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A hierachical example of the method of c–rating for combat readiness assessment technique

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Abstract
In this paper we present a follow up to an earlier method of c-rating models for combat readiness assessment in which we reported on a new development of immense importance to readiness managers and decision markers. The method is a multi-dimensional approach for resolving readiness problem via subresources in which the state and factor are the cardinal concepts with a concomitant relationship. We demonstrate the applicability of the method by using a hypothetical yet typical example within a naval environment. A step-by-step process is followed to determine unreadiness and consequently the readiness of the fleet as shown on the c-scale.

Keywords: Combat readiness, resource, areas, subresources

1. Introduction

The concept of readiness suggests the existence of some phenomenon such as a challenge or event, which requires some resource(s) to meet. The phenomenon can be regarded as the process of assuming a posture to meet an activity or task or a mission. The posture to be attained is indeed the required state of the system to meet the challenge. The desired posture has to be assumed before engaging the event (activity). In other words, the concept is essentially a pre-event phenomenon. Basically, various resources, human and (or) material, are ingredients that must be marshalled in some appropriate or desirable state to meet the challenge. Readiness of combat forces is widely accepted as the capability of such forces to perform the mission or function for which they are organized and designed. Within the military realm, readiness is a pre-D day/(pre- hostilities) phenomenon. We shall regard sustainability as the ability to maintain continuous readiness, since even when an operation is on-stream, to sustain the operation; it will mean ensuring that the unit/system is continuously ready for each activity that makes up the entire operation. By definition, Readiness is the level of preparedness to perform a task or embark on a mission. It is the aggregate capacity to carry out this basic function, given an inventory of resources and their status. It is of different types.

1.1 Types of Readiness

On a conceptual basis, there are three type of readiness. There are:

1. Perceived readiness (R_p)
2. Expected readiness (R_e)
3. Actual readiness (R_a)

During peacetime, the navy may for example, perceive a threat or task. The readiness of the navy to match this threat or perform the task will be known as perceived readiness. When an actual task has been identified, there will be some expected level of readiness required to execute the task successfully. This type of readiness is referred to as expected readiness. In combat situations, it is usually quite a difficult to assess this precisely and more often than not, this normally contributes to the battle by units. When a war or conflict is imminent, then an actual task has been identified. This situation normally gives raise to the need to re-evaluate your expected readiness because your perceived readiness may have been overtaken by developments. The resultant readiness following such a re-evaluation is what we call actual readiness.

1.2 Basic Issues
Assessing the combat readiness of a naval fleet could turn out to be as complex as the prosecution of war itself. Conventionally, five basic issues are addressed when assessing readiness, which we call the 5W – H of readiness assessment. They are:

1. What should be assessment?
2. Who should do the assessment?
3. How should the assessment be done?
4. When should the assessment be done?
5. Where should the assessment be done?

A naval fleet is usually made up of ships of different types designed to carry out specific roles. Various resources are committed in the process of performing the roles. It has because customary to classify these resources and then use the classification as a basis for carrying out the required readiness assessment. We make the point here that generally, attention is focused on pre-hostility regime. Modifications exist for handling hostility regime (sustained readiness) and post-hostility regime. Post-hostility assessment normally serves as input into the fine-turning of readiness plans for subsequent campaigns.

1.3 Sub-resources
Subresources are the foundation upon which mission (task) accomplishment depends on. The terms ''task'' and ''mission'' are used interchangeably. However note that in give mission there might be one or more tasks to be carried out for the mission to be accomplished. And of course, for every tasks there might be as a number of activities. When we use task we shall be referring to a single task, while mission could mean a single or more. The goal of the commander is for the fleet to accomplish successfully any identified task. Any further assumption (s) made subsequently will be stated as appropriate.

1.4 Description and conceptual frame work
Our method (Lambda (λ)) for combat readiness assessment is based on two main concepts, namely; 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 and this we call the λ-factor (Lambda factor). The two concepts are concomitant in the matrix of readiness assessment.

