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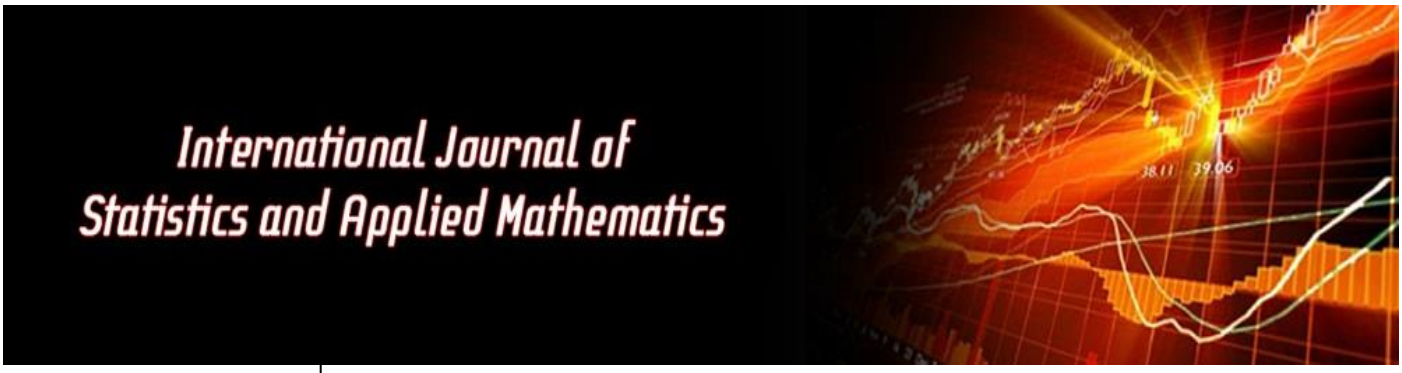

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Makinde SO
Department of Production Engineering, University of Benin, Benin-City, Nigeria

Mankilik IM
Department of Industrial Mathematics, Admiralty University of Nigeria, Delta State, Nigeria

Ovuworie GC
Department of Production Engineering, University of Benin, Benin-City, Nigeria

Corresponding Author:
Makinde SO
Department of Production Engineering, University of Benin, Benin-City, Nigeria

Contractor readiness assessment using Mankilik's λ-method

Makinde SO, Mankilik IM and Ovuworie GC

Abstract
The need to predetermine the capacity of a contractor to deliver a project prior to the contract award/commencement of such a project getting more evident in Nigeria based on the rate of failure of contractors to deliver. This, therefore, calls for analytical form of evaluation to pre-determine the capability of a contractor before award of contract is made. This work applied the Mankilik's modified C-rating technique originally developed for determining the readiness level (for combats or routine operation) of the military via sub-resources, to a civilian environment. The modified C-rating technique is termed "λ-Method". Four (4) levels of readiness exist namely, C-1 for fully ready, C-2 for substantially ready, C-3 for marginally ready, and C-4 for not ready.
In particular the technique was used to determine the levels of readiness of three (3) contractors (1.2. and 3) that bade, each for three (3) jobs, namely a drilling, a pipeline construction and supply projects. It was found that for the drilling project, Contractor 2 was not ready while contractors 1 and 3 were above substantially ready and almost substantially ready, respectively. For the pipeline construction project it was found that contractor 1 is almost fully ready, contractor 2 almost substantially ready and contractor 3 above substantially ready. For the supplies project, all the contractors were fully ready as they all possessed the requisite sub-resources to deliver the services required.

