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ESTABLISHING RELIABILITY OF THE FORD 1850 F–MAX TRUCK

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Abstract: Reliability measures the probability a system performs without failure over a specific time under stated conditions, while availability gauges the proportion of time the system remains operational and accessible overall. Reliability focuses on failure prevention, quantified by metrics like mean time between failures, emphasizing consistent correct operation. In automotive high–performance computing, reliability ensures computation integrity during operation, while availability maintains system access via redundancy, critical for safety–critical composites and sustainable manufacturing uptime. Balancing both reduces downtime costs in circular economy processes. This study aims to establish the reliability of the truck through a program carried out over a period of twelve months, that includes monitoring of operational behavior, namely the number of kilometers at which defects occur, the causes of these defects, the downtime, etc. 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 estimate the reliability of the truck and make possible decisions regarding the improvement of its operating behavior.
Keywords: reliability, failure, defects, accidents, overload, wear, FORD 1850 F–MAX truck

INTRODUCTION

RELIABILITY quantifies the likelihood that a system, component, or product performs its required function without failure over a specified time and under defined conditions. Reliability depends on mission time (e.g., operational hours or cycles), environmental conditions, and failure modes. In engineering, reliability guides redundancy, monitoring, and testing to achieve system–level targets, even if individual parts have lower reliability. Automotive and industrial systems, like those in high–performance computing, prioritize it for safety and cost–effectiveness.

RELIABILITY, denoted by R, is the ability of a product to perform a specified function, under specified conditions and for a specified period of time. It should be viewed as the probability that no failure will occur during the specified period of operation that would affect the performance of the required function. This should not be understood as meaning that some component parts are not allowed to fail, but through appropriate restoration activities, they will be maintained in operation. [1]

Reliability being a probability [1], it is deduced that it will admit values between 0 and 1, but also that it cannot be measured directly, being determined based on probability theory and mathematical models.[2]

Since reliability is the probability of functioning without failures, its disjunct is the probability of non–functioning, respectively of failures. Failure is the fundamental event in reliability theory. Failure or failure is understood as the process of cessation of the function imposed on a product. If a product must function for a certain period of time, it can be considered to fulfill a mission, and the result can be "success" or "failure". Defects can be caused by accidents, overload, wear, etc.

Reliability, as the probability of good operation, rests on three fundamental criteria:

- probability,
- function, and
- environment.

The three criteria of reliability, i.e. the probability of good operation, are: [3]

- failure rate z(x);
- mean time between failures MTBF;
- viable life VR or quantile p: $p = 1 - R$ the corresponding time of failure. It is calculated in the design phase (predictive reliability), estimated through tests carried out on prototypes and zero series in the development phase (potential reliability) and confirmed by operation during the useful life of the equipment (operational reliability).

In the reliability design phase, the main drawback is the lack of statistical data (from operation or from the manufacturers of materials, parts or subassemblies), but the most important disadvantage is the duration and difficulty of probabilistic dimensioning calculations due to the lack of adequate computer programs. Ensuring the requirements of precision and complexity in design requires the transition, based on probability theory, to the use of computing techniques. [4]

Probabilistic design is the most realistic way to estimate manufacturing, operation and maintenance costs.

METHODOLOGY ON DETERMINING MAINTAINABILITY

To establish the reliability of the truck, an observation program was drawn up over a period of twelve months, which includes data on: the times at which changes occur in the condition or behavior of the truck, the time of commissioning after the last repair, the time of interruption of operation, the time of re–commissioning, the time of the fall, the time of re–commissioning after the causes of the fall were eliminated, the causes of the falls.

Maintainability quantifies how quickly and economically a system can be repaired or restored to operational status after failure, often predicted using standardized methodologies. Procedures break down maintenance into subtasks, factoring in accessibility, diagnostics, and tools, with predictions at design, prototype, or production stages.

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	Number of km at which the failure occurred
1.	brake sensor	12.819
2.	engine coolant expansion tank	21.719
3.	engine oil level sensor	28.200
4.	drum temperature sensor	43.353
5.	attack pinion seal	47.253
6.	front chassis shock absorber	47.253
7.	adblue probe	57.553
8.	adblue injector	57.553
9.	catalytic converter gaskets	72.268
10.	transverse steering rod	80.423
11.	longitudinal steering rod	80.423
12.	engine crankshaft	127.480
13.	rear axle bearing	137.200
14.	EGR cooler	227.189
15.	engine cylinder head	275.213

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

ReliaSoft Weibull++ from Hottinger Bruel & Kjaer Inc. offers a powerful suite of reliability estimation software solutions to facilitate a comprehensive set of engineering reliability modeling and analysis techniques. ReliaSoft Weibull++ is a complete life cycle analysis tool that performs life data analysis using multiple life distributions, warranty and degradation data analysis, experiment design, and more, with a clear and intuitive interface geared toward reliability engineering. The software offers optional licensed features of Accelerated Life Testing for accelerated test planning and analysis, as well as Reliability Growth to analyze data from both development tests and field–repairable systems to monitor reliability and predict failures ahead of time.