1.5 The Φ–state concept
Suppose that F_h is any given naval fleet, then F_h will comprise a number of ships. Further, suppose that M is the total number of ships in F_h, F_h will most probably be made of ships of different types according to the roles they are expected to play (Frigates, Aircraft carries, submarines, Fast Attack Craft, Land Ship Thanks, etc,). Let S_h be any Man of War (Fighting Ship) of F_h ($S_h \in F_h$), then Sh has four RA'"s namely operation, Logistics, Manpower and Engineering. Each of these RA's will be made up of a number of subresources. Note that the various subresources will normally be in some "functional" state. The state for particular subresource at a given point in time (or defined interval) could be described in terms of its quality, quantity performance level, or some other characteristic of interest. This measure will be known as the Prescribed Performance Statement (PPS). The PPS at the time of evaluation is what we refer to as the static condition (Φ-state) of the subresources. Obvious by, for a given type or set of subresources, differentiated PSS apply depending on what is being measured or even depending on the elements of 5W-H, with particular reference to the achievement of the desired objective. Each subresource that is relevant to the accomplishment of a particular task, contributes to fleet readiness.

1.6 The Concept of Resource Criticality (RC)
The concept of resource criticality or the λ–position, is rooted in what we call the Resource Requirement Question (RRQ): "Is the subresource in question required for the identified task or mission?" In order words, we are interested in knowing whether or not a given subresources is a combat essential for the specific task. If the answer to the RRQ is "Yes", then we say that, that subresource is a readiness candidate (or indicator). Otherwise, we say that it is inconsequential in the matix of readiness for the identified task regardless of its Φ–state standing.
This paper aims at demonstrating the applicability of the method for c-rating approach to readiness assessment of combat forces, we use extensively the work developed in an earlier paper titled method of c-rating for combat readiness assessment technique. A scenario within a naval environment is captured. A task T_k is identified for which a fleet made up of frigate f is to accomplish. The concept of ϕ state and λ-factor are employed as concomitant factors for assessing the fleet readiness.

1.7 Motivations and organzation
The current effort is motivated by the need to advance the effort of previous researchers, particularly, by extending the contributions of Frank *et al*. (1968) our development attempts to address adequately those issues some previous researchers had failed to address.

1.8 The scenario
Suppose that, we have a fleet, which is divided into two flotillas each of which is organised in squadrons according to their types or roles. Suppose further that a task, T_k has been identified which only one type of ship (for simplicity) will be relevant. Assume that the squadron to be engaged for this task has 15 such tenders. Let it be a squadron of frigates. From intelligence and operational experience combined with careful analytical assessment, it is concluded that only 10 of the relevant tenders will be required for this task.
Suppose further that each ship has 22 different subresources, which make up the resource areas – Operations, Logistics, Manpower, and Engineering System.
Let these subresources be as named in table 1.

Table 1: Resources in one frigate for the example problem

S/N	Subresource	Abbreviation	Resource Area
1.	Personnel Strength	- PLST	M
2	Petrol, Oil, Lubricants	- POL	L
3	Ammunition	- AMM	L
4	Spares	- SPR	L
5	ASPIDE	- ASP	L

6	Transport	- TPT	L
7	Training	- TNG	M
8	Intelligence Gathering	- INT. G	O
9	Fleet Configuration	- F CON	O
10	Replenishment Gears	- REP GR	L
11	Weapons	- WPN	E
12	Leaders	- LDR	M
13	Manning	- MANN	M
14	Ration	- RTN	L
15	Electronics	- ELEC	E
16	Maritime Culture	- MAR. CUL	O
17	Distribution Network	- DNET	O
18	Safety Equipment	- STY EQUIPT	L
19	Uniform	- UNIF	L
20	SENSORS	- SNRS	E
21	Dockyard	- DY	E
22	Mechanical Systems	- MS	E

Legend:
M = Manpower
L = Logistics
O = Operations
E = Engineering

2. Analysis

Let the letter F stand for frigate such that all the fifteen frigates in the fleet are designated F_1, F_2, F_3, …, F_{15}. Based on an established standard for determining the ϕ– state of subresource, the navy will assess and assign ϕ– state for each of the subresource. Suppose that the performance measures have been established, and then we obtain.

Table 2: Φ- State of Subresources.

