VOL. 11, NO. 17, SEPTEMBER 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

LRSS MAINTENANCE MODEL: CONCEPTS AND APPLICATION METHODS FOR IMPROVING THE AVAILABILITY OF THE NATIONAL ELECTRICAL NETWORK

M. Z. Bouzoubaa[1], M. A. Soulhi[2] and Mme J. El Alami[1]
[1]LASTIMI, Mohammed V University of Rabat, Higher School of Technology, Salé, Morocco
[2]National Higher School of Mining, Rabat, Morocco
E-Mail: zakaria_bou78@yahoo.fr

SUMMARY

The present article is the edifice of the implementation of a maintenance management model called LRSS. Our model, aimed at the ongoing improvement of the performance of industrial systems, namely in terms of service availability and continuity, rests on the fight against scheduled maintenance stops-related unavailability. Thus, and for the purposes of research thesis, we have taken the Moroccan national electricity network as a case study. In the present article, and given the first positive results published in a previous study [1], we seek to analyze the concepts and methods of implementation of our model and its application to each constituent in order to avail industrials and manufacturers of a toolbox, which will be incorporated in maintenance manuals with regard to similar industrial systems.

Keywords: availability, maintainability, redundancy, safety.

1. INTRODUCTION

Following a first experience of the new maintenance management model, conducted in accordance with the base logical flow chart we have applied [1] to the studied system, we, based on the road map of our research, geared ourselves towards the development of the constituents of this model. These constituents are henceforth taken as a new benchmark methodology in terms of maintenance methodology resting on the fight against or, at least, reduction of scheduled unavailability.

In the present article, and for each constituent of the LRSS model, we expose the conditions related to the studied system (electrical transformer station facilities), namely:

- Requirement of hot maintenance
- Introduction of redundancies
- Merger of operating ranges
- Safety concepts related to the new model.

2. DEFINITION AND INTERESTS OF THE APPLICATION OF THE NEW LRSS MODEL TO THE STUDIED SYSTEM

The analysis adopted in the previous works [1] has made it possible to confirm the technical and economic interest of our new maintenance management model applied to the facilities of the national electricity network.

We henceforth plan to give it a specific designation, LRSS, an acronym which stands for Live Work Redundancy, Simultaneity and Safety.

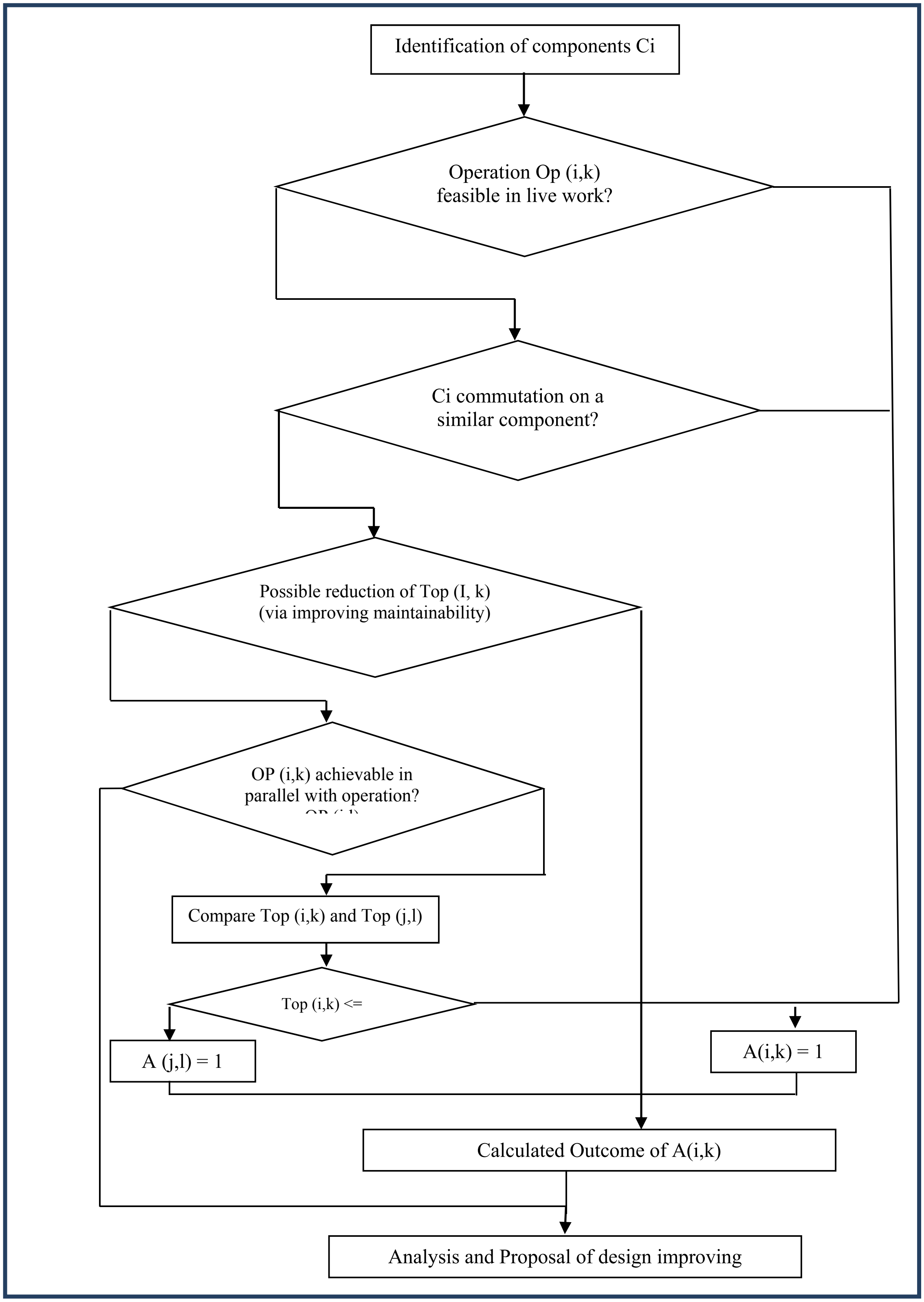
The different concepts we address in details may be applied in different industrial or service sectors, particularly those characterized by the financial impact arising from scheduled maintenance service or production stops

