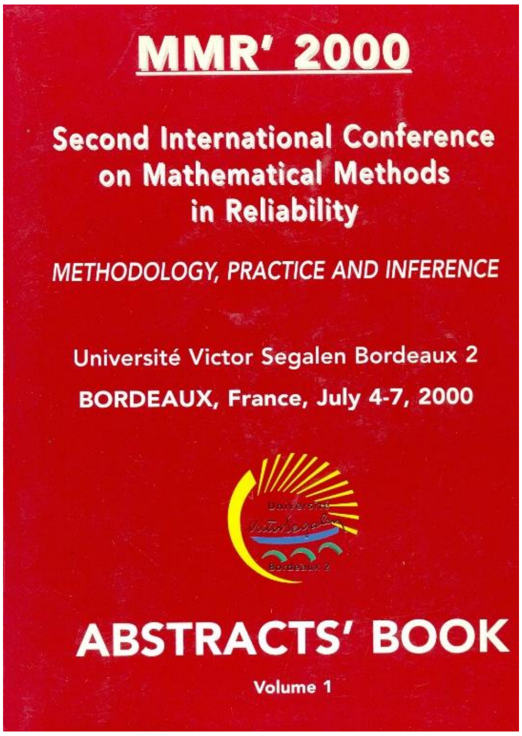

Experience Fastback Analysis for Maintenance Optimization at the Engines' Depot of Bejaia Harbor Company.

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Abstract:

This study helped us to clarify many features related to engines failure in Bejaia harbor depot. The first step was Pareto analysis, that yields the class of engines with the highest cost. The second step is modeling the behavior of the sub-systems composing the engines. This is done by two approaches: non parametric modeling validated with the graphical test, and parametric modeling. The last approach uses Lyonnet and Kaplan-Meier methods. These two approaches have the advantage of being able to take into account the incomplete life times. The third step is an engine reliability study. The model associated with the behavior of each type of engine has indicated that lifting trolleys are more reliable than cranes. The fourth step is devoted to study economically the renewal phenomenon. The last step is a study of engines availability. This study has shown the most maintainable engines and brought to sight the spare parts problem which is the main reason for engines immobilization.

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ABSTRACTS' BOOK

Volume 1

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Introduction and Position of the Problem

Maintainability, availability and safety of equipment, are technical notions that increasingly interest big international harbors. Hence, a detailed report, by CNUCED, has recently addressed the equipment renewal problem [6]. The Algerian harbor companies are now realizing the importance of maintainability problems (cf. [5], [4]).

This work is aimed to support the project of Bejaia Harbor company which is planning to settle a preventive maintenance policy. The project was recently published in Arassif article (Bejaia Harbor Letter, N°14, page 4), meanwhile the company was announcing a purchase of 20 engines. However, this maintenance policy can't be performed without a thorough knowledge of the material's behavior. For instance, preventive renewal is recommended only for usury components with preventive costs higher than curative cost. However, not all usury components have the same ageing rate, therefore, the optimal renewal periodicity vary with the type of components. Thus, reliability analysis is necessary to bring into focus all these features.

This work demonstrates how to carry out a material reliability analysis using its experience fastback. We will give an insight to the application of the obtained result in maintenance decision making. Using reliability, we will see how to

- detect weak sides of the system;
- optimize maintenance cost (life cycle cost optimization);
- detect the components needing preventive renewal and how to establish optimal renewal periodicity.

In the other hand, the study of engines availability, based on: reliability, maintainability and logistic maintenance, has enabled us to answer the following question: which parts should we effect in order to improve the equipment' s availability ?

1. Data of fastback experience

Bejaia harbor company is a joint stock company instituted by the law on the autonomies of companies. Its function is the management, the exploitation, the development and the protection of the harbor equipment. It ensures a global minimum fare for vessels and goods. Maintenance department deals with the repairing and serving of handling engines. It comprises an office of methods, a corrective maintenance workshop and a preventive maintenance workshop (cf. [4]).

The handling engines' office of Bejaia harbor comprises 63 lifting trolleys of different tonnage. A steaker, 06 harbor cranes, 07 mechanical spades, 15 taking trucks and 2 harbor tractors. A machine record is erected for each engine (cf. [7]).

It is only on January 1996 that the department of maintenance had started to keep record of the data related to the engines' failures, although the major part of the engines had cumulated a service time exceeding ten years. In addition of the insufficiency of the data, we have faced some inaccuracies (cf. [7]).

2. Pareto analysis

We have based our study on the cost criterion in order to better direct our work. We have carried out a Pareto analysis to determinate the class of engines that produces the highest cost. We have associated a code for each engine to simplify their identification.

The results of the Pareto analysis are shown on figure 2.1 (cf. [6], page 79). They indicates that 60.64% of costs incurred during the period of study were produced by 34.56% of failures. The engines that have caused these costs, which constitutes 25.5% of engines steal running, will compose the elements of the initial sample.

From this analysis, we can draw a first conclusion : the lifting trolleys of small and medium tonnage generate the most important cost of maintenance. The lifting trolleys of great tonnage, the tractors and the mechanical spades have caused hardly 10% of the total cost.

