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New Little "q" for Decision-Making in Lean Six Sigma Project

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Summary: *Lean Six Sigma is a well-known methodology to drive process improvement. Companies worldwide share the success story about breath-taken achievements. However, this approach as well has a strong opposition consisted from people, whose Lean Six Sigma projects have failed. Hard to say what exactly is the key for success or reason of failure: it is individual for each project and depends from a lot of criteria. But some generalization can be done. The guiding light of success is constant following to the common sense and correct application of efficient tools – strongly connected Big "Q" and little "q", as it was named by Dr. Joseph Juran. This article is presenting a new approach for one of the most critical steps in DMAIC cycle – solution selection. This tool eliminates the limitations of existing approaches and offers some significant advantages.*

Key words: *Lean Six Sigma, DMAIC, solution selection, decision-making, multi-criteria objects, generalized parameter, Genichi Taguchi Loss Function.*

1. INTRODUCTION

Concept of Big "Q" and little "q" was coined by Dr. J. Juran in 1980s. The idea was that managing for quality should not be limited to manufacturing companies and manufacturing processes (little "q"). It should also include service companies and business processes (Big "Q") [1]. With the time, the umbrella of Big Q was growing and became an ideology that says: all tools, methods, approaches and ideas (little "q"), used in production to achieve the high quality are applicable to all areas of business, to all types of activities. Big Q has become an integral component in the business world, and is without question here to stay. People just may not call it Big "Q". Some may call it TQM, some Six Sigma and others just common sense [1].

Lean Six Sigma is one of well-known name of Big "Q". In Juran Quality Handbook [2] Six Sigma defined as multifunctional, organizationwide method to improve process effectiveness and customer satisfaction. It has developed into one of the most widely recognized methods for creating breakthrough improvement. Today Lean Six Sigma continue its development in a part of little "q" – creation of new tools should help to come through Lean Six Sigma DMAIC cycle (Define, Measure, Analyze, Improve and Control).

As we know, Lean Six Sigma is a data driven structured problem-solving approach [3]. However, it has a limitation of data application in Improve phase. The biggest part of tools for decision-making in this phase are not based on statistical approach. Continuous Improvement suspects that this should be improved and in this article, we are describing a new little "q" of Lean Six Sigma – statistical approach for decision-making.

2. LEAN SIX SIGMA

Common sense should penetrate through everything that we are making as blood circulatory system penetrate through our body. It is because unreflecting application of any tools or ideologies will fail, even if it is the greatest idea ever existed. Big "Q" and little "q" are strongly connected to each other. Big "Q" consists of a millions of little "q", which bring us to business excellence. In the same time little "q" deprived the common sense will bring more problems than help. They cannot exist without each other. That is why the best way to describe a new little "q" is to make it in the context of real Lean Six Sigma project (Spear Parts Delivery), where we can see big "Q" and little "q" working together. And every Lean Six Sigma project starts with problem definition.

3. DEFINE

The first phase is Define. Define your problem as clear as one can in words. It sounds very easy to make and often people think that this step is a formality. However, this task is not as simple as it looks from the first view.

Name of the project has already said to us that a problem was with spare part delivery. Everything is clear; but if we look more careful, we see this definition is very general and it is more a statement than information to work with. Clear definition of the problem is necessary to choose a right focus area of our project. It will help us to define a scope, targets and route to achieve results. So we need to identify what is exactly our problem, because under "delivery" problem can be everything listed below:

1) customers receive a damaged boxes,
2) deliveries are delayed,
3) customers receive wrong goods,
4) customers can't sign documentation, because of mistakes,
5) we don't know when goods will be delivered on site,
6) we don't know what will be delivered on site,
7) we can't plan our service works.

List can be continued.

Some of these problems are crossing each other, but other are leading a problem solving process in fully different directions. If we try to speed up the delivery time while the problem is in damaged goods, we will get a good results (for delivery time), but problem will stay the same or even became worse. It will be a project failure.

Successful problem statement is the half of the project success only. If we identify a problem wrong, we will try to solve something what is not the problem at all. In our case, the problem was with a delivery time: it often was longer than lead-times in the contract that were used for planning. As consequents, the planning of service and customer expectation was not manageable. Simply, we were not able to plan anything efficient, because we did not know when a spare part would be delivered on a site. So our target was not to increase a speed of delivery or to solve the problem of damaged goods, it was to make the process manageable, to be able to deliver strictly on time. For simplification, we gave the following definition: **"Spare parts delivery delays according to lead-times".**

4. MEASURE

The second phase is Measure. We need to measure our problem, to give it number to feel the extent of the problem and see if it is a real problem or just our emotional evaluation. Emotional reaction and evaluation are human nature, but it can lead us in a wrong direction. Target of this step is mitigating mistakes, which this habit can bring. Sometimes our feelings are right, but very often we under- or overestimate the situation. It is possible that after the evaluation, we see process in this part actually works well, but our personnel perception lets us think that here is a big problem. In addition, it is a small checkpoint, where we can see, if in the previous step we define the problem wrong and now should start from the beginning.