The methodology we have adopted is schematized in picture-1, taking into consideration the following definitions:

- Ci: Component i
- Op(i,k): Operational mode no. of preventive maintenance of the facility Ci
- Top(i,k): Operational mode time Op(i,k)
- A(i,k): Availability value equivalent to stop during operational Top(i,k)

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com



ARPN Journal of Engineering and Applied Sciences

3. HOT MAINTENANCE: DESIGN REQUIREMENTS AND OPERATING CONSTRAINTS

One of the major advantages of LRSS Model is undoubtedly hot maintenance. This concept includes all operational modes and maintenance activities carried out by intervention teams, and which make it possible to:

- Preserve the functioning of the facility being maintained and avoid its stop or withdrawal from operation;

- Carry out the different maintenance operational modes that enable facilities to preserve their reliability and extend their global useful (service) life [2].

To do so, we have highlighted the following principles:

- Take into consideration the requirements of this method so much for design as for operation.
- Take into account the technical constraints of live or operational facilities.

The feasibility of hot maintenance operations (Live Work) requires that accessibility to the work zone by operators and their equipment be taken into consideration during the design of facilities in question.

In fact, such a requirement is realized by respecting the distance between conductors distance (e.g. picture-1) as well as by taking into consideration operators' passage distance and location near the different facilities being hot-maintained. (e.g. picture-2).

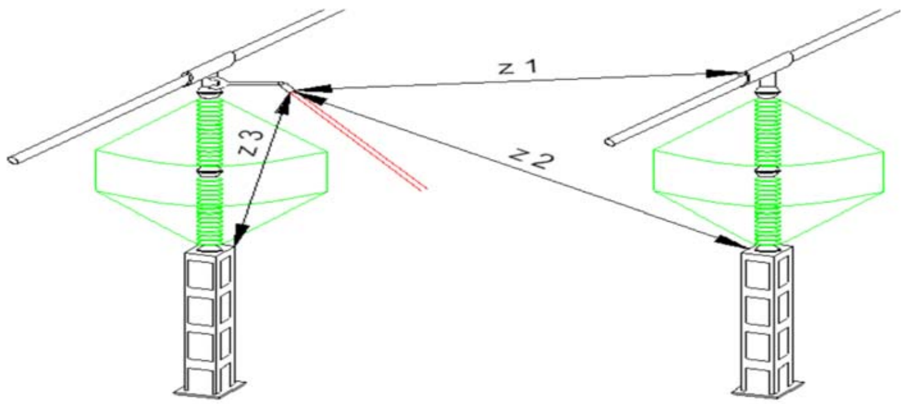


Figure-1. Electrical field evolution space and related distances.

