forces for the attainment of some task or mission. Such ratings could be conducted at aggregate or disaggregate level.
6. Task are any duty, mission, job or assignment that requires resources to accomplish.

2. Literature Review

2.1 Historical Background

The C-rating technique was created to evaluate preparedness using sub-resources. Each ship's combat readiness (C-rating) is reported by the Pacific Fleet Operational Status (OPSTAT) system under eleven sub-resources that include personnel, supplies, equipment, and training, according to (Frank *et al.*, 1968) [5]. The Status of Resources and Training System (SORTS), developed by (Penny *et al.*, 1996) [6] has historically been used to gauge the readiness of armed forces at the unit level. Assessment of readiness has changed throughout time; up until recently, controlling readiness was almost identical with managing input. (David *et al.*, 2004) [7] rated individual units according to how much training they completed.

2.2 Military Readiness

Creating a thorough assessment technique was one of the biggest challenges in evaluating readiness. (Gaver, 1976) [18] is more specifically concerned with the issue of rotating maintenance staff in order to improve fleet readiness and availability. He points out that there is good cause to manage the assignment of such employees as prudently as possible inside the military due to the rising costs of recruiting and training high-quality support workers. He stated that having sufficient skilled maintenance and operating personnel will boost equipment availability and, as a result, force effectiveness.

The Resources and Training System is the main tool the DOD uses to assess preparedness (SORTS). This system assesses the degree to which troops are equipped and prepared to carry out their tasks during a war. The C-rating metrics are arguably the most often mentioned readiness indicators. However, (SORTS) statistics are necessary for determining the readiness of the unit. Other techniques exist, including GSORTS, ESORTS, and Mankilik (1999) [1] 's LAMBDA (λ) approach. The Lambda (λ) approaches will be the subject of our forthcoming report and the purpose of this research investigation. There are many ways to evaluate readiness, from ingenious mathematics to individual judgment. Actual measurements have ranged from simple "yes" or "no" questions to complex probability statements and indexes, among other things (Barzily *et. al.*, 1974) [14].

2.3 Current Trend

2.3.1λ - Approach

The Prevailing Static Condition (PSC) of resources or subresources, also known as the Φ-state of the resources or subresources, and the criticality status of the resources or subresource with respect to a specific task, also known as the λ- factor, are the two concepts that form the basis of the Lambda (λ) method for combat readiness assessment **(**Lambda factor).

2.3.2Φ - State Concept

F_n is any given naval fleet, then F_n comprises of n number of ships. Suppose M is the total number of ships in F_n, then $_{Fn}$ will most probably be made up of ships of different types, such as Frigates, Destroyer, Submarine, Covert tees, etc.

Let $S_h \in F_n$, the S_h has four – resources areas (RA), namely

- Operation
- Logistics
- Manpower
- Engineering.

Each (RA) will be composed of sub resources. Each sub resources will be in some functional state defined by quality etc, which might meet the Prescribed Performance Standard (PPS). The attained PPS at the time of evaluation is what we refer to as the Φ - state or Prevailing Static Condition (PSC) of the sub resources at that point in time. It is worthy of note that sub resources that are relevant to the accomplishment of a particular task contributes to fleet readiness (Mankilik, 1999) [1].

3. Methodology

3.1 The Lambda (λ) Method

The Lambda (λ) method is an extension of the C-rating technique developed by (Frank *et al.*, 1968) [5], 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

3.2 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). See Mankilik (1999) [1].

3.3 The concept of Resource Criticality (RC)

The concept of resource criticality or the λ - position which is called the λ - factor as it relates to readiness via sub resources is rotted in the Resource Requirement Question (RRQ). Mankilik (1999) [1]. Is the in question required for the identified task or mission? If the answer to the RRQ is "yes", then the sub resource is a readiness candidate (RC) or indicator. Otherwise, it is inconsequential in the matrix of readiness for the identified task regardless of its Φ - it is inconsequential in the matrix of readiness for the identified task regardless of its Φ - state standing i.e. regardless of Prevailing Static Condition (PSC).

