[1.]Adina BUDIUL BERGHIAN, [1.]Teodor VASIU, [2.]Dragoş BUDIUL BERGHIAN

# DETERMINING THE MAINTAINABILITY OF THE FORD 1850 F–MAX TRUCK

[1.] Politehnica University of Timisoara, Department of Engineering and Management, 5 Revolution Street, Hunedoara, ROMANIA
[2.] "Iuliu Haţieganu" University of Medicine and Pharmacy – Cluj–Napoca. Str. Victor Babeş No. 8, 400012 Cluj–Napoca, ROMANIA

**Abstract:** This study aims to establish the maintainability of the truck through a program carried out over a period of twelve months that includes monitoring of replaced parts and the duration of operations to restore optimal functioning. The data thus obtained were processed using specialized software, namely Weibull++ developed by ReliaSoft, which allows easy analysis of the results through the generated graphical representations. The results obtained from statistical processing allow us to determine whether the service activity is well established with a direct effect on the entity's restoration time.
**Keywords:** maintainability, trucks, Weibull++, Ford 1850

## 1. INTRODUCTION

Maintainability was defined as: The ability of a device under given conditions of use to be maintained or restored to perform its specified function, when maintenance is performed under imposed conditions, with prescribed procedures and remedies. Maintainability represents the design and installation parameter, respectively the ease and safety with which maintenance can be performed. Maintenance is a consequence of design and maintainability and represents the way in which operations are carried out through maintenance and restoration (repair) actions, in order to return the system to its normal operating state [1]. Maintainability refers to design activities, and maintenance is located in the operation (operation) activity.

Briefly, maintainability can be expressed through the notion of repairability and maintenance through the notion of repair [2]. Maintainability as a design characteristic must ensure:

- that an element, subsystem and system is maintained with a prescribed probability in working order, through maintenance activities;
- establishing the size and frequency of maintenance activities;
- establishing maintenance costs, respectively the level of expenses generated by this activity, which does not exceed the approved level per total product.

Maintainability through design activity must ensure [3] [4]:

- interchangeability, which is the property that the elements, subassemblies and component assemblies of a machine or installation can be replaced with similar products of the same kind, with the same characteristics that are currently produced;
- accessibility, which is the property of a complex product to allow easy disassembly and assembly of any component element. When designing and executing elements, assemblies and subassemblies, the way they are placed and the ease with which they can be operated must be taken into account;
- diagnostic availability, which represents the possibility of determining the technical condition of the operating parameters of the component elements through high–resolution measurement techniques. The design must provide for the measurement points, devices, methods, frequency and recording mode;
- the quality and reliability of the component elements and of the entire system. If redundant elements are also provided for technical and economic reasons, their operating mode must also be established;


ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

- spare parts and spare parts in accordance with the type and frequency of maintenance activities;
- establishment of handling and transport conditions and means;
- level of manufacturing, maintenance and warranty costs per product;
- environmental protection and safety measures in operation and maintenance activity;
- service activity, namely the workforce and intervention means (tools, devices, etc.) with which the maintenance activity is effectively carried out.

## 2. METHODOLOGY ON DETERMINING MAINTAINABILITY

In studies regarding the establishment of maintainability, it is necessary to observe the behavior of the entity over a certain period of time, a period in which the moments in hours, minutes, km, etc. are noted, in which a change in optimal functioning, the defect, the cause of the defect, and the repair time for each of these are observed.

The defects that occurred in the operation of the FORD 1850 F–MAX truck over a period of 12 months are presented in Table 1.

Table 1. Occurred defects and repair time

| Nr.crt. | Defects | Repair time [h] |
|---|---|---|
| 1. | brake sensor | 2 |
| 2. | engine coolant expansion tank | 1 |
| 3. | engine oil level sensor | 4,4 |
| 4. | drum temperature sensor | 2,9 |
| 5. | attack pinion seal | 3,8 |
| 6. | front chassis shock absorber | 1,8 |
| 7. | adblue probe | 2,4 |
| 8. | adblue injector | 1,4 |
| 9. | catalytic converter gaskets | 4,6 |
| 10. | transverse steering rod | 2 |
| 11. | longitudinal steering rod | 2 |
| 12. | engine crankshaft | 84 |
| 13. | rear axle bearing | 3,8 |
| 14. | EGR cooler | 8 |
| 15. | engine cylinder head | 20 |

The restoration times were statistically processed using the specialized Weibull++ software developed by ReliaSoft [5], in order to determine the maintainability of the Ford Trucks 1850 F–MAX truck.