Keywords: C-Rating, contractor readiness criticality factor (λ-factor) prevailing static condition (Φ state), readiness assessment, sub-resources

Introduction
Due to the fact that many projects in Nigeria have either been poorly executed or abandoned without being completed or the execution had to be terminated and sometimes re-awarded to other contractors because of non-performance, who may equally under-perform or fail to perform too; there is a need to assess the capability of contractors before jobs are awarded.
The C-Rating technique was first developed to measure the readiness of ship for the US Navy and the Military via the sub-resources that make them up (Frank *et al*, 1968) [5]. Measured readiness of ships, and the Navy is dependent on the mission to be undertaken (Isenberg, 1995) [2] and not on the actual number of ship or sub-resources available. This has led to the development of a new approach that considers the λ-factor which is a measure of the criticality of sub-resources to the mission to be undertaken and the level of functionality of the sub-resource measured as its prevailing static condition called the Φ-state (Mankilik, 1999) [6].
This paper reports on an application Mankilik's modified/refined C-rating technique of readiness measurement via sub-resources to contractor readiness assessment for an oil and gas servicing company. The application examines the Φ-state of the contractor's sub-resources and processes the data obtained, based on criticality (λ-factor) of each sub-resources to the delivery of the objective of the project in order to obtain the C-rating status of each sub-resources. Using the unreadiness level of all the sub-resources evaluated, the total unreadiness level of the contractor is computed and the contractor C-rating (readiness level) is obtained.

Some Basic Concepts
a. Readiness Assessment is the determination of the level of readiness of a unit or an organisation to undertake and complete a task, job, or project.

b. C-rating is a grading system namely C-1. C-2, C-3and C-4) for showing the level of readiness, where C-1 represents' fully ready, C-2 represents substantially ready, C-3 represents marginally ready and C-4 rating means that the unit is not ready.
c. Sub-resource is a group of elemental resource.
d. Criticality Factor (λ-factor) is the level or importance attached to a sub-resource in achieving the overall goal/objective for which the assessment is being carried out.
e. Prevailing Static Condition (Φ-state) is an assessment showing the current state of functionally of a sub-resources, etc.

Data capture

Data were collected from the contractors' technical bid submissions to an indigenous oil and gas exploration and production company (see appendices 1-4 for some details). The assessment was applied to the contractors that bade for the provision of three (3) different services:

1. Drilling
2. Pipeline Construction
3. Supplies

The contractor sub-resources were grouped under three resource area namely; Equipment, Manpower and Finance, for the purpose of using the λ-factor based assessment technique.

Definition of concepts

a. Readiness Assessment is the determination of the level of readiness of a unit or an organization to undertake and complete a task, job or project.
b. C-Rating is a grading system namely C-1, C-2, C-3 and C-4for showing the level of readiness, where C-1 is fully ready C-2 is substantially ready, C-3 is marginally ready and C-4 is not ready.
c. Sub-resource is a group of resource.
d. Criticality factor (λ-factor) is the level of importance attached to a sub-resource in achieving the overall goal/objective for which the assessment is carried out.
e. Prevailing Static Condition (Φ-State) is an assessment showing the current state of functionality of a sub-resource with respect to the requirement. It is dependent on the type of sub-resource, number of sub-resource such as electrode where quantity determines the need, quality for skill of personnel, etc.

Evaluation of data

The criticality (λ-factor) of each sub-resource expected to be possessed by each contractor was first determined with respect to the objectives of the project (service) to be performed by the contractor and awarded a λ-factor. The sub-resources possessed by each contractor are then evaluated to determine their Φ-states.

Contractor Unreadiness is then computed using

$$U_f = \beta[NR(\phi_1 \nabla \lambda_0)] + \gamma[NR(\phi_2 \nabla \lambda_0) + NR(\phi_2 \nabla \lambda_1)] + \sigma[NR(\phi_3 \nabla \lambda_0) + NR(\phi_3 \nabla \lambda_1) + NR(\phi_3 \nabla \lambda_2)]$$

Where U_f = Total Unreadiness of the contractor
$\beta = 0.2$, $\gamma = 0.5$, $\sigma = 1.0$

Drilling Contractors Evaluation

Each of the sub-resources of 3 drilling contractors was evaluated and awarded a score on a scale of 0.0-1.0 to show how much the sub-resource meets the requirement to perform the service to be undertaken. The values for the sub-resource are as provided in Table 1, with Table 2 showing the corresponding Φ-states.