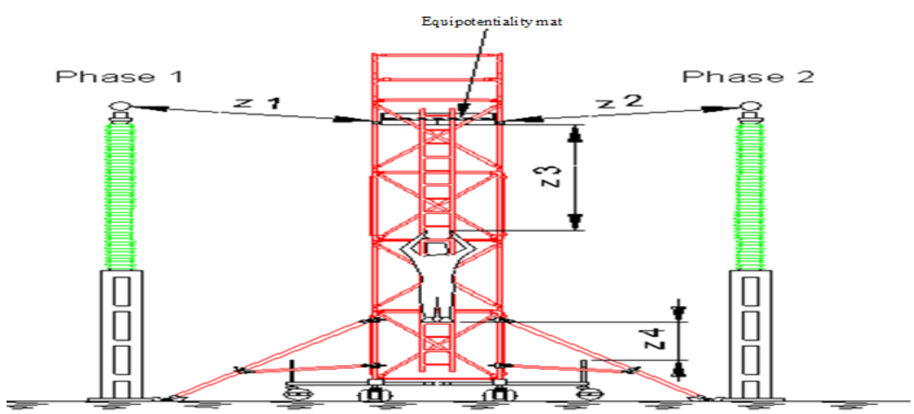


Figure-2. Sample passage between live facilities and related distances.

In fact, the working distances that we have elaborated in accordance with the analysis of electrical risks are summarized as follows:

Un (kV)	**60**	**150**	**225**	**400**
DmT	0,70	1,2	1,30	1,90

4. SIMULTANEOUS OPERATIONS: FUSION OF OPERATION SCLAES

We have noted that each electrical facility installed in the transformer stations subject of this study are made by different manufacturers and have maintenance rangess proper to them [4] and [5] and are independent of the other facilities.

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

Consequently, the operator is left with no option but to draw an annual preventive maintenance schedule [6] and [7] based on each manufacturer's recommendations and on the facilities operating hypotheses. This situation results in frequent and repetitive stops [9], which, in turn, lead to important disruptions of service provisions and unavailability, most often in periods of high consumption of electricity.

Below is a comparative analysis of the impact of stops of two different facilities, installed in series and having two maintenance manuals from distinct manufacturers, on the overall availability of the system [10].

Each facility is, thus, subjected to a series of maintenance operations in accordance with manufacturer's recommendations, operations resulting in a stop of the whole station.

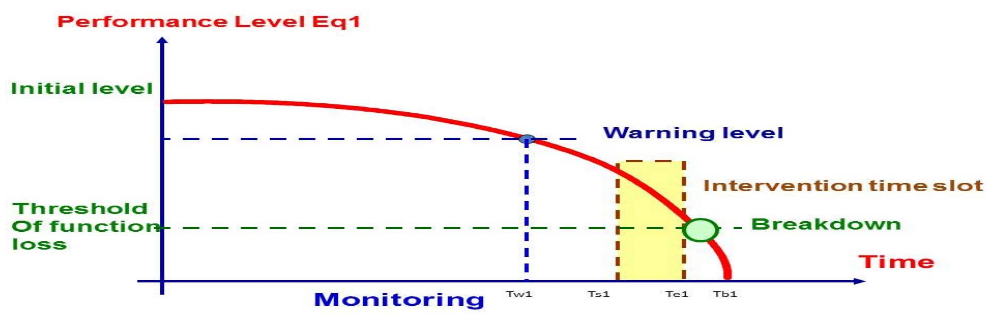


Figure-3. Equipment performance degradation curve.

We define the following variable:

Tw1 : Date of warning level for facility (Equipement) 1
Ts1 : Date/hour of start of intervention1 on facility (Equipement)1
Te1 : Date: hour of end of intervention 1 on facility (Equipement) 1
Tb1 : Expected date of breakdown of facility (Equipement)1
Tsw2 : date of warning level for facility 2
Tds2 : Date/hour of start of intervention2 on facility 2
Tfe2 : Date : hour of end of intervention 2 on facility 2
Tpb2 : Expected date of breakdown of facility 2

It should be clear that the system we studied is composed essentiallility of one of whose component (equipment)results in the unavailability of the system, i.e., a total stop of service [11].