ReliaSoft Weibull++ from Hottinger Bruel & Kjaer Inc. is the industry standard in life data analysis for thousands of companies worldwide. Accelerated Life Testing (ALTA) provides intuitive and easy–to–use mathematics for a highly complex and powerful use case model for quantitative analysis of accelerated life test data. Reliability Growth (RGA) is a powerful software tool that allows you to apply the Reliability Growth Model to analyze data from both development tests and field–repairable systems. During the development stage, the software allows you to quantify the reliability gains achieved with each successful design prototype and also provides advanced methods for reliability growth design, planning, and management. For field–operating systems, RGA allows you to calculate optimal overhaul times and other outcomes without the data setup that would normally be required for repairable system analysis.

## 3. RESULTS ON DETERMINING MAINTAINABILITY

Regarding maintainability, it is found that it complies with the lognormal distribution law, a fact certified in figure 1 and the distribution law of the repair times is lognormal [6], with the correlation coefficient 0.908282. The mathematical expression of the maintainability law is:

$$M(\tau) = 1 - \int_0^{\tau} \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{(\lg x-\mu)^2}{2\sigma^2}} dx \quad (1)$$

where: x is the random variable; μ is the recovery rate; σ is the standard deviation; $\sigma^2$ is the variance. Following the processing of the obtained data, the results were obtained in graphical form presented in the figures below.

The maintainability graph as a function of time (figure 2) shows that the service activity for the truck is well organized. It is found that maintainability increases in approx. sixty hours, which means that the probability of restoring the truck after failure approaches 1 in this time interval. Considering the complexity of the entity, regardless of the mechanical or electrical problems that arise during operation, they will be remedied in sixty hours at most, which is an advantage. [7]

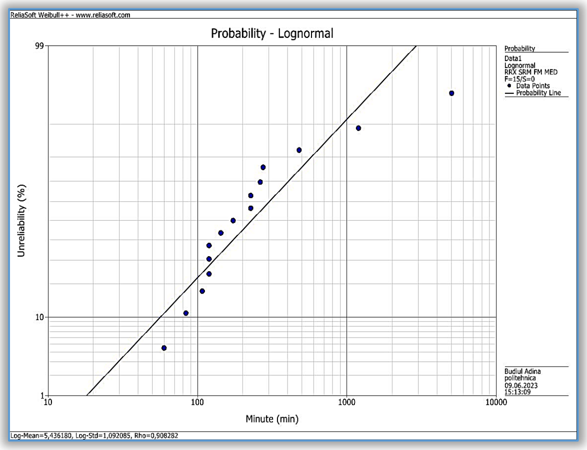


Figure 1. Maintainability graph versus time in Cartesian coordinates

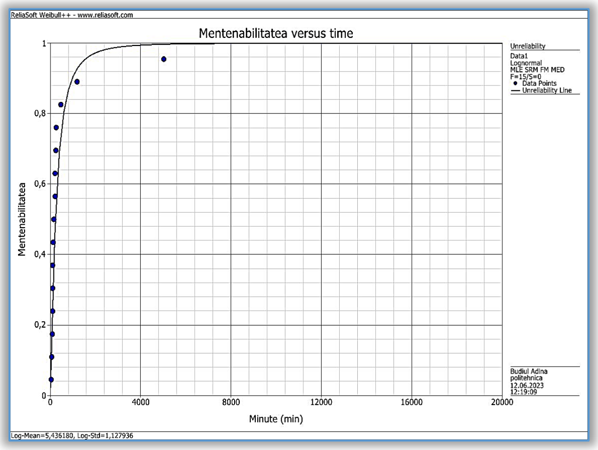


Figure 2. Maintainability graph over time

The dependence shown in Figure 3 is actually called the repair rate and its evolution is normal, because during the warranty period hidden defects manifest themselves, then it has an approximately uniform evolution during the normal life of the entity. [8], [9]