In our case in D-phase, we saw that the problem is very serious, more serious than we had estimated **– 59% of all deliveries were not on time.** How did it help to the project? We understood against of what we are going to fight. It is unapt to fight with the dragon by children shooter, as well as to shoot the sparrow from bazooka. When we gave the number to our problem, when we saw how often the delivery was done not according to the lead-times, we was able to identify how much resources, what kind of resources and how much time we need to solve the problem. And of course, we need this data to compare it with the result to be able to evaluate the success of our project in the end.

5. ANALYZE

The third step is Analyze. There we analyze process data to find the root causes of our problem. Very often analysis of situation changes our picture of problem. Root cause likely will be unexpected and, what is more important, it will be unpleasant. It happens because the root cause is always in us, directly or by implication. With the spare parts delivery we were sure that the problem is on the side of Delivery Company. In the worst case is in Warehouse. However, all problems were created inside. The reason of all delays and instability of the process from the beginning to the end were our achievement. First step on our side made delivery success almost impossible. Information we provided on the next steps often contained mistakes and it creates a lot of reworks, double-cheeks and all of this leads to a big delivery delays. During this phase, we discovered **seven root causes** of our problem: weak process opened doors to 100 small mistakes.

6. IMPROVE

Improvement is the stage where we generate and choose solutions to solve the problem. It is a teamwork, which required in one hand a lot of creativity, and a structured data based approach in other.

I-phase consists of two big stages: potential solution creation and the best solution selection. Potential solution creation process is the creative part of this phase. Effectiveness of this stage is highly depended from process facilitation and required to have a good soft skills and nonstandard way of thinking to succeed.

In our project, we carried out 7 session of brainstorming for each root cause. As the result, we received **38 potential solutions.** Implementation of all 38 solutions would not be a rational decision. First, not every potential solution can give a big impact on problem solving. Second, implementation of some ideas consumes too much time and money. Third, some solutions can improve our process, but damage the others. Therefore, we need to choose the best solutions, which correspond to our requirements. This way we were coming to the next stage of I-phase.

On the second stage we need to choose the best solutions out of (for some projects) hundred ideas, which will solve our problem. Our choice of the solutions should not be based on our personal preferences or believe in solution success, but on facts. As it clear from the clause above, to do this we need selection criteria. It is individual for every project, but there are three main: impact on problem, implementation costs and time.

For our project, we developed the following criteria: the solution impact on the problem, time for solution implementation, cost of solution implementation, regulatory and business risks connected to solution implementation, impact on customers and impact on a workload.

We can see that it is not one or two criteria; it is a pool of them. It is hard to make the decision. Lean Six Sigma methodology offers many tools to make it more efficient. Let's list a few the most famous [3]: Paired Comparisons/Pairwise ranking, Prioritization and Pugh Matrix. All of them have the common limitations – the fist of all they are not statistically based and, secondly, they do not use natural values of the criteria, but ask to give them the score. Why is it not so good? Problem will be to make the balanced evaluation of the solution. For example, the cost of implementation of the solution 1 is 100$, for solution 2 – 105$. For us it is not the critical differences, but the score of the solution 1 will be higher in the same time they are almost equal. Moreover, this situation we will have for a few criteria and almost for each solution. Normally we have a few root causes, because the problem is coming as the sum of small mistakes and, as the result many potential solutions. Finally, we have solutions, which are similar to each other by some criteria, but scoring is making them look like they are very different. Scoring is unbalancing approach to make an evaluation of milti-criterial object. This way we have a high risk to choose the solution, which is better a little bit by one criteria, but worse by others. Standard tools can play a bad jock to us by putting up the solution that is not for far the best one.

New little "q" is a new tool, new approach for decision-making, which helps to find the best balanced evaluation of each solution based on statistical approach.

The idea of the tool is based on building a generalized parameter. Generalized parameter building is the transformation of the individual values of the parameters (individual dimensions) in partial response parameters (unified dimension) and building the universal generalized parameter, which include the balanced evaluation of all criteria (Figure 1). The transformation of characteristics is done on a basis of evaluations of their correspondence to the possible ideal value of the parameter.

This parameter is a complex characteristic, which already includes the evaluation of all parameters of this object. The first plus is that this generalized index allows avoiding a one-side optimization, because it doesn't evaluate just separate characteristics but the combination of them. The second advantage is the use of natural values of criteria; this makes the method more sensitive to small difference of criteria values. The methods allow making complex evaluation of objects for appropriate decision making [4,5].