Ship Subresource	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}	F_{13}	F_{14}	F_{15}
PLST	0.8	0.5	0.8	1	1	1	0	0.5	0.8	0.8	0.8	1	0.5	0.8	1
POL	0.5	1	0.8	0	0.5	1	0.5	0.8	0.8	1	1	1	0.8	0.8	0.5
AMM	0.8	0.8	1	1	0.5	0	0.8	0.8	0.8	1	1	0.5	0.8	1	0.8
SPR	0.5	0	0.5	0	0.8	0.5	0	0	0.5	0.8	1	1	0.5	1	0.8
ASP	0.8	0.8	0.8	0.8	0.5	1	1	0.5	0.8	0.8	1	0.8	0.5	0.8	1
TPT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TNG	1	0.8	0	0	0.5	1	0.5	0.5	0.8	0	1	0.8	0.8	0.5	1
INT.G	0.8	1	0.5	0.8	0.5	0.8	1	1	1	0.5	0.8	1	0.5	0.8	0.8
FCON	1	0.5	0.5	0.8	1	1	1	0.8	1	0.8	1	1	0.8	0.8	0.8
REP.GR	0.8	0.5	0.5		0.8	0.8	1	0	0.8	0.5	1	0.8	0.5	0.8	0.8
WEAPONS	1	0.8	1	0.8	1	1	1	1	1	0.8	0.8	0.8	0.8	0.8	0.8
LDR	0.8	0.8	1	1	1	0.5	0.8	0.8	0.8	1	0	0	0.8	0.5	1
MANN	0.8	0.5	1	1	1	1	0.8	0.5	0	0.5	0.8	0.8	0.5	0.8	1
RTN	0.8	0.5	0.8	1	0.5	0	0	0	0.5	0.5	0	0.5	0	0.5	0.5
ELEC	1	1	1	0.8	0.5	0.8	1	1	1	1	1	1	1	0.8	0.8
MAR.CUL	0.8	0.8	0.8	0.8	0.8	1	0.8	1	1	1	0.8	0.8	0.8	0.5	1
DNET	0.5	0.5	0.8	0.8	0.8	1	1	0.8	0.8	0	1	1	1	1	1
STY EQUIPT	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.5	0.5	0	0.5	0.5
UNIF	0.8	0.8	0.5	0.8	1	1	1	0.8	1	0.5	1	0.8	0.5	1	1
SNRS	0.8	0.5	0.5	1	0.8	1	1	1	0.8	0.5	1	1	0.5	0.8	1
DY	0.5	0.5	0.8	1	1	1	0.5	0.5	0.8	0.8	0.5	1	1	0.5	1
MS	1	0.5	0.8	0.8	1	1	0.5	0.8	1	0	1	0.8	1	0.5	1

Following the identification of the task another evaluation is commenced so as to determine the criticality level for each of the subresources on board. The evaluation, gives the following λ– factors:

Table 3: λ- factors of subresources wrt the mission

Subresource	λ_0	λ_1	λ_2	λ_3
PLST		√		
POL	√			
AMM			√	
SPR		√		
ASP				√
TPT		√		
TNG		√		
INT.G	√			
FCON			√	

REP. GR				√
WEAPONS			√	
LDR		√		
MANN	√			
RTN		√		
ELEC		√		
MAR. CUL	√			
DNET				√
STY EQUIPT	√			
UNIF		√		
SNRS			√	
DY	√			
MS			√	
	6	8	5	3

Observe that for a particular subresource, its λ – factor will be the same for all the ships unlike the ϕ - state that may differ from one ship to another. Observe that, 6 of the subresources are highly critical, 8 are critical the tasks at hand, 5 are non – critical while the 3 subresources, ASP, REP.GR and DNET are inconsequential. These subresources will, therefore, be discarded from the subsequent Readiness Matrix of Evaluation (RME). In fact, when "passed" through the RCPC, what we have as output is the ϕ - state, not the C – rating. Of the 15 frigates only 10 are required for the task. Therefore, the worst 5 frigates will be dropped and the readiness will be assessed based only on the best 10 ships. It is important to note that to arrive at the number 10 as the required number of frigates, consideration would have adequately be given to eventualities. Now that we have the ϕ - state of each subresource as it stands in each ship and we also have the λ – factor of each subresource wrt to the task, we are then in a position to process our information in the Readiness Processing System (RPS). Applying the development (Mankilik, 2004) we obtain table 2.4. While the upper diagonal of each small square carries the ϕ - state a subresource at the time of assessment in a particular frigate, the lower part of the diagonal is the C – rating (output) of processing such a subresource based on its criticality with respect to the identified task. Now to determine the readiness of the fleet to accomplish the task, we first evaluate the unreadiness of each ship. The five ships with the worst (highest) value of unreadiness will the ones to be dropped from our RME.