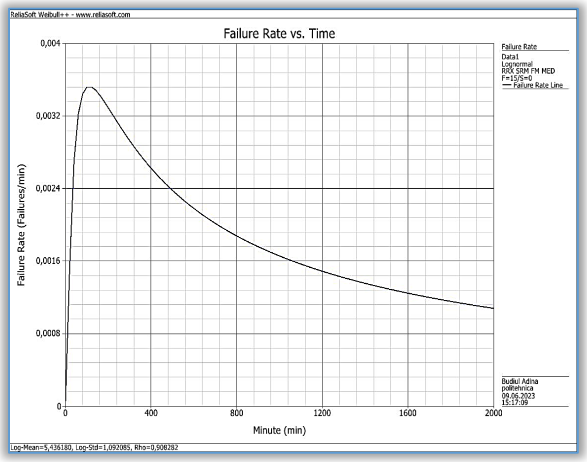


Figure 3. Graph of recovery rate versus time

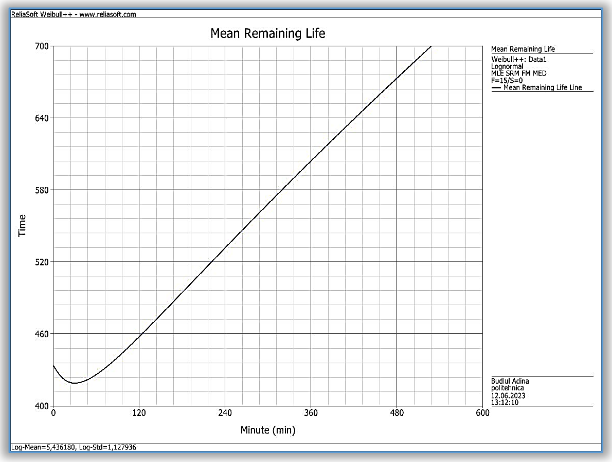


Figure 4. Time remaining until next maintenance

The dependence represented in figure 4, namely the time remaining until the next intervention, has a favorable evolution, which certifies that the truck is at the beginning of the normal period or the life period which represents the main period of operation with the longest duration (maturity).

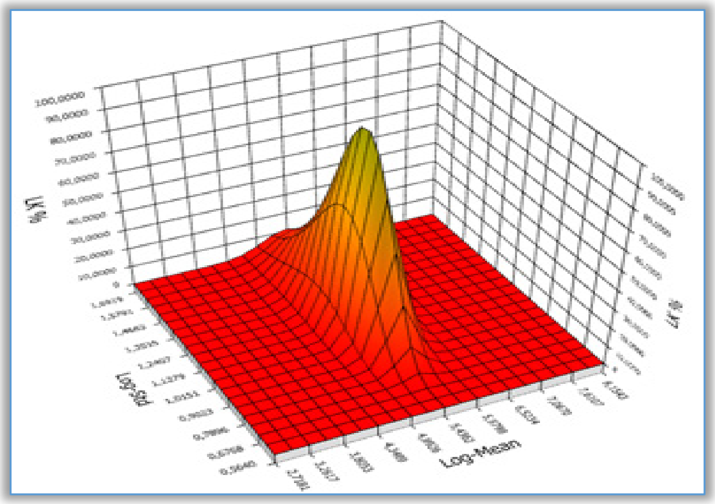


Figure 5. Graphical representation of the Likelihood function

A likelihood function (figure 5.) measures how well a statistical model explains observed data by calculating the probability of seeing that data under different parameter values of the model. [10]

## 4. CONCLUSIONS

Establishing maintainability is a critical aspect in the design, operation, and optimization of modern technical systems. Maintainability refers to a system's ability to be efficiently maintained and repaired with minimal resources and downtime, thereby ensuring optimal equipment availability and performance.

In the context of truck operations, maintainability has been observed to follow a lognormal distribution. Analysis indicates that the process of restoring the truck to operational status is well–organized, with maintainability increasing rapidly within approximately 60 hours post–failure. This suggests a high probability—approaching 1—of successful restoration within this timeframe, highlighting the effectiveness of the maintenance process.

Furthermore, the time until the next required intervention demonstrates that failures during this period occur randomly, with a low and relatively constant failure rate. This interval represents the system's reliable operating phase, which is critical for performance analysis and optimization. Efforts to extend this phase form the core of reliability improvement studies, aiming to enhance operational continuity and reduce downtime.

In conclusion, establishing maintainability is not merely a technical component but a strategic imperative for ensuring efficiency, safety, and sustainability in industrial operations. Implementing a proactive approach to defining and monitoring maintainability significantly contributes to the long–term success of organizations.

**References**

[1] Budiul, B., A., Vasiu, T., Reliability and maintainability of industrial entities. Theory and applications, "INFOMIN" Publishing House, Deva, 2008;
[2] Vasiu, T., Reliability of electromechanical systems, Bibliofor Publishing House, Deva, 2000;
[3] Boroiu, A., Mihail Aurel Titu, M., Systems reliability and maintainability management, Publisher: A.G.I.R., 2011;
[4] Simionescu, C., S., Machine maintenance and reliability, Publisher: A.G.I.R., 2014;
[5] https://www–hbkworld–com.translate/products/software/analysis–simulation/reliability,
[6] Lazăr, I., A guide for statistical analysis of data in the educational research, Cluj University Press Publishing House, 2019;
[7] Alexandru, A., Caragea, N., Statistica. Concepte, tehnici si instrumente software, Editura: Pro Universitaria, 2018;
[8] Soltanali, H., Garmabaki, A.H.S., Thaduri, A., Parida, A., Kumar, U., & Rohani, A. (2019). Sustainable production process: An application of reliability, availability, and maintainability methodologies in automotive manufacturing. Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability, 233(4), 437–449;
[9] Budiul Berghian, A., Vasiu, T., Birtok Băneasă, C., Determination of Maintainability for Dacia 1304, 1,9 D utility vehicle, IOP Conference Series: Materials Science and Engineering, volum number 294/1/012040, 2018;
[10] https://en.wikipedia.org/wiki/Likelihood_function.

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665