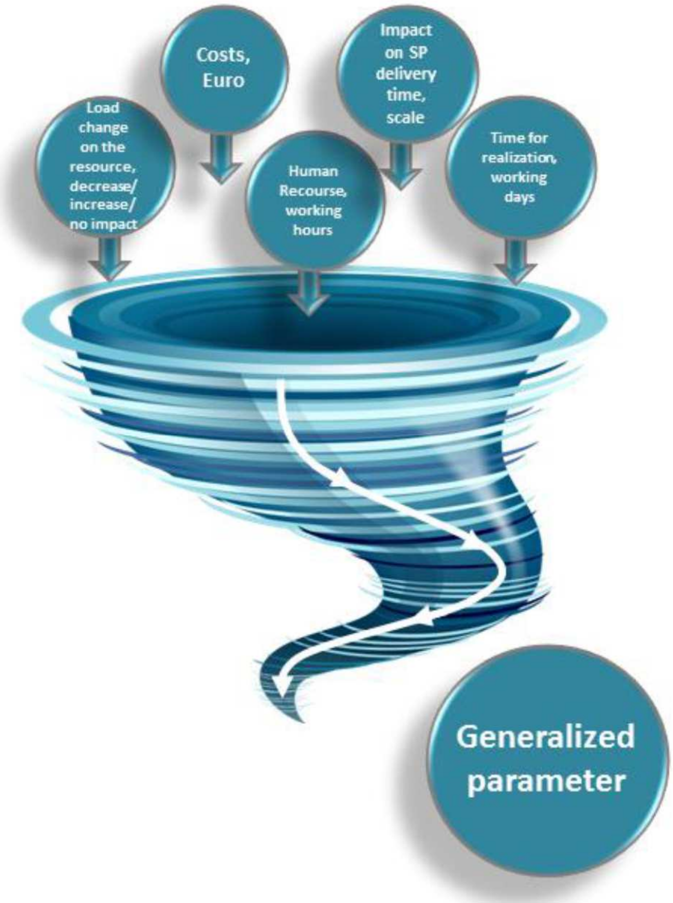

Figure 1. The idea of generalized parameter building

On Figure 2 we can see the comparison between tools we get used and new tool. Scoring is additional step, which in one hand make the evaluation easier, but in other hand leading us to the wrong solution selection. We rarely have a difference between the criteria values equal to the rank. In the example above (implementation of the solution 1 is 100$, for solution 2 – 105$), we give the score 1 to the first solution and score 2 to the second. But solution 1 is not 2 times better than solution 2. New tool helps fully avoid this issue.

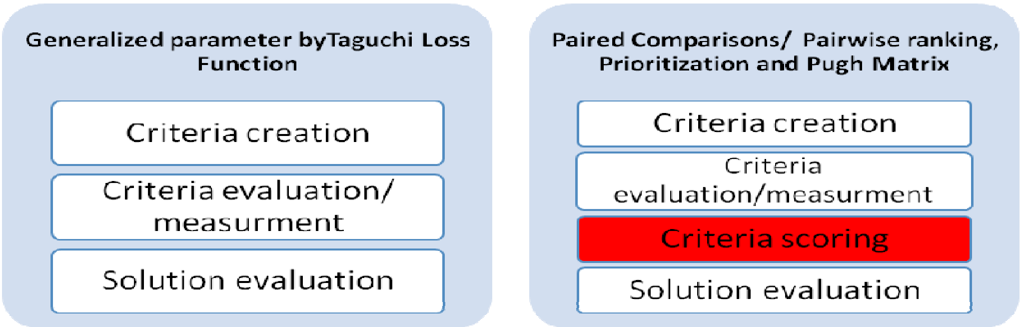

Figure 2. Comparison between tools

There are a lot of different methods to build the generalized parameter: from simple to complicated, based on expert's opinion approach or which has some statistical background.

We prefer to use G. Taguchi Loss Function for this purpose due to key peculiarities of this approach: statistical background and empirical nature. Those peculiarities give much more trust to the result in the real world.

The detailed description of Genichi Taguchi Loss Function was published in the reference [6].

6.1 Theoretical Introduction

6.1.1 Generalized Parameter Construction by the G. Taguchi Loss Function

Taguchi function [5] is used to calculate the financial losses in case of nominal deviation. The approach is based on the transformation of the individual partial characteristics that have different dimensions (hardness, density, etc.) in monetary units.

Japanese scientist G. Taguchi proposed a new approach of production quality assessment. The traditional idea of product quality is defined the following way: all manufactured products are equally qualitative, if their quality parameter values correspond to the technical documentation. So, while the quality parameter value is into the borders of tolerance, quality loss is zero. If the quality parameters are outside the tolerance limit T, the loss of quality declared as inadmissible. Such a function of quality loss (see Figure 3, broken line 1) is called a "breaking stepped function".

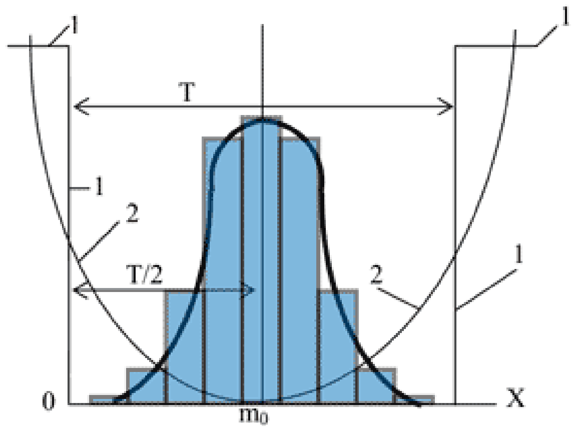

Figure 3. Taguchi loss function and "breaking stepped function"

According to the loss function L (proposed by Mr. Taguchi) a good quality product is only the product with quality parameter values equal to the nominal value and any deviation from the nominal value associated with some loss of quality (see Figure 2, curve 2):

$$L = k(x - m_0)^2 \tag{1}$$

where:
m_0 - nominal value,
k- constant of proportionality,
x - criteria value (current).