3. Computation

The computations of the readiness of each ship to perform its roles is based on the formula:

$$^{z}F_{,} = \beta\,[NR\,(\phi_1 \nabla \lambda_0)] + \gamma\,[NR\,\{\Phi_2\,\Delta\,\lambda_0) + NR\,(\Phi_2\,\Delta\,\lambda_1)] + \sigma\,[NR\,(\phi_3 \nabla \lambda_0) + NR\,(\phi_3 \nabla \lambda_1) + NR\,(\phi_3 \nabla \lambda_2)]$$

Where:

$^{z}F_{,}$ = Total Unreadiness of the frigate F_j j = 1, 2, 3, …......, 15

$\beta = 0.2, \Upsilon = 0.5, \sigma = 1.0$

Let

$NR\,(\phi_1 \nabla \lambda_0) = A$

$NR\,(\phi_2 \nabla \lambda_0) = B$

$NR\,(\phi_2 \nabla \lambda_1) = C$

$NR\,(\phi_3 \nabla \lambda_0) = D$

$NR\,(\phi_3 \nabla \lambda_1) = E$

$NR\,(\phi_3 \nabla \lambda_1) = G$

Such that $zfj = \beta\,(A) = \Upsilon\,(B + C) + \sigma\,(D + E + G)$

J = 1, 2, 3, …, 15

β, y, σ *are defined.*

$\beta =$ *Substantially ready,*

$\mathfrak{R} =$ *Marginally ready*

$\mathfrak{D} =$ *Not ready*

Table 4: Unreadiness of each tender to perform the task

Unreadiness/Ship	**β(A)**	**ϒ (B + C)**	**σ (D + E + G)**	**U_{Fj}**	**U_{Fj} = U_{Fj} 19**
F_1	0.2 (3) = 0.6	0.5 (3+1) = 2.0	1.0 (0 + 0 + 0) = 0	2.6	0.137
F_2	0.2	2.5	1.0	3.7	0.195
F_3	0.6	2.0	1.0	3.6	0.189
F_4	0.4	0.5	3.0	3.9	0.205
F_5	0.2	2.5	0	2.7	0.142
F_6	0.2	1.5	2.0	3.7	0.195
F_7	0.4	2.0	3.0	5.4	0.284
F_8	0	2.5	2.0	4.5	0.284
F_9	0.2	1.5	1.0	2.7	0.142
F_{10}	0.6	2.0	2.0	4.6	0.242
F_{11}	0.6	1.5	2.0	4.1	0.216
F_{12}	0.4	1.0	1.0	2.4	0.126
F_{13}	0.4	3.0	0	4.4	0.232
F_{14}	0.6	3.0	0	3.6	0.189
F_{15}	0.2	1.5	0	1.7	0.089
	5.6	29.0	19.0	53.6	

Arranging the ships in ascending order of unreadiness we have F_{15}, F_{12}, F_1, F_5, F_9, F_{14}, F_3, F_2, F_6, F_4, F_{11}, F_{13}, F_8, F_{10} and F_7. The positions of F_5 and F_9 can be swapped. So also can F_{14} with F_3 and F_2 with F_4 ships F_{11}, F_{13}, F_8, F_{10}, and F_7 will be dropped for the task.