Specifies operating conditions like temperature, vibration, humidity, or pollution exposure, critical for context-specific predictions in sustainable manufacturing. Reliability holds only within stated environments, necessitating stress testing for real-world validation.

RESULTS ON DETERMINING MAINTAINABILITY

The certification that the real reliability of the studied truck complies with the Weibull distribution law can be seen from figure 1, which shows the Alain Plait diagram whose double–logarithmic coordinates show the time dependence of the cumulative relative frequency.

The calculated values of the Weibull law parameters are, with the correlation coefficient $\rho=0.977$: $\beta=1.419581$, $\eta=150960.807$. Therefore, the mathematical expression of the reliability distribution law of the Ford Trucks 1850 F–MAX is: [6]

$$R(x) = e^{-\left(\frac{x-\gamma}{\eta}\right)^{\beta}} = e^{-\left(\frac{x-0}{150960{,}807}\right)^{1{,}419581}} \qquad (1)$$

where:

– x is the random variable;
– β is the shape parameter;
– η is the scale parameter;
– γ is the position parameter.

Following the processing of the obtained data, the results were obtained in graphical form presented in the figures below.

From figure 2, reliability chart based on km, it is noted that the reliability has a sharp decrease since the moment of putting the machine into operation. Respectively, it is observed that the reliability of the truck drops below 0.2 over 170,000 km. [7]