Taguchi defined that quality loss increases with the square of the deviation of current parameter values from the nominal [7].

For a generalized parameter building, we use the Taguchi function to convert the quality parameter values with different measurement units into particular losses for each criterion expressed in monetary units. A generalized parameter is calculated as the arithmetic sum of the losses of each parameter.

To construct the loss function, as we can see from the theoretical introduction, we need to know a nominal value, tolerances, coefficient of proportionality k and losses that the company incurred in case of tolerance failure. The nominal value and tolerance are established based on a consumer feedback. The nominal value is the quality parameter value that a customer defines as perfect for him and the tolerance - a sort of concession to the consumer, the extent to which the desired value can be varied.

The coefficient of proportionality k is calculated by the following formula:

$$k = \frac{Loses}{Tolerance^2}, \quad (2)$$

Now we can review the generalized parameter on practice.

6.2 <u>Practical Implementation</u>

Let's step by step have a look how to implement generalized parameter for solution selection.
As the result of criteria creation, we received the following criteria and measurement units:

1. impact on SP delivery time, scale,
2. time for realization, working days,
3. cost, Euro,
4. human recourse, working hours,
5. load change on the resource, decrease/increase/no impact,
6. direct influence on customer, positive/negative/absent,
7. potential risk for business, scale.

For Generalized parameter building based on Taguchi Loss Function we can use criteria values measured in different measurement units. That is a big advantage of the tool, as it has been already mentioned above.

The next step is criteria assessment for each solution.

Small tip and lesson learned from this project. Before the evaluation of every solution by all criteria, we evaluated the potential impact of the solution on the problem solving. These way 13 potential solutions were excluded from the further evaluation due to the low impact on problem solving. This is a good strategy to save the time on evaluation of solutions, which are not efficient.

6.2.1 Potential solutions evaluation

1) Data consolidation.
In our project we had 7 root causes and 38 potential solutions to solve our problem. Each potential solution was evaluated by 7 criteria (solutions with low impact were not included into further evaluation). Result of solution assessment is consolidated in the matrix presented on Table 1.

2) k- constant calculation.
Next thing we should to make is to calculate k- constant of proportionality:

$$k = \frac{Loses}{Tolerance^2}.$$

For this we need to identify the tolerance and losses. When we are talking about measures of some detail, it is very simple, tolerance is known from the beginning and losses are the detail market price. But for non-material objects it is a little bit complicated, that is why it is helpful to use "the worst value" to find out the tolerance. For this purpose the project team was asked to identify the best criteria value (it is our nominal value) and the worst acceptable. Tolerance was calculated as a difference between the best and the worst values.

Let's have a look on it on the example. We are a distributer of medical devices. We have received the order to deliver 500 items to our customer in 30 days. For this first we should order the goods from producer. We would like to get it on our stock in 22 days ideally. This way we have available storage location for this order and for sure enough time to deliver it to our customer. If goods would come in 17 days, we would not have a storage in our Warehouse and would have to spend additional money to rent location for this. If goods would come in 27 days, we would not be able to deliver on time and would pay penalty for delivery delay to our customer. For simplification let’s assume that the payment for additional location renting and penalty are the same and equal to 1000$. In this example the best value is 22 days. The tolerance is 5 days (22 -17=5; 27-22=5). The losses are 1000$.

Delivery time is only one criteria for delivery evaluation. Accuracy of delivered quantity can be the next example. 500 items are our best value. If we would receive 600, we would not have enough space and again have to rent additional location for storage. If we would receive 400 items, we would pay penalty to our customer, because can’t complete the order according to the contract. Our losses are 1000$. Our tolerance 100 items.

The example can be continued for every criterion of delivery.But iff at least one criterion is going away from the tolerance – "border of our acceptance", we will lose the money.

Similar is with the potential solution. In theory, if criteria are out of tolerance, solution implementation will not be successful and we will not solve the problem. So the losses for every potential solution for each criterion are the preliminary losses of project failure. If we don't know the number, we can take any estimation, because the main target of losses value in Taguchi function is to calculate the coefficient.

In Table 2 you can see the numbers for k-constant of proportionality calculation for each criteria and the results. For our project as losses we took value 100 because we didn't have a reliable financial estimation of project failure.

3) Table simplification.
efore to go to calculation for simplification of calculation tables let's give a short name to each potential solution which participates in the evaluation and numbers the criteria. Results are shown on Table 3 and Table 4.

Result of simplification is shown in Table 5.

4) Losses calculation.
Now we can make the Losses calculation.
Table 6 consolidates all data we need for calculation ($L = k(x-m_0)^2$) and Table 7 represents the result of calculation.