Table 1: Assessment Scores of the Sub-Resources of the Drilling Services Contractors

			λ-Factor	Contractor 1	Contractor 2	Contractor 3
				1	2	3
I	MSDU Working Area	L_1	λ_0	1.0	0.4	1.0
2	Rotary Table	L_2	λ_0	1.0	0.2	0.8
3	Derrick & Draw works	L_3	λ_0	0.8	0.6	0.8
4	TDS	L_4	λ_0	1.0	0.2	0.8
5	BOP	L_5	λ_0	1.0	0.2	0.8
6	Crane	L_6	λ_0	1.0	0.2	0.8
7	HP Mud Pumps	L_7	λ_0	0.6	0.6	0.4
8	Mud Storage & Mixing	L_8	λ_0	0.8	0.4	0.8
9	Support Facilities	L_9	λ_0	0.6	0.4	0.6
10	House Boat	L_{10}	λ_0	0.6	0.4	0.4
11	Specialist Personnel	L_{11}	λ_1	0.8	0.8	0.8
12	Personnel	L_{12}	λ_1	0.6	0.4	0.6
13	Catering Personnel	L_{13}	λ_1	0.6	0.6	0.6
14	Safety/Quality Staff	L_{14}	λ_1	0.8	0.8	0.8
15	Medical Staff	L_{15}	λ_1	0.8	0.8	0.8
16	Funds, $300,000	L_{16}	λ_1	0.6	0.6	0.6
17	45 days credit limit	L_{17}	λ_1	0.8	0.8	0.8

Table 2: The Φ States: The Sub-Resources of Drilling Services Contractors

			λ Factor'	Contractor 1	Contractor 2	Contractor 3
				1	2	3
I	MSDU Working Area	L_1	λ_0	Φ_0	Φ_3	Φ_0
2	Rotary Table	L_2	λ_0	Φ_0	Φ_3	Φ_1
3	Derrick & Draw works	L_3	λ_0	Φ_1	Φ_2	Φ_1
4	TDS	L_4	λ_0	Φ_0	Φ_3	Φ_1
5	BOP	L_5	λ_0	Φ_0	Φ_3	Φ_1
6	Crane	L_6	λ_0	Φ_0	Φ_3	Φ_1
7	I-IP Mud Pumps	L_7	λ_0	Φ_2	Φ_2	Φ_3

8	Mud Storage & Mixing	L_8	λ_0	Φ_1	Φ_1	Φ_1
9	Support Facilities	L_9	λ_0	Φ_2	Φ_2	Φ_2
10	House Boat	L_{10}	λ_1	Φ_2	Φ_2	Φ_3
II	Specialist Personnel	L_{11}	λ_1	Φ_1	Φ_1	Φ_1
12	Personnel	L_{12}	λ_1	Φ_2	Φ_2	Φ_2
13	Catering Personnel	L_{13}	λ_1	Φ_2	Φ_2	Φ_2
14	Safety/Quality Staff	L_{14}	λ_1	Φ_1	Φ_1	Φ_1
15	Medical Staff	L_{15}	λ_1	Φ_1	Φ_1	Φ_1
16	Funds, $300,000	L_{16}	λ_1	Φ_2	Φ_2	Φ_2
17	45 days credit limit	L_{17}	λ_1	Φ_1	Φ_1	Φ_1

Applying equation1 in computing the unreadiness levels of each contractor yields Table 3

Table 3: Drilling Services Contractors' Unreadiness Evaluation

	β (A)	**γ (B+C)**	**σ (D + E + G)**	**U_f**	**$\bar{U} = \frac{Uf}{17}$**
Contractor 1	0.2 (1) = 0.2	0.5 (2-14) = 3.0	1.0 (0 + 0 + 0) = 0	3.2	0.188
Contractor' 2	0.2(0) = 0	0.5 (I + 2) = I.5	1.0 (8 + 0 + I) = 9	10.5	0.617
Contractor 3	0.2(0) = 0	0.5 (I + 4) = 2.5	1.0 (I + 0 + I) = 2	4.5	0.265

With the unreadiness level computed for each contractor their readiness levels areas follow:
Contractor 1: 1 - 0.188 = 0.822
Contractor 2: 1 - 0.617 = 0.383
Contractor 3: 1 - 0.265 = 0.735

Pipeline Construction: The evaluation of the prevailing static conditions the three (3) pipeline contractors is shown in Table 4 and subsequently, the Φ-state in Table 5.