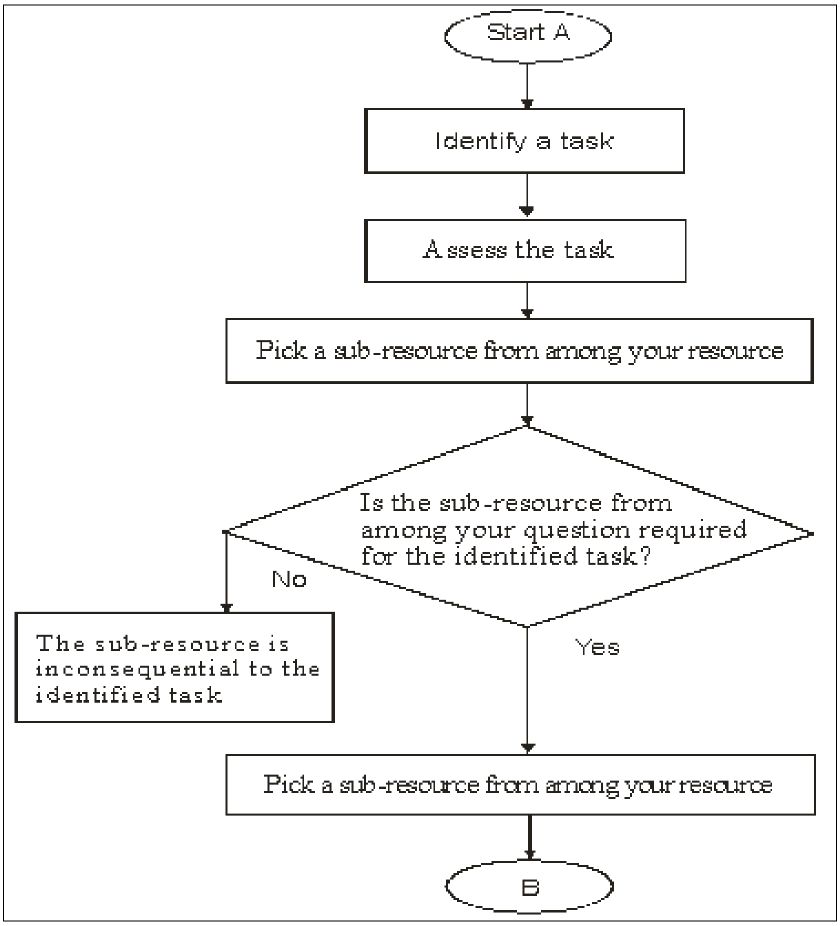
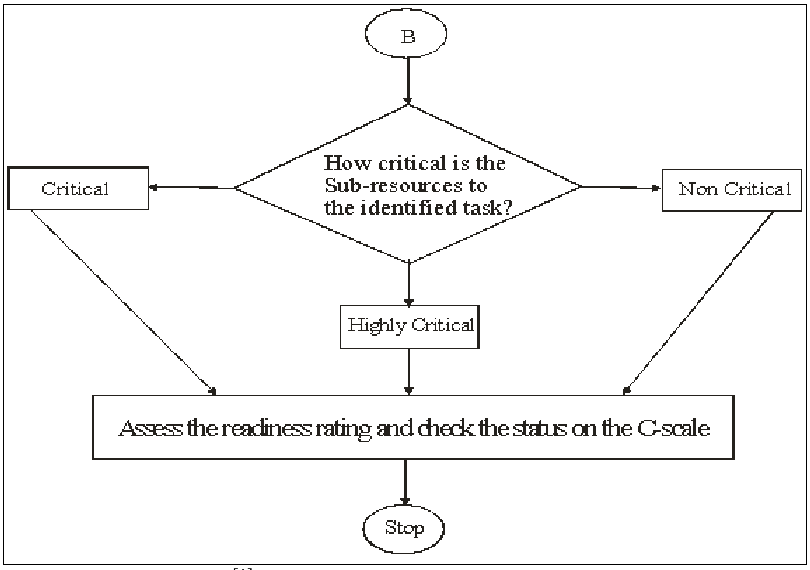


Fig 1: Flow-Chart for the Determination of Readiness Candidates

Having identified the sub-resource as a readiness candidate, the answer to RRQ is "yes" then what is the criticality question (CQ)? How critical is the sub-resource (readiness indicator) to the accomplishment of the identified task? The flow chart shows the process of identifying a readiness candidate until you get to the last point.