Normally there we can calculate the total losses for object by each criterion and choose the best solution. But sometimes we have one-two main criteria and we would like to give them evaluate them considering their weights. This happened with our project.

5) Calculation of weight.
The most important criteria for the team was impact on Spare Part delivery time, the second was the cost of implementation. The way in which weights were distributed is shown on Table 8.

Table 1. Matrix presentation of evaluation each of 38 potential solution by 7 criteria

	Impact on SP delivery time, scale	Time for realization, working days	Costs, Euro	Human Resourse, working hours	Load change on the resource, decrease/ increase/ no impact	Direct influence on customer, positive/ negative/ absent	Potential risk for business, scale
Root Cause 1							
Potential Solution 1	3	-	-	-	-	-	-
Potential Solution 2	9	2	0	2	0	0	5
Potential Solution 3	6	1	0	1	1	0	0
Potential Solution 4	9	10	0	20	-1	0	3
Potential Solution 5	9	1	0	1	-1	0	0
Potential Solution 6	6	1	0	1	0	0	1
Potential Solution 7	3	-	-	-	-	-	-
Potential Solution 8	3	-	-	-	-	-	-
Potential Solution 9	3	-	-	-	-	-	-
Root Cause 2							
Potential Solution 10	9	66	3000	3	-1	0	0
Potential Solution 11	9	5	0	9	0	0	0
Potential Solution 12	9	10	0	20	-1	0	3
Potential Solution 13	9	5	0	1	-1	0	0
Root Cause 3							
Potential Solution 14	9	66	0	120	-1	1	0
Potential Solution 15	6	66	3000	3	-1	0	0
Potential Solution 16	3	-	-	-	-	-	-
Potential Solution 17	9	22	0	25	-1	0	0
Potential Solution 18	6	1	0	1	1	0	0
Potential Solution 29	9	1	0	3	1	0	0
Root Cause 4							
Potential Solution 20	9	1	0	1	0	-1	6
Potential Solution 21	9	1	0	1	1	0	0
Potential Solution 22	9	1	0	1	1	0	0
Potential Solution 23	9	5	0	5	-1	0	5
Potential Solution 24	6	10	0	6	0	0	5
Potential Solution 25	3	-	-	-	-	-	-
Potential Solution 26	3	-	-	-	-	-	-
Root Cause 5							
Potential Solution 27	6	44	0	10	1	0	8
Potential Solution 28	6	22	0	8	0	0	8
Potential Solution 29	6	1	0	1	0	0	8
Root Cause 6							
Potential Solution 30	3	-	-	-	-	-	-
Potential Solution 31	3	-	-	-	-	-	-
Potential Solution 32	9	10	0	20	-1	0	3
Potential Solution 33	9	132	250000	528	-1	0	0
Root Cause 7							
Potential Solution 34	6	1	0	1	1	0	5
Potential Solution 35	3	-	-	-	-	-	-
Potential Solution 36	3	-	-	-	-	-	-
Potential Solution 37	3	-	-	-	-	-	-
Potential Solution 38	3	-	-	-	-	-	-

Table 2. Numbers for k-constant of proportionality calculation for each criteria and the results

	Impact on SP delivery time, scale	Time for realization, working days	Costs, Euro	Human Resourse, working hours	Load change on the resource, decrease/ increase/ no impact	Direct influence on customer, positive/ negative/ absent	Potential risk for business, scale
The best value	9	1	0	1	-1	1	0
The worst value	3	22	300	60	1	0	5
Tolerance	6	21	300	59	2	1	5
Losses	100	100	100	100	100	100	100
Constant of proportionality	2.778	0.227	0.001	0.029	25.000	100.000	4.000

Table 3. Criteria names and numbers

Criteria name	Criteria Number
Impact on SP delivery time, scale	1
Time for realization, working days	2
Costs, Euro	3
Human Resourse, working hours	4
Load change on the resource, decrease/ increase/ no impact	5
Direct influence on customer, positive/ negative/ absent	6
Potential risk for business, scale	7

Table 9 presents the results of calculation of individual losses considering their weight and total losses per object.

6) Final Solution selection.

After total loses calculation we rank the objects based on their total score. The best object- best solution has the lowest losses and lowest score.

To create the final solution list was decided to take the solutions with rank from 1 to 10. But for some root causes no solution received the rank from 1 to 10 due to costs or time of implementation. Team decided to take into the list additional solutions with highest rank into their group (group of potential solution to resolve exact root cause). As well team added a few solutions, which is necessary to complete the improvement, because, as it often happened, solutions were connected to each other.

In the result we received 15 solutions to implement. List of the solutions is shown in Table 10.

Summary of selection process is shown on Figure 4.

Calculation looks very heavy from the first point of view, but it is only because of detailed description. This calculation is very quick and easy can be done in Microsoft Excel.

We can come to the final phase of our Lean Six Sigma project.