3. Model for the subsystems' behavior

3.1 Non-parametric modeling of the reliability factor

We opted for the graphical test because it is more suitable with samples of small size. To better appreciate the aspect of the data from which we should make a decision about the distribution F, if it is an IFR age class or a DFR one, we have plotted the trend curve having the highest determinant coefficient R^2.

3.2 Parametric modeling of the reliability factor

The data collected are of the type right multiple censured. Therefore, we have used two suitable methods for this type of data. We have chosen the Weibull, with two parameters, as a model.

3.2.1 Estimating the reliability function using Lyonnet procedure

Its principle is to correct, at each iteration, the range of times of failures the same empirical function. In order to operate the iterative process, it is necessary that the procedure estimating the parameters take into account the corrections made on the ranges of failures' times. Then, it should include the empirical repartition function.

3.2.2 Estimating the reliability function using Kaplan-Meier procedure

The parameters were estimated by the last square procedure, the model was validated using Kolmogorov-Smirnov test with a significant threshold = 0,05.

This part of the study had allowed us to calculate reliability measures for the subsystems, and showed that the major part of the engines, all types concerned, may fail frequently. This is due to the kind of spare parts used.

We have noticed that the validated models by the graphical test agree with parametrical models. Whereas some systems of whom behavior is described differently by the Lyonnet and Kaplan-Meier procedures, the graphical test agrees with the former.

4. Engines' reliability study

The obtained models for engines reliability were validated by both Chi-square and Kolmogorov-Smirnov tests. The behavior modeling for each type of engines had shown that lifting trolleys are reliable than cranes. Reliability curves of failure rates of engines are shown on figure 4.1 and 4.2 respectively.

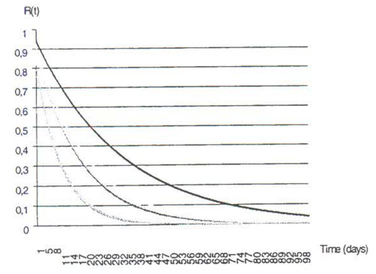

Fig (4.1): Reliability functions of engines

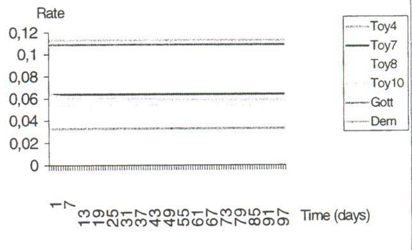

Fig (4.2) : Failure rate of engines

5. Economical renewal study

The matter here is to check which kind of renewal, curative renewal or preventive one, is cheaper. If the preventive renewal is shown to be the cheapest, then the matter is determinate its optimal periodicity.

The cost of failure C_f of a component is assumed to be the amount (of money) lost due to its failure. Hence, C_f is the average hourly income multiplied by the time of immobilization.

The average cost C of curative renewal is the sum of the cost C_f caused by failures and the renewal cost C_p divided on the mean time to failure. The later cost is the sum of spare parts cost C_{sp} and labor cost C_l. Whereas, the average cost of preventive renewal C(T) is a time function (cf. [7]).

Figure 5.1 (cf. [7], p. 79) shows that preventive renewals' cost C(T) of the admission system and the battery is far greater than the renewal curative cost C, this remains true for every period T. Probably this is due to the cost of spare parts which much higher and inaccuracies of information which was used in cost evaluation.

6. Calculation of engines' availability

We have noticed that some engines were sometimes immobilized for several days, even several months, due to shortage of spare parts, whereas their repairing needs only few hours. In order to show the impact that may be caused by supplying delays on engines' availability, we have adopted the following approach :

- First, we have calculated the renewal availability for each engine (i.e. taking into account immobilization), we have denoted this by D1.
- After that, we have calculated availability when this times of immobilization were neglected. The calculated availability was denoted by D2.

- Then, we evaluated unavailability D2 – D1 caused by the waiting time for spare parts. The results are shown on table 6.1.

Engines	MUT(hours)	MTTR(hours)	MDT(hours)	D_1	D_2	$D_2 - D_1$
Toy4	368,79	3,52	123,36	0,75	0,99	0,24
Toy7	189,18	3,63	34,32	0,85	0,98	0,13
Toy8	221,30	4,14	25,97	0,90	0,98	0,08
Toy10	195,97	3,63	24,95	0,89	0,98	0,09
Gott	103,03	9,62	28,93	0,79	0,93	0,14
Dem	106,38	7,88	45,50	0,70	0,92	0,22

Table (6.1) : Engines' availability

We have remarked that

- The lifting trolleys fit better servicing than cranes (the average repairing time for lifting trolleys is less than that of the cranes).
- Unavailability of engines is caused by immobilization times due to spare parts storage or sending parts to subcontracting. Reliability and maintainability have no effect on lifting trolleys availability. However, their effect is more perceptible on cranes. This indication indicates that the stock management policy of spare parts should be reviewed and the repairing mechanism should be enhanced.

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