Source: Mankilik (1999) [1]

Fig 2: Shows the Flow Chart for Determining Criticality Level of a Sub-resource

3.4 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

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

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	$\Phi_{(N.1)}$	$\Phi_{(N.2)}$	…	$\Phi_{(N.M)}$

Source: Mankilik Ph.D. Thesis 1999 [1]

The structure is a matrix of type (N.M). Φ(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.

3.4 Mathematical Representation of the Simulation Model

Measure of performance (MoPs) for a platform/modification/role i.e. MoP_{pmr} is defined as a function of the variables:

a. Range performance (R_p)
b. Endurance performance (E_p)
c. Lethality performance (L_p)
d. Survivability (S_p)

Where
pmr is the platform/modification/role combination.
These are represented in the matrix MOP pmr

$$MoP_{pmr} = \begin{bmatrix} R_p & E_p & L_p\, S_p \\ R_m & E_m & L_m S_m \\ R_h & E_h & L_h\, S_h \end{bmatrix} \quad (1)$$

The weighting of the relative importance of each MOP in each threat environment where Wr is vector weighted relative importance of MoP.

$$W_r = \begin{bmatrix} W_R \\ W_E \\ W_L \\ W_S \end{bmatrix} \quad (2)$$

The threat environment in a given time frame (year) T is

$$T = (T_p \;\; T_m\, T_h) \quad (3)$$

The measure of effectiveness for each environment and time unit MoE is a product of MoP and the waiting W.

$$MoE = MoPW \quad (4)$$

When we pre-multiply by the threat vector T. we obtained the measure of capability for a given platform/modification in a given role and time frame Cpmr.
That is;

$$C_{pmr} = T\ MoE\ T_{pa} \quad (5)$$

We can create a separate file for the number of available platforms in the corresponding *role/ mod/* year combinations as may be determine by the Fundamental inputs to capability (FICs) and so total capability will be product of these.

4. Data simulation framework and analysis

We shall present data simulation and then attempt to carry out some analysis that will lead to the desired measures of performance for each resource.

- Data Simulation Framework
- Presentation of simulation results
- Analysis of result

4.1 Data Simulation Framework

Let's consider that the Nigerian Navy has 100 platforms in its arsenal. The fleet is set up or organized so that a specific goal or purpose can be accomplished. The examination into the hypothetical fleet, Fh, revealed that 8 of the platforms are undergoing substantial repairs, 13 platforms were being updated to modification state X1, and 5 platforms were being modified to X2. Systems X1 and X2 are weapons. Three platforms were out of service and in need of maintenance. 9 platforms could not be used because of routine operations, and 6 platforms could not be deployed because their deployment time was about to expire. A total of 12 platforms were deployed during the training exercise. 44 platforms were then made available to complete a specific mission or assignment.
The mission calls for the Navy to carry out policing duties, sea control, sea command, maritime interdiction, operations against the shores, rescue operations, and the territorial waters, as well as ward off any external aggression from neighboring countries, as it did in the case of the Bakasi peninsula in Cross River State. The Navy demands that personnel have a particular degree of training and experience in order to be able to complete these jobs. There are 320 crews trained to perform these various tasks, but the task requires 5 crews per platform, capability is therefore reduced to 64. The base has facilities and support for 300 personnel for six weeks. Each X requires 11 maintenance support staff and 2 crews of 2 persons, therefore the base can support 22X's for six weeks. Capability is reduced to 22. If the task requires more than 22 units of X or will take longer than six weeks, then capability is insufficient but if in this case, it will take less weeks and requires only 8 units of X, so there is sufficient capability. The challenge of the commander is to determine the readiness or the capability of the platforms in accomplishing the given mission.

