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REVIEW OF SIX SIGMA

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Abstract
This article focuses on the criticism of the Approach The Six Sigma in showing a few weak points of the Approach The Six Sigma and that it cannot be applied regardless of the problematic, we focus on this observation in taking as real case, maintenance and in particular when it is the reliability of industrial equipment.

Introduction
The approach Six Sigma has been developed in the middle of the 1980s by the US company Motorola which operates on the sector of electronics. The said approach is a methodology based on the improvement of the performance of the manufacturing process, as well as the quality of the products, and by way of consequence, the satisfaction of clients, responding to their requirements. The main purpose of Six Sigma, being the reduction of variations in the manufacturing process that cause of faults and generate unacceptable gaps in relation to the average and the target required by the customer of the company. Operational excellence in the framework of Six Sigma corresponds to 3.4 defects per million of opportunities. By doing this, it is possible to increase the financial profitability of enterprises. In this framework, Motorola having claimed to have saved several million dollars, while General Electric. By managing several projects Six Sigma has added over $300 million in operating profit for the financial year 1997. However, despite its success perfect, Six Sigma can be criticized. This article attempts to answer the question, what are the weak points of Six Sigma.

Presentation of The Approach The Six Sigma

Criticism of the philosophy Six Sigma
Referring to the history of philosophy Six Sigma, the latter is, in part, a synergy between the approach TQM (Total Quality Management) and the approach Statistical Process Control (SCP), however, it remains very tainted by the culture of Motorola. In this framework, we are seeing a pure and simple release of Six Sigma in all companies and this regardless of the Sector of activity. We find, for example, parameters that are not adapted to all sectors of activity, such as the maintenance. The basic parameters of Six Sigma, namely, the standard deviation **σ** which is linked to the normal law, as well as the notion of the DPMO (Default by million of opportunity) may not be used to the concept of reliability in the field of maintenance. On the other hand, the failure rate **λ** which is essential may not be represented or by the control cards nor by the normal law which considers itself as the main aspect of the Approach Six Sigma. On the other hand, the philosophy Six Sigma depends strongly on the AIAG standard (Automotive Industry Action Group) specifying the methodology for the evaluation of the capability of the Measure System specific to the manufacturing process of the automotive sector. As to the methodology DMAIC (Define, Measure, Analyze, Improve, check) characterizing the approach Six Sigma in stating it is based on the measures and statistics, it is wise to note that even the approach of Deming (PDCA, Plan, Do, Check,…), there is also a use of indicators and measure and this to better evaluate the actions of the improvements made, that it is possible to strengthen by field visits the reality on the ground. Certainly the DMAIC the particularly stresses this aspect of structured the measure as scientific method but it must bring a critical eye. Some authors feel that the approach DMAIC remains a variant of the PDCA approach.

The lack of integration of automatic data

At the time of the phase "measure", the approach Six Sigma does not clearly statistical solutions capable of treating the data already saved from the sources of structured data according to models of transactional storage and multidimensional [1] (Excel files bases,…). We quote the databases relating to information systems implemented within companies such as ERP (Enterprise Resources Planning, the MY (Manufacturing Execution System) [2]. In the case of the equipment of the production requiring a improvement of the reliability, the collection of data that characterize a process which will be the subject of an improvement through Six Sigma therefore does not require a plan for the collection of data [3] nor a study " Gage of Repetability and Reproductibility (GR&R)[4]. There is a wealth of data that is done without human intervention, subject of automatic stations, as the plcs of monitoring industrial equipment registering a lot of parameters very rich in education as regards the failures that the said equipment can suffer. These stations allow the acquisition of data and their storage in a transactional database through the local industrial networks related to computer networks which ensure the dissemination of the data and allow the supervision in "real time" of different equipment of the production system. Therefore, it is important to rethink the concept system of measurement which takes into account the different formats Automatic data when it comes to the improvement of the reliability of industrial equipment. Measure System Analysis (MSA) is not adapted to the maintenance. At the time of the phase "measure" of the Approach The Six Sigma, it is essential to choose a system of measurement of critical parameters required by the client (CTQ) and its capability to produce measures reflecting the reality so that each drifting between two successive measure reflecting that this is really a drift in the process [4] object of the Six Sigma project. In this perspective, the standard AIAG (Automotive Industry Action Group) fixed the reference framework for the_Measure System Analysis[5]. According to this standard, a system of measurement is acceptable if the share in % of the variability of the system to measure in relation to the total variability of the process is significantly lower than 30% [5]:

- Case 1: A variability in % less than 10%, the measurement system is accepted.
- Case 2: A variability in % between 10 and 30%, the measurement system can be accepted, but it is strongly recommended to carry out the improvements on the said system for the new variability in % is reduced to the first case.
- A value greater than 30%, the measurement system can not be accepted and must be improved. If you look at the Column % contribution, the corresponding standards are the following.

