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Towards a first implementation of the internal Weibull Distribution in Power BI and the related Software architecture

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It is inevitable for companies to maintain reliability data for prediction. For this reason, it is important to perform reliability calculation with defined assumptions. The outgoing idea here is the dependency of both the data and the reliability information from external sources. This idea constitutes the starting point of this study. The Weibull distribution function was calculated within the company. The function graph was obtained and reflected in Power BI. This paper shows the results architectural topology of the reliability data Software and presents the Weibull distribution of failed parts. This curve shows the linear distribution of the failure numbers of related failure categories. The advantage of Weibull analysis without using external software is to develop the intern know-how and be able to control the calculation which allows an independent view. The development of the software and the data maintenance are one of the complexes works for gaining valuable results and prediction for the devices in the field.

Keywords: Reliability, availability, maintainability, Weibull Distribution, Software architecture

1. Introduction

With developing technology, reliability gains great importance. This development also causes complex product designs. At this point, run time and other necessary data in case of errors and their sustainability are also other important factors. Especially calculating and knowing sustainable data and reliability parameters are indispensable for companies. System and component reliability examines the behavioral features of the products. This review considers the performance of the system's desired functions for a specified time period. Reliability is not a phenomenon that can be measured directly and is subject to a stochastic process. In this process, measurements can be described qualitatively and quantitatively. The basis of this definition is the possibility of survival. It is necessary to distinguish between the deterministic properties of the system and the component. Deterministic features also refer to product characteristic that can be measured. It is necessary to make a distinction between these features such as weight, dimensions, electricity and thermal conductivity. Reliability is a concept inherent in systems and the high technologies they contain. No technical product is immune from the possibility of malfunction and today it is being reviewed in much more detail. Product reliability is determined empirically and by calculating the reliability values of the product parts, and this period occurs analytically. In the case of simple technical devices, the empirical approach is usually chosen. In the case of complex large-scale industrial plants, proof of reliability with regard to hazardous conditions can usually only be carried out analytically.

2. The Main Text and Important Considerations of the Paper

The paper shows the Weibull distribution in Power BI application and therefore provides great support for dynamic considerations. The failures are displayed in Power BI and their error types are shown in different colors. This provides an important perspective on the types of errors in the visualization presented. The advantage is that the process is controllable, and the failures are categorized. The Weibull distribution is useful for finding the focal points of the failures. This distribution is used in statistical analysis to obtain failure rates of various types of systems. The Weibull distribution can provide valuable insight into the reliability of a system, enabling better decision making and more efficient for maintenance strategies.

The other important aspect is the Weibull Distribution and the related Beta factor by using of the software Weibull++. This paper shows the Beta values between internal calculation and assumption of the Weibull 1P-method by Weibull++ Software. The results will be presented in next sessions.

3. Reliability Analysis

This section shows the necessity of the modelling and the related reliability parameters. Major change is the application of Power BI by of the Weibull distribution with failure categorizations.

3.1.1. *Purpose of the data modelling*

The main philosophy is to realize the Weibull distribution function in Power BI with real Beta value and show failure categories of the failed parts. After gathering data from OneSubsea reliability database, the reliability results are going to be presented in the software. The other important point is the update opportunity of the Power BI for multiple users. The availability and maintainability actions for data is important actions.

The other important parameter is the calculation of realistic Beta value for understanding lifecycle and show the failure categories. Therefore, the software Weibull++ will be compared to internal calculation of the linear transformed Weibull distribution function including the beta factor.

3.1.2. *Reliability Parameters*

In order to internalize the fundamentals of the Weibull analysis in Power BI application, and the related other parameters, it is essential to rewrite the meaning of specific terms. As a matter of fact, the terms are as important as the calculation. The reliability terms like MTBF, failure rate, Weibull distribution, Beta factors are essential. The definition of the reliability is as also important, and the meaning of the terms are given below:

- Reliability: „The ability of an item to perform a required function under given conditions for a given time interval. " (IEC 60050, 191-02-06). „The probability that an item can perform a required function under given conditions for a given time interval. "(IEC 50, 1992). „The capability of the software product to maintain a specified level of performance when used under specified conditions. " (IEC 9126-1, 2001)

- MTBF: Mean time between failures [2] is the useful or operation time for the related equipment or component. The repair action can be done by happening of failure cases.
- MTTF: Mean time to failures [2] means the useful time or operation time until the failure happens in system or component. The repair mechanism is not possible.
- Beta factor: The Beta factor (β) is a parameter of the Weibull distribution that determines the shape of the distribution curve. It can take various values, each representing different failure patterns.
- Failure rate: The failure rate [2] is ratio of failures to total time. In useful time, the failure rate of the equipment equals to 1/MTBF.