Table 3: Resources Required for a Frigate

S/NO	Sub-Resource	Abbreviation	Resource Area
1	Intelligence	INT	Operations
2	Gathering	FCON	
3	Fleet configuration Maritime Culture	MARCUL	
4	Personnel strength	PLST	Manpower
5	Training	TNG	
6	Leader	LDR	
7	Manning	MANN	
8	Petrol, Oil, Lubricants	POL	Logistics
9	Ammunition	AMM	
10	Spares	SPR	
11	Transport	TPT	
12	Aspide	ASP	
13	Ration	RTN	
14	Uniform	UNIF	
15	Safety equipment	STYEQMPT	
16	Replenishment gears	RE GR	
17	Distribution network	DNET	
18	Weapons	WPN	Engineering
19	Sensor	SNRS	
20	Dockyard	DY	
21	Mechanical systems	MS	
22	Electrical/Electronics	ELEC	

Simulation Framework of the Capability Rating for Each Ship: (Banks 1984) [13] stated that the capability measurement provides decision-quality information as to the readiness of the ship. A major concern of these making those decision is the possibility of a capability gap that may be created by the reduced efficiency of the ships and the timeliness of improving on readiness. In order to determine the capability rating (c-rating) for each ship, a performance measured in up to four areas was considered. These are:

- Range of the ship against the threat environment
- Endurance of the ship in operational area
- Lethality of the ship (platform)
- Survivability of the ship (platform)

Performance in these measures areas is modified by the threat environment in up to three "Zones" which is tailored according to intelligence assessments of the operational environment. The three zones are:

- Ships (platform)
- Medium threat environment
- High threat environment

This can be represented in matrix form:

$$\begin{bmatrix} R_p & E_p & L_p\, S_p \\ R_m & E_m & L_m S_m \\ R_h & E_h & L_h\, S_h \end{bmatrix}$$

Then capability is an aggregate score derived from these twelve individual scores. In aggregating these capability scores, we normalize across all platforms, FICs, and roles. The score in anyone of the "bin" is expressed as a ratio or relative importance of capability to an arbitrary standard this normalization allow for comparison of capability on a common scale.

The measure of performance MoPs for a ship (platform modification combined with a given role at a given time is: Recall equation (1).

$$\text{MoP}_{pmr} = \begin{bmatrix} R_p & E_p & L_p\, S_p \\ R_m & E_m & L_m S_m \\ R_h & E_h & L_h\, S_h \end{bmatrix}$$

The value of MOP_{pmr} is obtained by assigning scores to the twelve bins. The scores are assigned on the basis of how the alternatives meet various objectives. In our case, we have four objectives, i.e. Range, Endurance, and Survivability. A well known method of assigning these scores is Analytical Hierarchy Process which provides decision makers the choice to be made in situations involving multiple objectives.

Weights are assigned to each objective. For convenience, the chosen weights always sum up to 1. The following scores are assigned.

$R_P = 0.571$	$R_m = 0.286$	$R_h = 0.143$
$E_p = 0.159$	$E_m = 0.252$	$E_h = 0.589$
$L_p = 0.088$	$L_m = 0.069$	$L_h = 0.243$
$S_p = 0.069$	$S_m = 0.426$	$R_h = 0.506$

So.

$$M_oP_{pmr} = \begin{matrix} \\ p \\ m \\ h \end{matrix} \begin{bmatrix} R & E & L & S \\ 0.571 & 0.159 & 0.088 & 0.069 \\ 0.286 & 0.252 & 0.069 & 0.426 \\ 0.143 & 0.589 & 0.243 & 0.506 \end{bmatrix}$$

The chosen weight for each objectives, W_1 (I = 1, 2, 3, 4) is $W_i = 0.5115$, $W_2 = 0.0986$, $W_3 = 0.2433$, $W_4 = 1467$. The weights indicate that Range is most important followed by Lethality, Survivability, and Endurance.

The weighting of the relative importance of each MoP in each threat environment, W_r is

$$W_r = \begin{bmatrix} W_R \\ W_E \\ W_L \\ W_S \end{bmatrix} = \begin{bmatrix} 0.5005 \\ 0.0986 \\ 0.2433 \\ 0.1467 \end{bmatrix}$$

The threat environments in a given frame (year) T is

$T = (t_p\, t_m\, t_h)$

Where $t_p = 5$, $t_m = 6$, $t_h = 8$

T = (5, 6, 8)

We can now calculate the MoE (Measure of Effectiveness) for each environment and time unit. The measure of effectiveness is a weighted sum of normalized MoPs.