This concept of the system of measurement is not valid in the case of the maintenance, including the key parameters of the performance are already known and are standard. In this framework, we include mainly the Overall Equipment Effectiveness (OEE) for measuring the efficiency of machines [6], the MTBF (Mean Time betwen failure), as well as the MTTR (Mean Time To Repair), on the other hand, during the phase "measure", once the measurement system is acceptable and this according to the requirements of the standard AIAG, there is a need to develop a data collection plan [3] which must contain eight (8) columns, namely:

- **What** : Designation of the parameter to measure
- **Type** : Type of parameter (real, boolean, …)
- **When** : When measure this parameter
- **Who** : Who should the measure
- **Or** : Or the measure
- **How** : How the measure
- **How many** : Frequency of Measurement
- **With** : With what means of measurement

As regards the "how" aspect (manual entry, semi-automatic, automatic) data creates a problematic (in link with the Heading 3.): How to put a data collection process which responds to the concept of the MSA and the requirements of the standard AIAG taking into account the complexity of the data relating to the maintenance (The history (CMMS, Excel)?

According to the vocabulary of Six Sigma, we talk about the concept of the xi and yi, these two terms are respectively, the inputs and outputs of the process. The Say outputs are other that the CTQ (critical of quality) required by the client, to determine through the diagram CTQ [7]. After it is important to collect the data in order to calculate the capability of the process according to the Formula 1, according to the formula below, the term it refers to the tolerance interval required by the customer. Before calculating the said capability according to the formula below; it is strongly recommended to check first if the process is stable and in statistical control, respecting these natural limits (+/- 3σ). If this stability is not verified, the calculation of the capability has not utility, since we can only think directly to the satisfaction of customer requirements as long as the process is not stable, in other words it must reduce the variability in leaving only the residual variability or natural process by eliminating special causes. Gold in the case of the maintenance, we have two specificities, the failures arrive in a random order and which may have several causes, including most of the time are extrinsic to the machine as the adjustment, the aging forced, the wear of the internal parts and even human mistakes, and therefore, there has always special causes which are the source of failures. In this case of the figure, the concept of the capability is not appropriate in the case of the maintenance.

Formulae 1: Calculation of the capability of a process

$$Cp=\frac{IT}{6\,\sigma}$$

On the other hand**,** most of the software of statistics used in the framework of projects Six Sigma, advocate two methods for the study of the repeatability and reproducibility (R&R) which represent the heart of the standard AIAG in order to determine at what point the variation of the measure System leads to the variation in the process to consider:

- A study GR&R (Crossed) when each part is measured several times by each operator.
- A study GR&R (Nested) when each part is measured by a single operator, as in the case of destructive test. In the destructive tests, the characteristic measured is different before and after the measurement process. The impact test is an example of a destructive test.

We have presented and interpreted example below which illustrates a study GR&R (crossed). In relation to this example of study, there are three (3) operators who have measured 10 identical parts so that each operator has measured the same exhibit three(3) times. We can logically conclude that the study GR&R cannot be adapted to the case of the maintenance, because the notion of parts and operator does not exist. All the more so as the key parameter to interpret that it should take into account is the probability p of the operator interaction*Exhibit of the table the ANOVA (analysis of Variace). When the p-value of this interaction is > 5%, this shows that given that the value p represents the probability of committing the error to accept the hypothesis H1 then that it is false (in this case p>5%). In other words, we have 95% chance of having reason when we say that the operator interaction*exhibit is not significant (hypothesis H0 is just).

Below the results according to the method ANOVA (analysis of variance) using a statistical software program :

Gage R&R Study - ANOVA Method

Two-Way ANOVA Table With Interaction

Source	DF	SS	MS	F	P
Part	9	88,3619	9,81799	492,291	0,000
Operator	2	3,1673	1,58363	79,406	0,000
Part * Operator	18	0,3590	0,01994	0,434	0,974
Repeatability	60	2,7589	0,04598		
Total	89	94,6471			