A. *3.1.4. Weibull Analysis and related equations*

The Weibull distribution is a continuous probability distribution that describes the probability that a particular event will occur given a value of random variable. It is parameterized by two parameters scale parameter λ and shape parameter (b). Understanding the Weibull distribution is critical for reliability engineering, durability testing, and other areas where failure rates must be estimated or predicted. The equations for calculation of the parameters are based on Weibull distribution and this is useful in reliability equations. Even early failure or random failure or wear out failures are presented with the Weibull distribution. The relevant reliability function equation is given below:

$$R(t) = e^{-(\frac{t}{T})^{b}} \quad (1)$$

The equation shows the reliability function R(t), the characteristic lifetime T, which is the 63,2 % of failure rate and the rest reliability equals 36,8 %. The formfactor or the beta factor equals b. The failure distribution density function is given below:

$$f(t) = \frac{b}{T} \cdot (\frac{t}{T})^{b-1} \cdot e^{(-\frac{t}{T})^{b}} \quad (2)$$

The failure rate is given below

$$\lambda(t) = \frac{b}{T} \cdot (\frac{t}{T})^{b-1} \quad (3)$$

The calculation of the ordinate parameters are going to be presented in the following formula:

$$X = \ln(t) \quad (4)$$

$$Y=\ln(\ln(\frac{1}{1-F(t)})) \quad (5)$$

$$Y=bX-b\ln(T) \quad (6)$$

The main purpose of these operations is to create a linear function for failed components. Therefore, the Weibull distribution is going to be created in linear form. The linear function allows to show the failed parts in controlled time interval. Therefore, the usage of the Weibull is especially for the failure recurrence is essential and this application is valuable to detect the correlations.

3.1.5 Reason of the evidence

The external used software for Weibull visuals uses the Weibull 1P MLE method. The parameter beta is constant value and the causations are right censored. The maximum likelihood estimation (MLE) bases on right censored parameters with assumed Beta value, does not present as reliable results. Without implementing the physical failure mechanism in MLE -1P with assumed Beta value, calculation result shows random failures. Under these cases, the calculation method must be proved, and the calculation method will be given in next session.

3.1.6 Calculation with LSM for comparison

The calculations bases on Least Squares Method. The steps are given below:

1. Linearization of the Weibull distribution by logarithmic transformation
2. Fitting a straight line to the transformed data points.
3. Ranking calculation with Rang method
4. Linear regression application on transformed data. The independent variable is ln(t) and the dependent variable is ln(-ln((1-F(t)))
5. Determine the parameters from the slope and intercept of fitted line

The LSM does not use in this calculation for any censored data. The real field parts and their down time are given in the Table 1. The number of failures for creating Weibull Distribution diagram is enough and thus, the calculation shows realistic results. For 2P-Distribution Function, the X and Y Axis equation are given in session 3.1.4. with related equations (4) and (5). The following visual shows the X and Y axis values. The ranking

Table 1-Failed parts from field [3]

failure	time [hours]	ranking	X-Axis	Y-Axis
1	24	0,083333	3,178054	-2,44172
2	24	0,202381	3,178054	-1,48667
3	696	0,321429	6,54535	-0,94735
4	1129	0,440476	7,029088	-0,54357
5	5019	0,559524	8,520986	-0,19857
6	23656	0,678571	10,07137	0,126615
7	31462	0,797619	10,35654	0,468505
8	35916	0,916667	10,48894	0,910235

The ranking values are bases on Bernards approximation:

$$F(t_i)= \frac{i-0.3}{n+0.4} \qquad (9)$$

The visual wit related equations and the Weibull distribution diagram is given below:

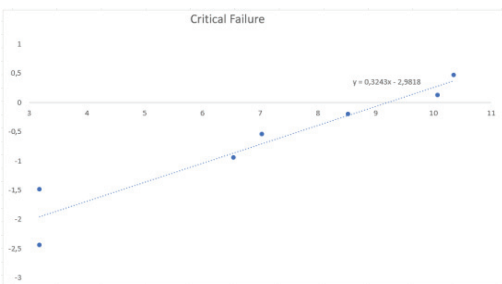

Figure 1-Linearized Weibull distribution function

The Beta factor equals 0,32. R-squared value of 0.92, which is a 92% best fit measure. This calculated Beta values is lower than the Beta value estimated by Maximum likelihood estimation used by extern software.

4.*Software architecture and Power BI result*

The topology is one of important bases and dataflow is built up like Figure 2 [1], which shows the communication path. The user interface, Services and the database build the main components. The dataflow starts from User interface to service and to the database.

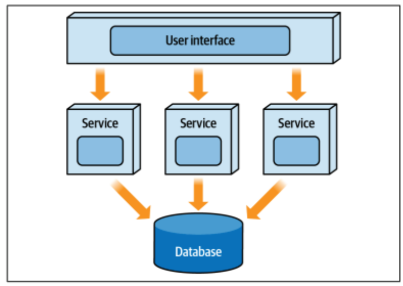

Figure 2-Dataflow between user and data source as Ref. [1]

The figure 3 shows the OneSubsea solution and the architecture allows to communicate with OneSubsea database, events, runtime and Weibull file. The Power BI gets the information from Database. This information flow between Database and Power BI is realized by getting information from run-time, field events and Weibull distribution. The related key parameters are obtained carefully and transferred into the Power BI.