MoP = MoPW

$$\text{MoE} = 0.268 \begin{bmatrix} 0.571 & 0.159 & 0.088 & 0.69 \\ 0.252 & 0.069 & 0.426 & 0.46 \\ 0.143 & 0.589 & 0.243 & 0.506 \end{bmatrix} \begin{bmatrix} 0.5005 \\ 0.0986 \\ 0.2433 \\ 0.1467 \end{bmatrix}$$

To obtain the capability for a given platform (ship)/modification in a given role and time frame C_{pmr}, we multiply by the threat vector. i.e.

$C_{pmr} = T\ MoET_{pa}$

$$C_{pmr} = (5, 6, 8) \begin{bmatrix} 0.339 \\ 0.396 \\ 0.265 \end{bmatrix}$$

$C_{pmr} = 74.34\%$

A file of number of available ships (platform) in the corresponding role/mod/ year combinations as may be determined by the Fundamental inputs to capability was created and stored in the Database Editor so that it can be recalled by analysts.

4.2 Presentation of Simulation Results

From our Database Editor, a file of Frigate Squadron and Fast Attack Craft Squadron was assessed. The various Φ-state of their sub-resources is presented in the Table 4.2 (1) Let F stand for Frigate and P stand for FAC. The Frigate which are 8 in number are upgraded to weapon system X_1, while the Fast Attack Craft, 5 in number are upgraded to weapon system X_2.

We designate the weapon system X_1 as F_1, F_2, F_3 … and P_1, P_2, P_3 ... P_s as weapon system X_2. We assigned Φ-state for each of the sub resources as they are in both ships (platform). Having established their performance measures, the Φ-state (PSC) is presented in then table 4.2 (1).

Table 4: Φ-State of Subresources

Ship sub resources	F1	F2	F3	F4	F5	F6	F7	F8	P1	P2	P3	P4	P5
PLST	0.8	0.5	0.8	0.8	1.0	0.8	1.0	0.8	1.0	0.8	0.8	1.0	0.5
POL	0.5	1.0	0.8	0.8	0.8	0.8	1.0	1.0	1.0	0.5	0.8	1.0	0.8
AMM	0.8	0.8	1.0	1.0	0.8	0.8	0.0	0.8	1.0	1.0	0.8	1.0	0.8
SPR	0.5	0.0	0.5	1.0	0.8	1.0	0.5	0.5	0.8	1.0	0.5	0.8	0.5
ASP	0.8	0.8	0.8	0.8	1.0	0.8	1.0	0.8	0.8	1.0	0.0	0.8	1.0
TPT	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.8	1.0	0.5	0.5	0.5
TNG	1.0	0.8	0.0	0.5	1.0	0.0	1.0	0.8	1.0	1.0	1.0	1.0	0.8
INTG	0.8	1.0	0.5	0.8	1.0	0.5	0.8	1.0	1.0	0.8	1.0	1.0	1.0
FCON	1.0	0.5	0.5	0.8	0.8	0.8	1.0	1.0	0.8	1.0	0.8	0.8	0.5
REPGR	0.8	0.5	0.5	0.8	0.8	0.5	0.8	0.8	0.0	1.0	0.8	0.5	0.8
WPN	1.0	0.5	1.0	0.5	0.8	0.8	1.0	1.0	0.5	0.8	1.0	0.8	1.0
LDR	0.8	1.0	0.8	0.8	0.8	1.0	0.5	0.8	0.5	0.0	0.5	0.5	0.5
MANN	0.8	1.0	1.0	0.5	1.0	0.5	1.0	0.0	1.0	0.8	0.5	0.0	0.5
RTN	0.8	1.0	1.0	0.8	1.0	0.5	0.0	0.5	0.8	0.0	0.8	0.8	0.8
ELEC	1.0	0.8	0.5	0.5	0.5	1.0	0.8	1.0	1.0	1.0	1.0	0.5	1.0
MARCUL	0.8	0.5	0.8	1.0	0.8	1.0	1.0	1.0	0.5	0.8	0.8	0.5	0.5
DNET	0.5	0.5	0.8	0.8	1.0	0.0	1.0	0.8	0.8	0.5	0.8	0.8	0.8
STYEQPT	0.5	0.8	0.5	0.8	1.0	0.8	0.5	0.5	1.0	1.0	0.5	0.5	0.5
UNIF	0.8	0.5	0.5	0.5	0.5	5.0	1.0	1.0	1.0	1.0	0.5	0.5	0.5
SNRS	0.8	0.5	0.5	0.5	1.0	0.5	1.0	0.8	0.8	0.5	0.8	0.8	1.0
DY	0.5	0.8	0.8	0.8	1.0	0.8	1.0	0.8	0.8	1.0	0.8	1.0	0.8
MS	1.0	0.5	0.8	0.5	1.0	0.0	1.0	1.0	0.8	0.8	1.0	1.0	0.5