Table 4: The Evaluation Scores for Pipeline Construction Contractors' Sub-Resources

	Resource Area		**λ Factor**	**Contractor 1**	**Contractor 2**	**Contractor 3**
	Equipment					
I	Welding	L_1	λ_0	0.9	0.7	0.6
	Machines					
2	Electrodes	L_2	λ_0	1.0	1.0	1.0
"*J*	X-Ray	L_3	λ_3	0.8	0	0
	Equipment					
4	Boring	L_4	λ_3	0	0	0.8
	Equipment					
5	Floater	L_5	λ_2	1.0	0	0.4
	Manpower					
I	Welders	L_6	λ_0	0.8	0.8	0.8
2	Filters	L_7	λ_0	0.8	0.6	0.9
"*J*	Labour	L_8	λ_1	1.0	1.0	1.0
4	Radiographers	L_9	λ_3	1.0	0	0
5	Inspectors	L_{10}	λ_2	1.0	1.0	1.0
	Safety/medical	L_{11}	λ_1	1.0	1.0	1.0
	Staff					
	Finance					
I	Funds	L_{12}	λ_1	1·0	1.0	1.0
2	45 days credit	L_{13}	λ1	1.0	1.0	1.0

Table 5: The Φ States for Pipeline Construction Contractors' Sub-resources

	Resource Area		**λ Factor**	**Contractor1**	**Contractor 2**	**Contractor 3**
	Equipment					
I	Welding Machines	L_1	λ_0	Φ_0	Φ_1	Φ_2
2	Electrodes	L_2	λ_0	Φ_0	Φ_0	Φ_0
".J	X-Ray Equipment	L_3	λ_3	Φ_1	Φ_3	Φ_3
4	Boring Equipment	L_4	λ_3	Φ_3	Φ_3	Φ_1
5	Floater	L_5	λ_2	Φ_0	Φ_3	Φ_3
	Manpower					
I	Welders	L_6	λ_0	Φ_1	Φ_1	Φ_1
2	Filters	L_7	λ_0	Φ_1	Φ_2	Φ_0
3	Labour	L_8	λ_1	Φ_0	Φ_0	Φ_0
4	Radiographers	L_9	λ_3	Φ_0	Φ_3	Φ_3
5	Inspectors	L_{10}	λ_2	Φ_0	Φ_0	Φ_0
	Safety/medical Staff	L_{11}	λ_1	Φ_0	Φ_0	Φ_0
	Finance					
I	Funds	L_{12}	λ_1	Φ_0	Φ_0	Φ_0
2	45 days credit	L_{13}	λ_1	Φ_0	Φ_0	Φ_0

Computing the unreadiness levels for each contractor yield s table 6.

Table 6: Pipeline Contractors' Unreadiness Evaluation

	β (A)	γ (B+C)	σ (D + E + G)	U_f	$\bar{U} = \frac{Uf}{17}$
Contractor 1	0.2 (2) = 0.4	0.5 (0 + 0) = 0	1.0 (0 + 0 + 0) = 0	0.4	0.031
Contractor 2	0.2(0) = 0	0.5 (2 + 1) = I.0	1.0 (0 + 0 + 2) = 2	3.0	0.231
Contractor 3	0.2(0) = 0.4	0.5 (0 + 0) = 0	1.0 (0 + 0 + 2) = 2	2.4	0.185

From the Readiness level
Contractor 1: 1 - 0.031 = 0.969
Contractor 2: 1 - 0.23 I = 0.769
Contractor 3: 1 - 0.185 = 0.815

Supply Services

Table 7 shows the Prevailing Static Condition of the contractor sub-resources.

Evaluating these Φ states subject to the λ factor of each sub-resource yields the C-rating output shown in Table 8.