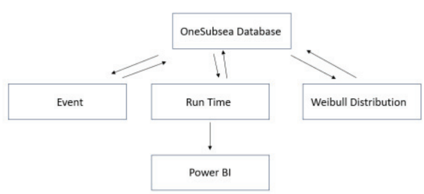

Figure 3-Dataflow between user and data source as Ref. [1]

The intention to be demonstrated in this study is to associate Weibull analysis with failure categories and to form the basis of deep analysis with internal software. For this study, the results are going to be compared and will be presented in next section. The previous data flow process is given below:

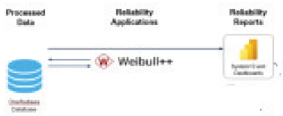

Figure 4-Dataflow between user and data

The Figure 4 shows the dependency to Weibull++ Software.This software was used to create the Weibull distribution with external software. The new data flow is given below:

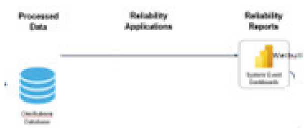

Figure 5-New Dataflow between user and data

The Figure 5 shows the created Weibull distribution with Power BI. Creating these results by simply following internal dynamics and ensuring accessibility anytime is a valuable step which have taken in an innovative sense. The comparison of the Beta values is given below:

Table 3. Failure categories.

Software	Beta
Weibull ++, 1P; MLE	1
Power Bi ; LSM	0,32

Eta-MLE-1P equals 360 years and the Eta value calculated by LSM equals 4576 hours. The Weibull distribution created by Power BI -2P is given below:

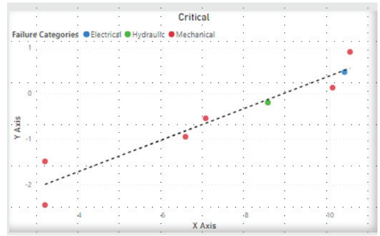

Figure 6-Internal creation- Power BI result ref [4]

Internal created Weibull analysis allows a connection between errors that occur with failed components (internal creation). During former studies, with ReliaSoft (Weibull ++) created results did not show the failure categories. The new process sequence is as follows:

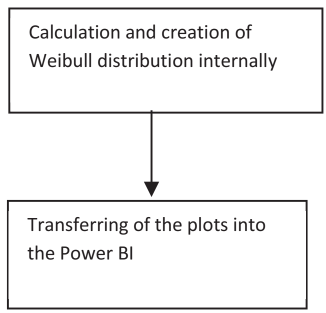

Figure 7- Data sequence

The sustainability of the program includes processes such as development, repair, and updating of the new Weibull distribution function. This process is perceived as a natural part of development. The failure categories like electric, mechanic and hydraulic are included into the Weibull distribution function. In order to understand the field related failures, the categorization becomes essential. The iterations of the related failures and the failure occurrence time is also important parameters for the calculations and for the transferring in Power BI application.

5. Table and summary

As shown in the Table 3, the error categorization in Weibull distribution becomes visible and the number with corresponding numbers is clearly presented. For a realistic representation and interpretation of the results, the error category must be known. This philosophy aims to show realistic reliability analysis in Power Bi application.

Table 3. Failure categories.

Equipment[a]	Category of failure	Number of critical failures
EQ1	Mechanic	6
EQ2	Electric	1
EQ3	Hydraulic	1

The table 3 presents the number of the failures and categorize the failed equipment's regarding their failures. The failure categories in table and Power BI result are mechanic, electric and hydraulic failures. In case of failure occurence and correct failure categorization, erroneous calculations can be prevented. The distinguishing of the failure is for deep reliability analysis indispensable. The software shows results dynamically with failure categorization which will lead in the future and will show significant advantages for industrial applications.

By comparison of the Beta values, the failure does not belong to random process. The results calculated by LSM method equals 0,32 and the characteristic lifetime is 4574 hours. This result is comparable with downtime values given in the Table 1. The junction into the Power BI diagram shows the failure categories which is important for separation of the failure categories. The physical features are given in diagram which shows realistic interpretations. The software Weibull++ software is not able to show the failure categories and only creates trendline under assumed values of Beta because of the MLE 1P-cestimation. Neither Beta value nor Eta value not comparable with the values given in the table 3. In order to avoid this misinterpretation, the LSM methods is applied and shows realistic Beta value and Eta values with failure categories in Power BI diagram.

References

[1] Richards, Mark. (2022). *Software Architecture Patterns*. Publisher Name.
[2] Birolini, Alessandro. (1997). Zuverlässigkeit von Geräten und Systemen. Springer verlag
[3] Özbilen, Tunc. (2024). Software for Reliability in Power BI
[4] Reliasoft. Reliasoft Weibull ++ . Edition RW9S

Footnote.[a]

[a] Equipments are from the same product family