Table 5: The Φ-States of the Subresources for Weapon X_1 and X_2

S/N	Subresources		λ-Factor	Weapon System X1	Weapon System X2
1	PLST	L_1	λ_1	Φ_1	Φ_0
2	POL	L_2	λ_0	Φ_0	Φ_0
3	AMM	L_3	λ_0	Φ_1	Φ_1
4	SPR	L_4	λ_0	Φ_0	Φ_1
5	ASP	L_5	λ_2	Φ_3	Φ_2
6	TPT	L_6	λ_1	Φ_0	Φ_1
7	INTG	L_7	λ_0	Φ_0	Φ_0
8	FCON	L_8	λ_1	Φ_1	Φ_0
9	REPGR	L_9	λ_1	Φ_1	Φ_0
10	WPN	L_{10}	λ_0	Φ_2	Φ_1
11	LDR	L_{11}	λ_0	Φ_1	Φ_2
12	MANN	L_{12}	λ_1	Φ_1	Φ_0
13	RTN	L_{13}	λ_0	Φ_0	Φ_1
14	ELEC	L_{14}	λ_1	Φ_0	Φ_0
15	MARCUL	L_{15}	λ_0	Φ_0	Φ_2
16	DNET	L_{16}	λ_1	Φ_1	Φ_1
17	STYEQPT	L_{17}	λ_0	Φ_2	Φ_1
18	UNIF	L_{18}	λ_1	Φ_0	Φ_0
19	SNRS	L_{19}	λ_1	Φ_1	Φ_1
20	DY	L_{20}	λ_1	Φ_2	Φ_1
21	MS	L_{21}	λ_1	Φ_2	Φ_0
22	TNG	L_{22}	λ_0	Φ_1	Φ_0

Using Φ-state table processed with criticality factors with respect to the task/mission the capability rating (c-rating) status for each subresources is obtained and presented in table (5).

Table 6: Present Unreadiness Level of each Weapon System X_1 and X_2

	$\beta\,(A)$	$\gamma\,(B + C)$	$\sigma\,(D + E + G)$	U_p	$U_p / \hat{U} = 13$
Weapon System X_1	0.2 (2) = 0.4	0.5 (2 + 4) = 3	1.0 (0 + 0 + 0) = 0	3.4	0.262
Weapon System X_2	0.2 (3) = 0.6	0.5 (2 + 1) = 1.5	1.0 (0 + 0 + 0) = 0	2.1	0.612

Using the table above, the unreadiness obtained is used to obtain readiness for the platform.

Weapon System X_1; 1 0.262 = 0.738 = 74%

Weapon System X_2; 1 0.161 = 0.839 = 84%

The result shows the weapons systems X_1 is substantially ready, i.e. unreadiness is low.
Weapon System X_2 is also substantially ready for the execution of the task/mission.
We present next the result of the simulation model.
The mathematical representation of the model is given thus:

$$M_oP_{pmr} = \begin{bmatrix} R_p & E_p & L_p\,S_p \\ R_m & E_m & L_m S_m \\ R_h & E_h & L_h\,S_h \end{bmatrix}$$

$$M_oP_{pmr} = \begin{matrix} \\ p \\ m \\ h \end{matrix} \begin{bmatrix} R & E & L & S \\ 0.571 & 0.159 & 0.088 & 0.069 \\ 0.286 & 0.252 & 0.069 & 0.426 \\ 0.143 & 0.589 & 0.243 & 0.506 \end{bmatrix}$$