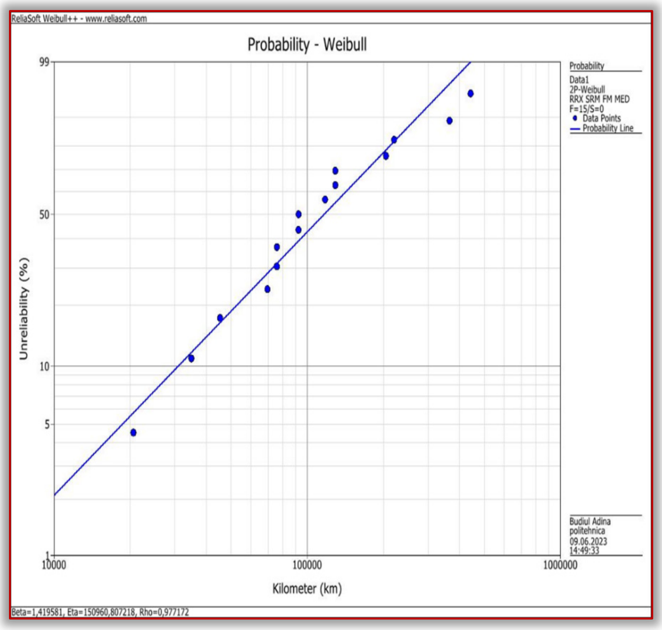

Figure 1. Alain Plait diagram

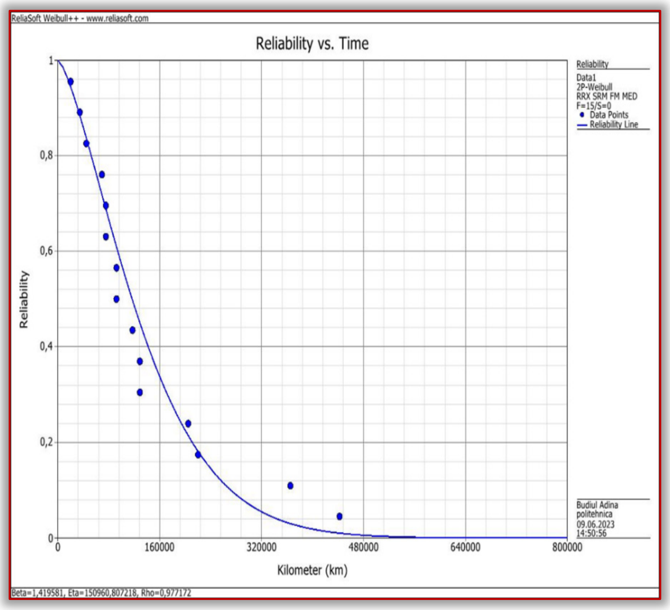

Figure 2. Reliability chart based on km

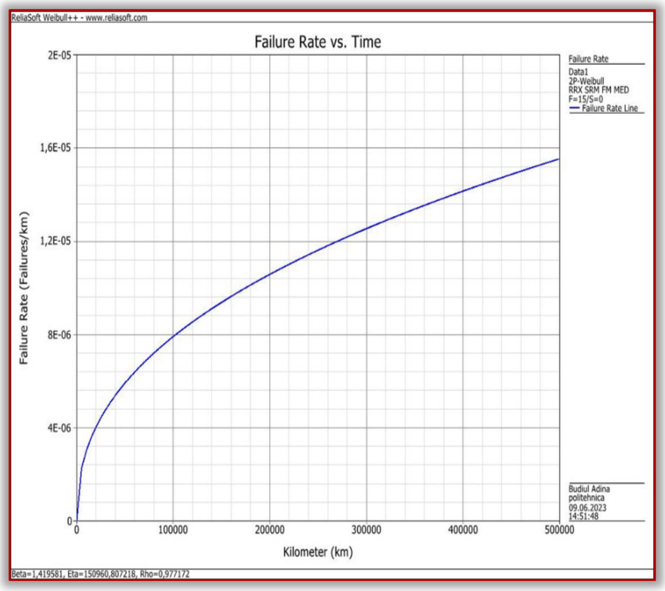

Figure 3. Graph of failure rate by km

The dependence shown in figure 3, the failure rate as a function of km, has a rapid increase up to 170,000km of distance traveled, meaning that the car's warranty period, the moment when reliability reaches the value of 0.2. [8], [9]

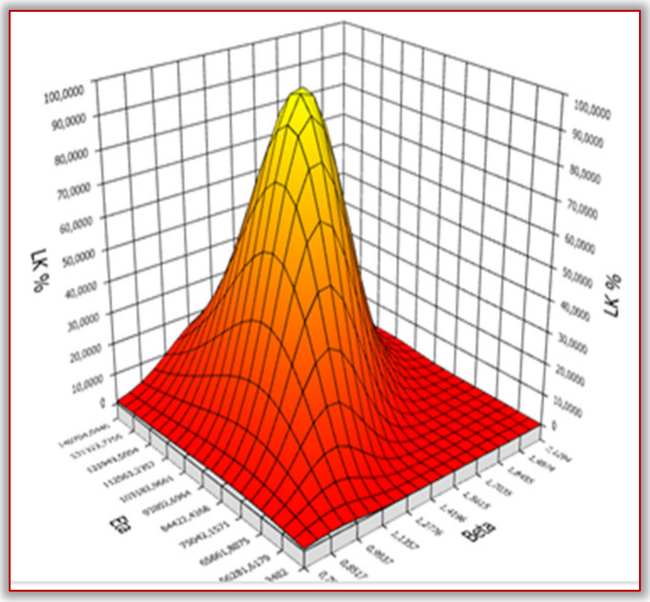

Figure 4. Graphical representation of the Likelihood function

A likelihood function (figure 4) 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]

The real reliability of trucks, including haul and dump models, frequently follows the Weibull distribution law, as evidenced by failure data analyses in mining and heavy-duty operations.

CONCLUSION

Establishing reliability is a critical aspect in the design, operation and optimization of modern technical systems. Reliability refers to the ability of a system to perform its intended function under specified conditions and for a specified period of time, thus ensuring the availability and optimal performance of the equipment.

In the context of truck operations, reliability has been observed to follow a three–parameter Weibull distribution.

By plotting graphs using Weibull ++ software, it is found that reliability has a sharp decrease since the moment the machine is put into operation. The points that contribute most to the appearance of defects must be analyzed with great responsibility both in terms of the quality of the material and processing, and in terms of their assembly and transport.

Also the failure rate increases rapidly up to 170.000km distance traveled, that is, the warranty period of the car, during which free maintenance operations are performed, respectively in accordance with the terms of the sales contract, which implies high costs on the part of the manufacturer. Although these interventions are during the warranty period, given that the truck is purchased for the transport of goods and goods, the duration of the interventions brings frustration to the car owner.

In conclusion, establishing reliability is a strategic imperative for ensuring efficiency, safety and sustainability in industry regardless of its nature. Implementing a proactive approach to defining and monitoring reliability contributes significantly to the long–term success of companies.

References

[1] Vasiu, T.,– Reliability of electromechanical systems, Bibliofor Publishing House, Deva, 2000;
[2] Budiul, B., A., Vasiu, T., Reliability and maintainability of industrial entities. Theory and applications, "INFOMIN" Publishing House, Deva, 2008;
[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 Reliability for Dacia Solenza 1,9D, IOP Conference Series: Materials Science and Engineering, volum number 477/012044, 2019;
[10] https://en.wikipedia.org/wiki/Likelihood_function.

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