In order to minimize the impact of the application of operational rangess related to the two systems, including the impact on the overall availability of the system, we proceed to a fusion of the operational modes of the two facilities while observing the following conditions:

- Max (Tei-Tsi) < Threshold admissibleby national network manager (Dispatching), namely 12 continuous hours.

- Labor force and logistics make it possible to realize the two maintenance operations of the two facilites simultaneously.

- All the conditions hereafter are proved:

* If we suppose that Twi>Twj, in other words, if facility j reaches warning level before facility i
* Tsi<Tbj-(Tej-Tsj) si (Tei-Tsi)<(Tej-Tsj)

The targeted improvement is, therefore, the fusion of the two operational modes (A et B), satisfying the aforementioned conditions in order to give rise to a 3rd operational mode called C.

The following diagram (picture-4) summarizes this optimization.

VOL. 11, NO. 17, SEPTEMBER 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

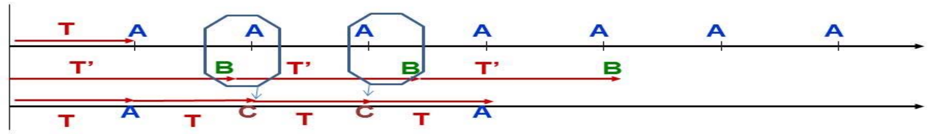


Figure-4. Principe of fusion of the two operational modes.

This optimization remains valid to fuse two operational modes having two different periodicities for the same facility.

Thus, the overall availability of the station improves by avoiding successive stops resulting from the need to carry out two different maintenance operations.

5. ACTIVE AND PASSIVE REDUNDANCIES

Although resorting to Live Work intervention methods or the fusion of technically and economically miscible operational rangess open up the scope of possibilities, there are facilities, of which the designing specificities, the nature and frequency of scheduled interventions do not respond to the rules described in the present article. In this case, the model recommends the implementation of functional redundancy of the facility in question, which will permit to swing over the fallback facility and have available the facility to be maintained without any impact on the functioning of the overall system. [12].

Based on the formulas largely used for the calculation of the functional redundancy systems (Parallel assembly), namely P. Lyonnet's [14] works, we can deduce that the availability resulting from the system during maintenance stops is about 1 (page 238).

However, designers will have to conduct a simple economic comparison in order to establish the cost-effectiveness (amortization) of the additional investment with regard to the gains of its implementation. A detailed discussion of this very point will be the subject matter of the works we carry out thereupon.

6. SAFETY-RELATED ASPECTS

The proposed model rests on the observation of safety notions that designers, manufacturers and operators should respect throughout the useful/service life of the concerned facility. Through our research, we can summarize these principles as follows:

- Respect distances between the different facilities (between phases, insulation columns) that are required for the entrance of maintenance operators
- Respect heights in accordance with the principle of the dielectric strength of facilities

The assessment of safety and risks [15] related to the intervention of maintenance operators is of capital importance in the implementation of our model. The meaning we allocate to it interferes with the definition provided by Villmeur [13]: ability of an entity to avoid the occurrence of critical or disastrous events under given circumstances.

The arrangements we summarize hereafter make it possible to prevent electrical risks likely to jeopardize operators' safety, namely risks of electrocution and risks of short-circuit. In fact, and following the network contexture, system start-up risks may result, especially from manipulation high voltage and/or from pollution.

Therefore, prior to the decision of conduction hot maintenance operations (Live work), the behavior of the facility in question should be taken into consideration. For this purpose, it is necessary to observe the following:

- If a facility is frequently set off for unknown reasons or because of incidents occurring on certain of its parts, maintenance operations on this facility are forbidden;
- 'Live Work' operations should be preceded by a checking of the insulation of the work zone, i.e., on the chain or column on which work is operated or adjacent columns.

Checking the electrical performance of a facility aims at ensure that the grounding insulation level of the concerned as well as that of the adjacent column permit its realization. It involves the calculation of the electrical performance with regard to manipulation high voltage and electrical performance with regard to pollution.