Table 4. Solutions, impacts and short names

Potential Solutions	Impact	Short name
Root Cause 1		
Potential Solution 1	3	-
Potential Solution 2	9	**Object 1**
Potential Solution 3	6	**Object 2**
Potential Solution 4	9	**Object 3**
Potential Solution 5	9	**Object 4**
Potential Solution 6	6	**Object 5**
Potential Solution 7	3	-
Potential Solution 8	3	-
Potential Solution 9	3	-
Root Cause 2		
Potential Solution 10	9	**Object 6**
Potential Solution 11	9	**Object 7**
Potential Solution 12	9	**Object 8**
Potential Solution 13	9	**Object 9**
Root Cause 3		
Potential Solution 14	9	**Object 10**
Potential Solution 15	6	**Object 11**
Potential Solution 16	3	-
Potential Solution 17	9	**Object 12**
Potential Solution 18	6	**Object 13**
Potential Solution 29	9	**Object 14**
Root Cause 4		
Potential Solution 20	9	**Object 15**
Potential Solution 21	9	**Object 16**
Potential Solution 22	9	**Object 17**
Potential Solution 23	9	**Object 18**
Potential Solution 24	6	**Object 19**
Potential Solution 25	3	-
Potential Solution 26	3	-
Root Cause 5		
Potential Solution 27	6	**Object 20**
Potential Solution 28	6	**Object 21**
Potential Solution 29	6	**Object 22**
Root Cause 6		
Potential Solution 30	3	-
Potential Solution 31	3	-
Potential Solution 32	9	**Object 23**
Potential Solution 33	9	**Object 24**
Root Cause 7		
Potential Solution 34	6	**Object 25**
Potential Solution 35	3	-
Potential Solution 36	3	-
Potential Solution 37	3	-
Potential Solution 38	3	-

Table 5. Result of simplification

	1	2	3	4	5	6	7
Object 1	9	2	0	2	0	0	5
Object 2	6	1	0	1	1	0	0
Object 3	9	10	0	20	-1	0	3
Object 4	9	1	0	1	-1	0	0
Object 5	6	1	0	1	0	0	1
Object 6	9	66	3000	3	-1	0	0
Object 7	9	5	0	9	0	0	0
Object 8	9	10	0	20	-1	0	3
Object 9	9	5	0	1	-1	0	0
Object 10	9	66	0	120	-1	1	0
Object 11	6	66	3000	3	-1	0	0
Object 12	9	22	0	25	-1	0	0
Object 13	6	1	0	1	1	0	0
Object 14	9	1	0	3	1	0	0
Object 15	9	1	0	1	0	-1	6
Object 16	9	1	0	1	1	0	0
Object 17	9	1	0	1	1	0	0
Object 18	9	5	0	5	-1	0	5
Object 19	6	10	0	6	0	0	5
Object 20	6	44	0	10	1	0	8
Object 21	6	22	0	8	0	0	8
Object 22	6	1	0	1	0	0	8
Object 23	9	10	0	20	-1	0	3
Object 24	9	132	250000	528	-1	0	0
Object 25	6	1	0	1	1	0	5

7. CONTROL

The fifth phase is Control. This is the step that people sometimes would prefer to live. When everything is done, what do we need to control? But the importance of this step is great; it is the moment of true, kind of exam for our project. We again measure the process and see, were our actions effective or not. It is very disappointing to see, that after so many efforts the situation have not been really improved. In this case we should slowly go back to find out where the mistake was done. If we a lucky, we just chose an ineffective solution to remove the root cause. It becomes worse, if we didn’t find the real root cause. And it coming bad, if we made mistakes in analysis: maybe we took a wrong data. But the worst case is, if we define the problem wrong.

Now you see that all five steps (Lean Six Sigma ideology – big "Q") are very important to be performed with the deep understanding of the sense behind of each phase.

For our project the result was measured during the 6 months on a monthly based. And we achieved a really great improvement. In the beginning we had only 41% deliveries on time (59% delays). After project was finished we had 100% deliveries on time. Efficiency of the project increased in 7 times (Figure 5): 50 min to process the "spare part delivery line" instead of 6 hours.

Table 6. Data for calculation

m_0 *k*	9 2.778	1 0.227	0 0.001	1 0.029	-1 25.000	1 100.000	0 4.000
x	1	2	3	4	5	6	7
Object 1	9	2	0	2	0	0	5
Object 2	6	1	0	1	1	0	0
Object 3	9	10	0	20	-1	0	3
Object 4	9	1	0	1	-1	0	0
Object 5	6	1	0	1	0	0	1
Object 6	9	66	3000	3	-1	0	0
Object 7	9	5	0	9	0	0	0
Object 8	9	10	0	20	-1	0	3
Object 9	9	5	0	1	-1	0	0
Object 10	9	66	0	120	-1	1	0
Object 11	6	66	3000	3	-1	0	0
Object 12	9	22	0	25	-1	0	0
Object 13	6	1	0	1	1	0	0
Object 14	9	1	0	3	1	0	0
Object 15	9	1	0	1	0	-1	6
Object 16	9	1	0	1	1	0	0
Object 17	9	1	0	1	1	0	0
Object 18	9	5	0	5	-1	0	5
Object 19	6	10	0	6	0	0	5
Object 20	6	44	0	10	1	0	8
Object 21	6	22	0	8	0	0	8
Object 22	6	1	0	1	0	0	8
Object 23	9	10	0	20	-1	0	3
Object 24	9	132	250000	528	-1	0	0
Object 25	6	1	0	1	1	0	5