Table 5: C – Ratings of required subresources and various required ships

Unreadiness/ Ship	F_1	F_2	F_3	F_4	F_5	F_6	F_9	F_{12}	F_{14}	F_{15}
PL ST	C-1	C-2	C–1	C-1	C-1	C-1	C-1	C-1	C-1	C-1
POL	C-3	C-1	C-2	C-4	C-3	C-1	C-1	C-1	C-2	C-3
AMM	C-1	C-1	C-1	C-1	C-1	C-4	C-1	C-1	C-1	C-1
SPR	C-2	C-4	C-2	C-3	C-1	C-2	C-2	C-1	C-1	C-1
TPT	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1
TNG	C-1	C-1	C-4	C-4	C-2	C-1	C-1	C-1	C-2	C-1
INT.G	C-1	C-1	C-3	C-2	C-3	C-2	C-1	C-1	C-2	C-2
FL. CON	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1
WPN	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1
LDR	C-1	C-1	C-1	C-1	C-1	C-2	C-1	C-4	C-2	C-1
MANN	C-2	C-3	C-1	C-1	C-1	C-1	C-4	C-2	C-2	C-1
RTN	C-1	C-2	C-1	C-1	C-2	C-4	C-2	C-2	C-2	C-2
ELEC	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1
STY EQUIRE	C-3	C-3	C-3	C-3	C-3	C-3	C-3	C-3	C-3	C-3
UNIF	C-1	C-1	C-2	C-1	C-1	C-1	C-1	C-1	C-1	C-1
SNRS	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1
DY	C-3	C-3	C-2	C-1	C-1	C-1	C-2	C-1	C-3	C-1
MS	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1
MARCUL	C-2	C-2	C-2	C-2	C-2	C-1	C-1	C-2	C-3	C-1

Note that table 5 follows from calculation of status of each Subresource – taking cognizance of the ϕ and A-factors.

From table 5, we have the following computations:

1. $\beta \sum(A)_{\mathrm{Fj}}$ = Total unreadiness of required subresources in the Required ships which are in good condition and highly. Critical yet only substantially (not fully) ready for the task

   j = 1, 2, 3, 4, 5, 6, 9, 14, 15= 5.6

Where (A) F_j is No of required Q_1 yet highly critical subresources in the fleet.
The mean unreadiness sum for this class of subresources is

$$\beta \sum(A)_{\mathrm{Fj}} = \frac{5.6}{190} = 0.029$$

2. $\gamma \sum(B + C)Fj$ = Total unreadiness of required subresources in the required ships which are in fair states condition and either highly critical or critical yet only marginally ready for the task.

   j= 1, 2, 3, 4, 5, 6, 9, 12, 14, 15.

Where (B + C)F_j is the No. of required Q_2 subresources with either λ_0 or λ_1 as their criticality level in the fleet. The mean unreadiness sum for this class of subresources is given by

$$\frac{\gamma \sum(B+C)Fj}{190} = 0.163$$

3. $\sigma \sum(D + E + G)Fj$=19.0

Total unreadiness of required subresources in the required ships which are in poor status condition and either highly critical or critical yet not ready for the task.

j= 1, 2, 3, 4, 5, 6, 12, 14, 15

Where $(D + E + G)Fj$ is the No. of required Q_3 subresources with λ_0 or λ_1 criticality in fleet.

The mean unreadiness sum for this class of subresources is given by

$$\frac{\sigma \sum(D+E+G)Fj}{190} = 0.1$$

The total unreadiness of the required ships to take part in the operation is given by

ΣZFj j= 1, 2, 3, 4, 5, 6, 9, 13, 14, and 15 J

Or

$$\beta \sum_{j}(A)_{\mathrm{Fj}} + \gamma \sum_{j}(B + C)_{\mathrm{Fj}} + \sigma \sum_{j}(D + E + G)_{\mathrm{Fj}} = 53.6$$

The mean unreadiness is then 0.282 This value is then read out on the C – scale to give us the readiness for the fleet to embark on the task. Using the scale in figure 3.12.3 we can say the fleet is almost substantially ready for the task. A decision can then be taken as to whether to go ahead with the operation or not. In a similar manner, we evaluate the readiness of each subresource with respect to the task. This provides the horizontal analysis for decision taking. It is important to note and to remember that we are evaluating through readiness. As such, the smaller the value obtained, the better. As stated elsewhere, it is adviceable to avoid rounding up of figures at the disaggregate level, rather, this should be done in the final analysis. It is of note that a decision on whether to go ahead with the mission or not could and indeed should be guided by own fleet level of readiness and enemy own perceived level of readiness. Caution is vital here as enemy level of readiness can hardly be actual infact it is never so known. It depends highly on the accuracy of intelligence data and analysis.

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