The Weighting of the Relative (W_R) importance of each M_oP in each threat environment.

$$W_R = \begin{bmatrix} W_r \\ W_e \\ W_l \\ W_s \end{bmatrix} = \begin{bmatrix} 0.5115 \\ 0.0986 \\ 0.2433 \\ 0.1467 \end{bmatrix}$$

$$T = (t_p,\ t_m, t_h) = (5, 6, 8)$$

Measure of effectiveness (M_oE_s) for each environment and time unit is:

$$M_oE = M_oPW$$

$$M_oE = \begin{bmatrix} 0.5115 \\ 0.0986 \\ 0.2433 \\ 0.1467 \end{bmatrix} \begin{bmatrix} 0.571 & 0.159 & 0.088 & 0.069 \\ 0.286 & 0.252 & 0.069 & 0.426 \\ 0.143 & 0.589 & 0.243 & 0.506 \end{bmatrix}$$

0.571 (0.571) + 0.0986 (0.159) + 0.2433 (0.085) + 0.1467 (0.069) = 0.339
0.5115 (0.286) + 0.0986 (0.253) + 0.2433 (0.069) + 0.1467 (0.426) = 0.396
0.55115 (0.143) + 0.0986 (0.589) + 0.2433 (0.243) + 0.1467 (0.506) = 0.265

$$M_oE = \begin{bmatrix} 0.339 \\ 0.396 \\ 0.265 \end{bmatrix}$$

To obtained capability for a given platform/mod/role, and in a given time frame, C_{pmr},
we multiply the vector $TMOET_{pa}$

$$C_{pmr} = TM_o\,ET_{pa}$$

Where
T_{pa} is the time frame per annual
M_oE is the measure of Effectiveness
T is the threat vector in a given environment

$$C_pM_r = (5, 6, 8) \begin{bmatrix} 0.339 \\ 0.396 \\ 0.265 \end{bmatrix} \qquad 12$$

C_{pmr} = 74.34% for a platform/mod/role.

Total capability for a platform/mod/role is calculated by the number of available platform (ships) combinations as determined by fundamental inputs to capability.

4.3 Discussion and Analysis of Results

We discovered a task or mission that needs to be carried out from a base in Nigeria's South-South region, specifically in the Niger Delta, where hostage taking, youth unrest, and militancy have made life intolerable. Eight of the thirteen platforms (ships) in the Frigate Squadron were in varying states of criticality with regard to carrying out the task or mission, according to further evaluations and assessments of the two squadrons. Additionally, five fast-attacking craft were at criticality levels. 13 platforms in all were evaluated for capability ratings. Using the Prevailing Static Condition (PSC) and their level of criticality to the completion of the task or mission, we conducted assessments of the numerous subresources in these platforms. The explanation is that we may complete any goal or assignment by using subresources as our means of transportation. According to these evaluations, the platforms (ships) are largely prepared for the task mission. The capability of the platforms in the two squadrons are significantly prepared for the task/mission as each platform (ship) possesses 74.34% effectiveness, according to a second assessment using the simulation model to carry out performance measured in up to four areas, i.e., range, endurance, lethality, and survivability.

Summary

In this study, we provided a framework for replicating the Combat Readiness Assessment λ-method. The (Mankilik,

1999) [1] (λ-method) evaluates the criticality level of the various resources at highly critical, critical, not critical, and inconsequential levels in order to address the question of the criticality of the resources that are being employed or deployed for the completion of the task. (Frank *et al*., 1968) [5] Previously examined this readiness issue using sub-resources by assessing their various current static conditions (PSC), or what they refer to as the Φ-state. They λ-method did not only identify the subresources and Φ-state, it also identifies the task/mission and carry out assessment of the resources critically, any resource or subresource that is found to be inconsequential is dropped from further consideration.

Conclusion

Eventually, the λ-method simulation framework has provided some insights and directions for the readiness issue. The outcomes of the simulations in the provided scenario are instructional and aid in the decision-making process. The decision-maker is also able to prevent needless material and resource waste thanks to the results.

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