Table 7: The Φ States for the Sub-Resources of Supply Contractors

	Resource Area		λ Factor	Contractor 1	Contractor 2	Contractor 3
1	Equipment	L_1	λ_3	Φ_1	Φ_2	Φ_1
	Manpower					
1	Drivers	L_2	λ_2	Φ_0	Φ_1	Φ_0
2	Supervisors	L_3	λ_1	Φ_0	Φ_0	Φ_0
	Finance					
1	Funds	L_4	λ_0	Φ_0	Φ_0	Φ_0
2	45 days credit limit	L_5	λ_0	Φ_0	Φ_0	Φ_0

Table 8: C-ratings Outputs for Supply Contractors' Sub-Resources

	Resource Area		λ Factor	Contractor 1	Contractor 2	Contractor 3
1	Equipment	L_1	λ_3	Φ_1	Φ_2	Φ_1
	Manpower					
1	Drivers	L_2	λ_2	C-1	C-1	C-1
2	Supervisors	L_3	λ_1	C-1	C-1	C-1
	Finance					
1	Funds	L_4	λ_0	C-1	C-1	C-1
2	45 days credit limit	L_5	λ_0	C-1	C-1	C-1

Applying the unreadiness
Applying the unreadiness equation yields Table 9.

Table 9: Supply Contractors' Unreadiness Evaluation

	β (A)	γ (B + C)	σ (D+E+G)	U_f	$\bar{U} = \frac{Uf}{17}$
Contractor 1	0.2(0) = 0	0.5(0+0) = 0	1.0(0+0+0) = 0	0	0
Contractor 2	0.2(0) = 0	0.5(0+0) = 0	1.0(0+0+0) = 0	0	0
Contractor 3	0.2(0) = 0	0.5(0+0) = 0	1.0(0+0+0) = 0	0	0

The contractors' readiness levels are as follows:
Contractor 1: 1 - 0 = 1
Contractor 2: 1 - 0 = 1
Contractor 3: 1 - 0 = 1

Discussion

The readiness obtained for the drilling contractors shows that Contractor 1 is above substantially ready, C-2; Contractor 2 is not ready, C-4; and Contractor 3 is almost substantially ready, C-2. This implies that Contractor 1 has most of the requisite sub- resources that are critical to the drilling project in very good states. Contractor 2, however, lacks the requisite critical sub-resources or has them in a poor state and, therefore, cannot deliver the project to the required specification. Contractor 3 also being almost substantially ready has a high level of capability to deliver the project. But Contractor 1 has the highest capability or readiness to deliver the drilling project to the required specification.

For the pipeline project, Contractor 1 is almost fully ready, C-1; Contractor 2 is almost substantially ready, C-2; and Contractor 3 is above Substantially Ready, C-2. This shows that all the contractors have significant number of the critical sub-resources in good states. Contractor 1, however, has most of his sub-resources in near perfect condition. Therefore, the cost at which the contractors are ready to execute the project could be the determining factor, particularly, if Contractor 1 is very expensive or unavailable.

All the contractors for the supply service are fully ready, C- 1. This shows that they all have the necessary sub-resources in perfect condition. This is so because the critical sub-resource is finance and credit period which they all possess. The determining factor will, therefore, be the price at which they are ready to execute the project.

Conclusion

We have successfully applied the Mankilik's modified C-rating technique of measuring readiness in the military to contractor readiness assessment using the data from contractors to an indigenous Oil and Gas Exploration and Production for 3 different services. The result shows that for the drilling project, Contractor 2 was not ready while contractors 1 and 3 were above substantially ready and almost substantially ready, respectively.

For the Pipeline Construction project, it shows that Contractor 1 is almost fully ready, Contractor 2 almost substantially ready and Contractor 3 above substantially ready. This implies that all the contractors have significant number of the required/critical sub-resources required to perform the Pipeline Construction Service. Furthermore, for the supplies project, all the contractors were fully ready as they all possessed the requisite sub-resources to deliver the services required.

The application has demonstrated that this emerging tool could give an objective evaluation of contractors when the need arises to pre-determine their capacity to deliver a service, based on the caliber of sub-resources possessed. It could also be used as a self-assessment by firms to determine their stand in competition for jobs or when there is a need to upgrade sub-resources so as to be properly positioned to bid for job.

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