Table 7. Results of calculation

	1	2	3	4	5	6	7
Object 1	0	0.22676	0	0.02873	25	100	100
Object 2	25	0	0	0	100	100	0
Object 3	0	18.3673	0	10.3706	0	100	36
Object 4	0	0	0	0	0	100	0
Object 5	25	0	0	0	25	100	4
Object 6	0	958.05	10000	0.11491	0	100	0
Object 7	0	3.62812	0	1.83855	25	100	0
Object 8	0	18.3673	0	10.3706	0	100	36
Object 9	0	3.62812	0	0	0	100	0
Object 10	0	958.05	0	406.808	0	0	0
Object 11	25	958.05	10000	0.11491	0	100	0
Object 12	0	100	0	16.547	0	100	0
Object 13	25	0	0	0	100	100	0
Object 14	0	0	0	0.11491	100	100	0
Object 15	0	0	0	0	25	400	144
Object 16	0	0	0	0	100	100	0
Object 17	0	0	0	0	100	100	0
Object 18	0	3.62812	0	0.45964	0	100	100
Object 19	25	18.3673	0	0.71818	25	100	100
Object 20	25	419.274	0	2.32692	100	100	256
Object 21	25	100	0	1.40764	25	100	256
Object 22	25	0	0	0	25	100	256
Object 23	0	18.3673	0	10.3706	0	100	36
Object 24	0	3891.38	6.9E+07	7978.43	0	100	0
Object 25	25	0	0	0	100	100	100

Table 8. The way in which weights were distributed

	Impact on SP delivery time, scale	Time for realisation, working days	Costs, Euro	Human Resourse, working hours	Load change on the resource, decrease/ increase/ no impact	Direct influence on customer, positive/ negative/ absent	Potential risk for business, scale
Weight of criteria	50	5	25	5	5	5	5
Weight fraction	0.5	0.05	0.25	0.05	0.05	0.05	0.05

Table 9. Results of calculation of individual losses considering their weight and total losses per object

	1	2	3	4	5	6	7	Total
Object 1	0	0.01134	0	0.00144	1.25	5	5	11.26
Object 2	12.5	0	0	0	5	5	0	22.50
Object 3	0	0.91837	0	0.51853	0	5	1.8	8.24
Object 4	0	0	0	0	0	5	0	5.00
Object 5	12.5	0	0	0	1.25	5	0.2	18.95
Object 6	0	47.9025	2500	0.00575	0	5	0	2552.91
Object 7	0	0.18141	0	0.09193	1.25	5	0	6.52
Object 8	0	0.91837	0	0.51853	0	5	1.8	8.24
Object 9	0	0.18141	0	0	0	5	0	5.18
Object 10	0	47.9025	0	20.3404	0	0	0	68.24
Object 11	12.5	47.9025	2500	0.00575	0	5	0	2565.41
Object 12	0	5	0	0.82735	0	5	0	10.83
Object 13	12.5	0	0	0	5	5	0	22.50
Object 14	0	0	0	0.00575	5	5	0	10.01
Object 15	0	0	0	0	1.25	20	7.2	28.45
Object 16	0	0	0	0	5	5	0	10.00
Object 17	0	0	0	0	5	5	0	10.00
Object 18	0	0.18141	0	0.02298	0	5	5	10.20
Object 19	12.5	0.91837	0	0.03591	1.25	5	5	24.70
Object 20	12.5	20.9637	0	0.11635	5	5	12.8	56.38
Object 21	12.5	5	0	0.07038	1.25	5	12.8	36.62
Object 22	12.5	0	0	0	1.25	5	12.8	31.55
Object 23	0	0.91837	0	0.51853	0	5	1.8	8.24
Object 24	0	194.569	1.7E+07	398.921	0	5	0	17361709.60
Object 25	12.5	0	0	0	5	5	5	27.50

8. CONCLUSION

G. Taguchi Loss Function application is a new tool for decision-making on the solution selection stage. It has a lot of advantages and eliminate all limitation of standard solution selection tools. First of all, method allows making complex evaluation of objects for appropriate decision making. Secondly, the use of natural values of criteria makes the method very sensitive to small difference of criteria values. Thirdly, generalized index allows avoiding a one-side optimization. And the last, but not the least, the key peculiarities of this approach: statistical background and empirical nature, which give more trust to the result in the real world.

I-Phase of Lean Six Sigma cycle is a crucial point of the project. There we take an important decision: we choose solutions should be implemented to achieve a significant process improvement. Mistake or imbalance solution evaluation can lead to the project failure. That is why the balance statistically based solution evaluation method is essential.