α to remove interaction term = 0,05

Two-Way ANOVA Table Without Interaction

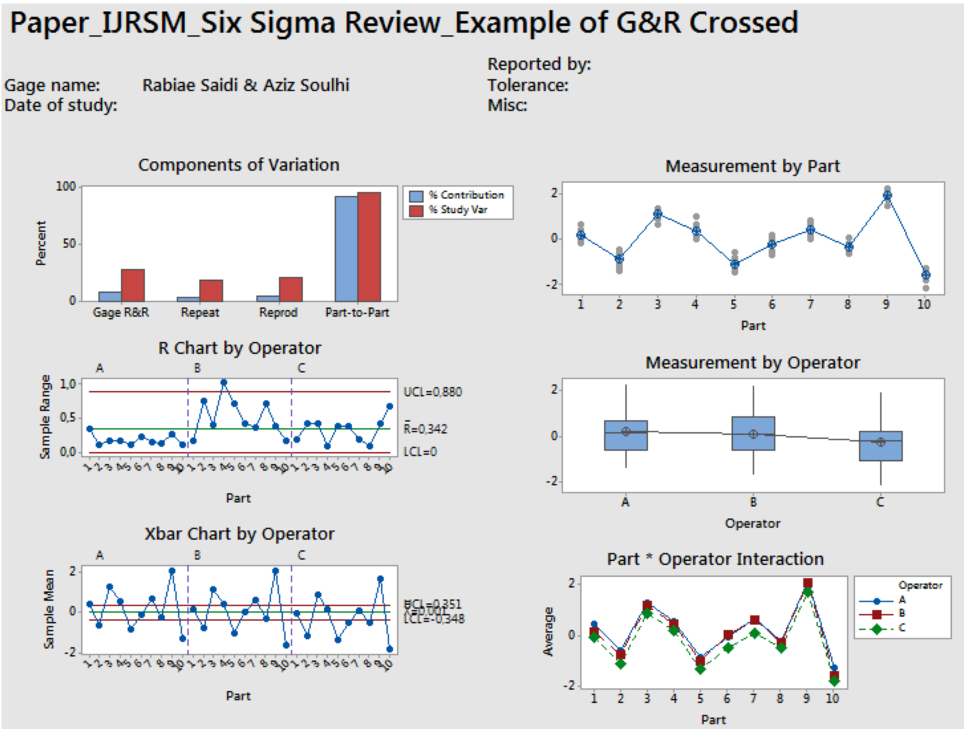
Source	DF	SS	MS	F	P
Part	9	88,3619	9,81799	245,614	0,000
Operator	2	3,1673	1,58363	39,617	0,000
Repeatability	78	3,1179	0,03997		
Total	89	94,6471			

Gage R&R

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0,09143	7,76
Repeatability	0,03997	3,39
Reproducibility	0,05146	4,37
Operator	0,05146	4,37
Part-To-Part	1,08645	92,24
Total Variation	1,17788	100,00

Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)
Total Gage R&R	0,30237	1,81423	27,86
Repeatability	0,19993	1,19960	18,42
Reproducibility	0,22684	1,36103	20,90
Operator	0,22684	1,36103	20,90
Part-To-Part	1,04233	6,25396	96,04
Total Variation	1,08530	6,51180	100,00

Figure 1 : Study R&R of cross-instrumentation using a statistical software



The limits of the analysis of variance (ANOVA)

At the time of the phase "measure" , the assessment of the measurement system MSA is intimately linked to the analysis of variance (ANOVA), which is a statistical method used to compare the averages of more than two samples of data, and this to check the statistical equality based on the statistical tests as the Z-test or the Student t test [4]. The ANOVA employs the assumptions H0 (two situations are statistically equal and H1 (two situations are statistically are different and taking the risk α=5% for a probability p is who is the probability to accept the hypothesis H1 then that it is false. The ANOVA analysis assumes that:

- The samples are both random and simple and must be drawn from a population (a larger series of data).
- The samples must also be independent (not to the assignment of other). This is appropriate for the comparison of the averages or even the comparison of a situation before and after an improvement each time by taking a sample of measurement.
- The samples follow the normal distribution that is characterized by the average and the standard deviation. In the case appropriate, the test will not give accurate results.

In the case of the maintenance, the Act of the failure of a equipment by example (see Formula 2) does not follow the normal law, because failures are rare events that arrive in a random manner during a period T on average λ times in which the law of probability follows the law of fish (**also called the law of rare events). This act is defined** for tout natural integer *k*, according to the formula below [8] **:**

Formulae 2:

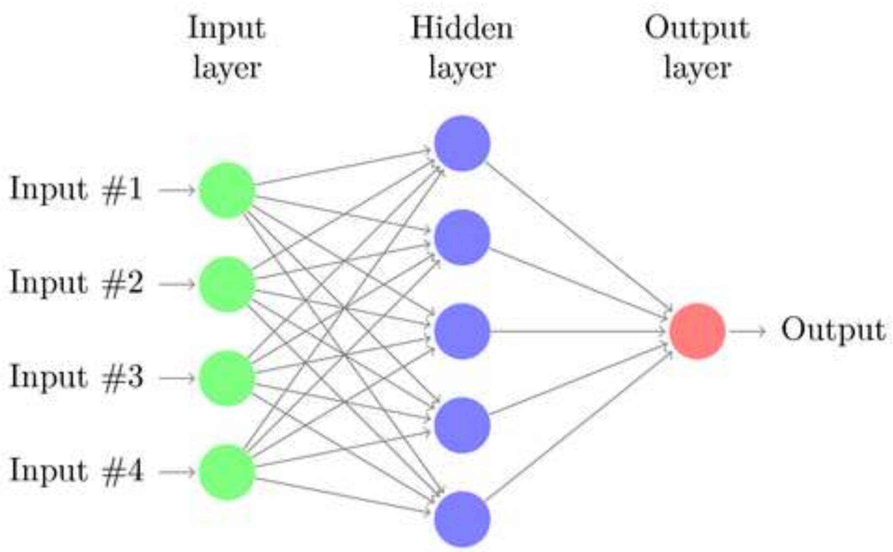
$$p(k) = P(X = k) = \mathrm{e}^{-\lambda}\frac{\lambda^k}{k!}$$

X is the random variable refers to the number of times that the failure happens during the period t

Lack of consideration of nonlinear interaction between variables

During the phases "analysis" and "control: C" that during which, the simple linear regression and multiple maps of controls mono-variables are widely used does not take into account the interaction not linear which may take place between the explanatory variables and the variables to explain. Six Sigma in low interaction with the technique of the artificial intelligence, particularly the use of the networks the neurons when it comes to the approximation of a case non-parametric including the interaction between the inputs and the outputs.

Figure 2 : Example of a network of neuron [9]



Problem of the evolutionary character of the target

The control cards regardless of the type (map of Shewhart, card Emwa,….) present a large gap assuming that the target is fixed not dependent on the time. By report to which, it should identify special causes, gold, in reality, the target to achieve undergoes fluctuations as a function of time, as a result of intrinsic and extrinsic factors such as the aging of the facilities. At this level, the control boards as well as the approach Six Sigma are limited by report to this problematic to the extent that there is no proposed solutions in a practical way. We know, that there is perpetually a natural degradation and forced of industrial equipment, this clearly means that the targets relating to the operating parameters of these facilities cannot be kept throughout their life cycle, all the more that the operating conditions are also scalable. The result is compared to this problem related to the use of the control cards during the phase "control" can have dangerous consequences on the safe operation of production systems especially when it is merely to determine targets in relation to what is recommended by the manufacturers of industrial equipment, in incorrectly assuming that the equipment can respond to these references all the time.

Conclusion

This article answers to the question posed in the introduction in providing arguments showing some limitations of the Approach The Six Sigma. Indeed, we have shown that the concept of the system of measurement that is required by the standard AIAG is not suitable when first the maintenance given those notions such as the operator, the room, the interaction between the workpiece and the operator does not have meaning in maintenance. Would it be that the notion of the fault that logically follows the law of probability of fish because the faults are events that arrive in a random manner according to a queue. This shows that the random variable linked to the number of outages arriving in a random manner can never follow the normal law according to these two parameters, namely the average and the standard deviation. On the other hand, if we suppose that it is possible to consider the reliability of the equipment in maintenance as a process of reliability, the latter may not be in the framework of Six Sigma, saw that there has always failures that are special causes, and a source of variability. This means that the process is not stable from the point of view Six Sigma, and therefore, the notion of capability which requires precisely the stability, may not have a meaning. It remains an aspect that requires more research is in relation to the evolution of the targets of the control cards that necessarily depend of the time.

References

[1] B. Burquier," Business Intelligence with SQL Server 2005", Editions Dunod, page 53.
[2] A. COURTOIS, C. BONNEFOUS, AND MR. PILLET, "Management of the Production", Editions of Organization, 2003, page 404-420
[3] J. Eckes, "Objective Six Sigma" World Edition, 2002
[4] Mr. Pillet, "Six Sigma, How to Apply", Editions of Organization, 2006,
[5] D. Duret, and Mr. Pillet, "quality in production, of the ISO 9000 to Six Sigma", Editions Organization, 3rd Edition, 2005, page 343.
[6] R. Saidi, A. Soulhi, and J. El Alami, "The Role of the Overall Equipment Effectiveness as a decision Support Tool for Structuring the Roadmap of a TFS Transformation (Constraint Theory, Safety of Operation, and Six Sigma)" Journal of Theoretical and Applied Information Technology,15th August 2017 -- Vol. 95. No. 15 -- 2017
[7] Caroline Fréchet, Implement the Six Sigma, Edition of Organization, 2005.
[8] http://www.techno-science.net/, consulted 05/09/2017
[9] http://www.texample.net/tikz/examples/neural-network/ consulted 05/09/2017