Electrical contact areas of conductor tools should be serviced so as to ensure the quality of electrical continuity during use.

7. CONCLUSIONS

The present work has made it possible to highlight certain realities in the industrial electrical sector, where organizational structures are often not aware of the need to implement a maintenance system based on the fight against unavailability.

The maintenance methodology proposed rests on the concepts of the LRSS Model. It suggests a set of tools and methods to be used according to well examined criteria and limited costs.

By applying it to the studied system, we have managed to improve significantly the overall value of the availability of the facility [1] and we have made managed to make this sharp improvement more durable by adopting a new preventive maintenance management methodology based on the four main levers:

a) Resorting to interventions does not require facility stops, known henceforth as hot maintenance (Live Work).
b) Updating of the Maintenance Manual and changing of standard intervention ranges, essentially through fusion of the operational modes.
c) Introduction of functional redundancies during designing or renovating phases, in accordance with the economic cost-effectiveness criteria.
d) Enhancing of safety-related aspects as a principal component of the model.

It follows from this that the choice of the tools proposed in this mode is mainly dictated by the context of the company as well as the objective levels of performance and availability.

Nevertheless, it remains true that the success of the implementation of a LRSS maintenance model depends essentially on the extent to which the company can ensure that the technical requirements and specifications which guarantee resorting to such methods are respected during the designing of facilities.

ACKNOWLEDGEMENTS

We would like to thank Mr Nourredine ELALAMI, professor at the Mohammedia School of Engineers (EMI)-Rabat for his precious advice. We also would like to thank Prof. Sadik Maliki, Department of English Studies, Faculty of Letters and Humanities, Ain Chock, Hassan II University of Casablanca, for the English translation of this article.

REFERENCES

[1] Z. Bouzoubaa, A. Soulhi, J. Elalami. 2016. Optimization of Maintenance Methods to Improve the Availability of the National Electrical Network, Journal of Innovative Technology and Education. 3(1): 23-35, HIKARI Ltd, //dx.doi.org/10.12988/jite.2016.612.

[2] H. Elhadaf, R. Benmansour, H. Allaoui, M. Tkiouat et Artiba. 2012. Preventive maintenance scheduling fora multi-component system and spare parts inventory. Asset management and maintenance Journal. pp. 25-27.

[3] H.D. GOEL, Weijnen, Grievinkj. 2004. Reliability and Maintainability and Optimization in conceptual process design. IEEE Transactions on reliability.

[4] K. Okumoto et EA Elsayed. An optimum group maintenance policy. Naval research Logistics Quarterly. 30(4): 667-674.

[5] Sukhwinder Singh Jolly, SS Wadhwa, Reliability. 2004. Availability and Maintainability study of high precision, Journal of scientific and Industrial Research. pp. 512-517.

[6] Y. LAVINA. 1992. Amélioration continue en maintenance. Editions d'Organisation.

[7] C.H.LIE et Y.H Chun. 1986. An Algorithm for preventive maintenance Policy. Reliability, IEEE Transactions. 35(1): 71-75.

[8] BOUTI A. and AIT-KADI D. 2004. State of the art review of FMEA/FMACA. International Journal of Reliability, Quality and Safety Engineering. 1: 515-543.

[9] R. Barlow et L. Hunter. 1960. Optimum preventive maintenance policies. Operations Research. pp. 90-100.

[10] D.I. Cho et M. Parlar. 1991. A survey of maintenance models formulti-units systems. European Journal of Operational research. pp. 1-23.

[11] GL Pahuja, R. Bhardwaj, Modular Common Mode Fault Tolerent NMR 2011. MIT International Journal of Electrical and Instrumentation Engineering. 1: 6-10.

[12] D. AIT-KADI. 1999. Les Stratégies de maintenance préventives pour la maximisation de la disponibilité des systèmes, Proceeding 3thd International conference Industrial and Automation, Montréal, pp. 1.13-1.16.

[13] A. Villemeur. 1988. sûreté de fonctionnement des systèmes industriels. Collection de la Direction des Etudes et Recherches d'EDF, ed. Eyrolles.

[14] P. Lyonnet. 1992. La Maintenance mathématiques et méthodes, Tech and Doc.

[15] B. Cameron. 1999. Computerized maintenance management systems CMMS. IIE Solutions. 31 : 44-47.