Table 10. List of the solutions

Potential Solutions	Short name	Losses	Rank
Root Cause 1			
Potential Solution 2	**Object 1**	11,26	**12**
Potential Solution 3	**Object 2**	22,50	**14**
Potential Solution 4	**Object 3**	8,24	**4**
Potential Solution 5	**Object 4**	5,00	**1**
Potential Solution 6	**Object 5**	18,95	**13**
Root Cause 2			
Potential Solution 10	**Object 6**	2552,91	**23**
Potential Solution 11	**Object 7**	6,52	**3**
Potential Solution 12	**Object 8**	8,24	**5**
Potential Solution 13	**Object 9**	5,18	**2**
Root Cause 3			
Potential Solution 14	**Object 10**	68,24	**22**
Potential Solution 15	**Object 11**	2565,41	**24**
Potential Solution 17	**Object 12**	10,83	**11**
Potential Solution 18	**Object 13**	22,50	**15**
Potential Solution 29	**Object 14**	10,01	**9**
Root Cause 4			
Potential Solution 20	**Object 15**	28,45	**18**
Potential Solution 21	**Object 16**	10,00	**7**
Potential Solution 22	**Object 17**	10,00	**8**
Potential Solution 23	**Object 18**	10,20	**10**
Potential Solution 24	**Object 19**	24,70	**16**
Root Cause 5			
Potential Solution 27	**Object 20**	56,38	**21**
Potential Solution 28	**Object 21**	36,62	**20**
Potential Solution 29	**Object 22**	31,55	**19**
Root Cause 6			
Potential Solution 32	**Object 23**	8,24	**6**
Potential Solution 33	**Object 24**	17361709,60	**25**
Root Cause 7			
Potential Solution 34	**Object 25**	27,50	**17**

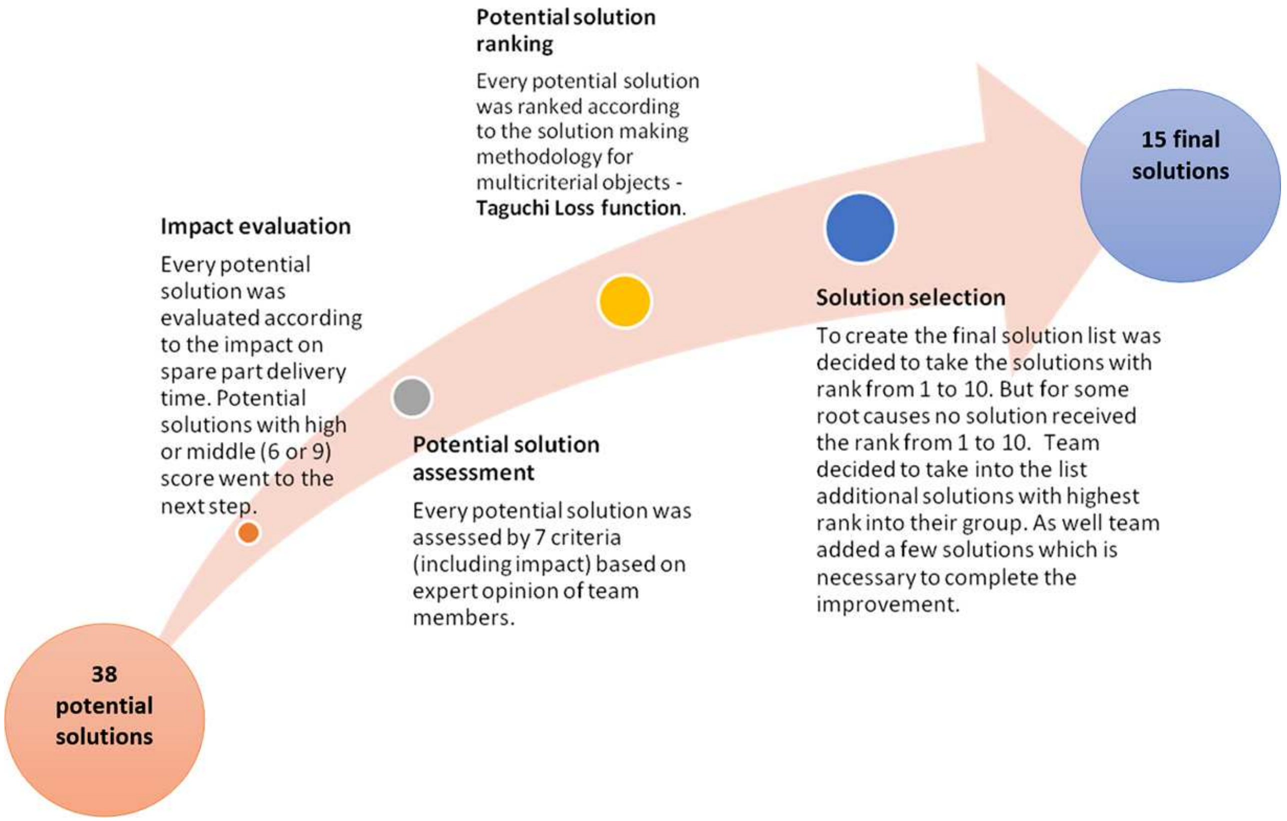

Figure 4. Summary of selection process

Figure 5. Increasing of the efficiency of the project

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