

SIX SIGMA - A NEW APPROACH OF QUALITY

Maria NICOLAI
Sofia TOTOLICI

Department of Management and Marketing
University "Dunarea de Jos" of Galati

The term six sigma was elaborated by Motorola Corp. in the early '80s, after a visit in Japan. The method's application with this name has reduced the fabrication deficiencies with 99,7%, thus, in 1998, Motorola Corp. was one of the first companies to receive The Quality National Award in USA, "Malcolm Baldrige". Then the method was used by other companies as well, which have declared that using the six sigma method, the 3,4 deficiencies per million of opportunities level may be achieved, attaining not perfection, but almost perfection.

1. Precedent approaches of the six sigma method

Statistical Process Control (SPC) has promoted the AQL programme (Acceptable Quality Level) - the acceptable quality level. Within this programme the maximum value of the deficiencies percentage was calculated as a number of deficiencies at 100 units- that the consumer considered satisfactory as an average of the process so that the continuity of fabrication with unexpected deficiencies shouldn't be affected. These aspects completed each other contractually.

The first fundamental step for six sigma was that one of defining clearly what the client wanted.

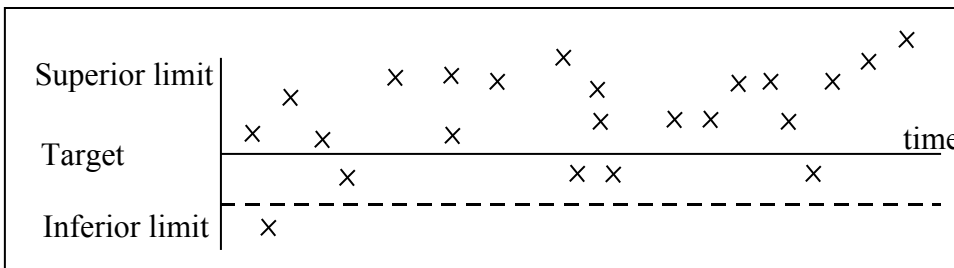
In the 'six sigma' language, the client's wishes are often called "CPCs" (critical characteristics for quality), assimilated to the Y- variables of the process, the quality of the Y variable will depend on the X variable and of the activities' quality that take place within the process. Thus, a car delivered with another color than the one wanted by the client will be considered as an Y deficiency. The same car delivered with the color required by client, but a week later, will also generate an Y deficiency.

The process outputs are analyzed under two forms. The first form is represented by the average of the Y variables and the second form is represented by the intensity of the variation towards the average of the Y variables. To these, three parameters are added in order to be analyzed:

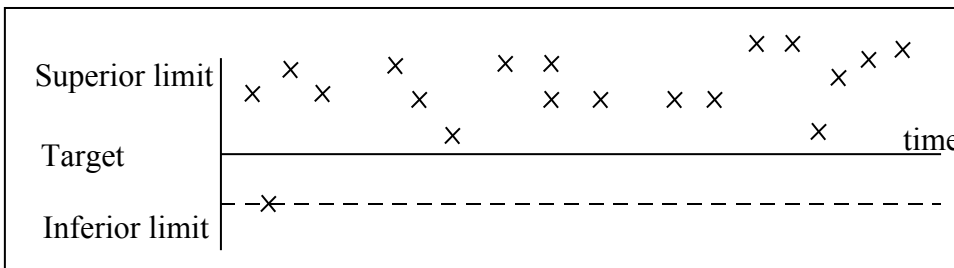
- **Target specifications** – are the specifications of the product as they have been required by the customers. It is impossible to result Y variables from one process according to the target specifications as the client accepts the product with the parameters included in a certain tolerance interval.
- **Upper specification limit (USL)** - is that one which determines the superior limit of tolerance.
- **Lower specification limit (LSL)** – is that one which determines the inferior limit of tolerance.

Every product whose parameters are out of the tolerance domain (USL, LSL) will be considered inadequate. The process in which the average of the Y variables arrives to be equal to the target specification is called centered process. The development of the measures result on the Y variable can determine the following aspects. (Figure 1)

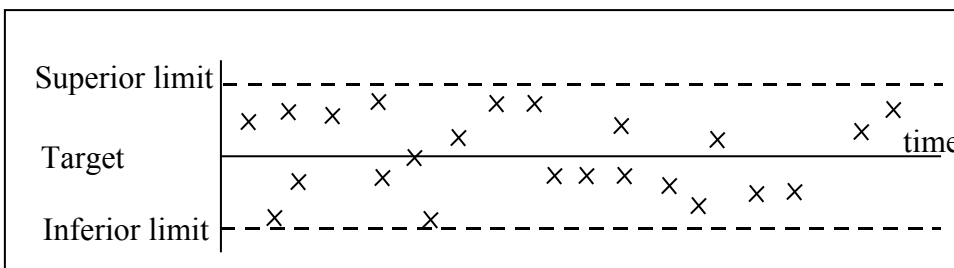
Instable process



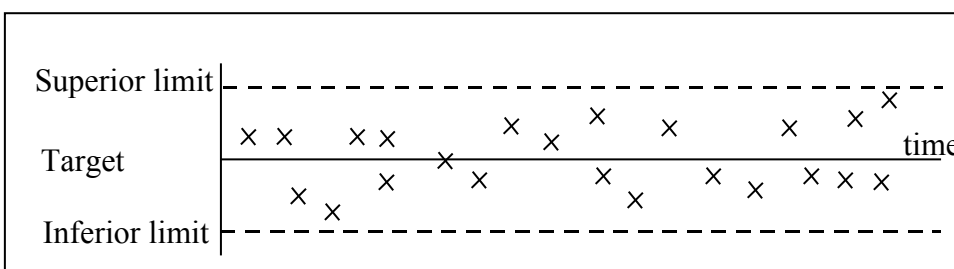
Stable process non-centered, that remains in the tolerance limits



Process centered in average on the target (with a dispersion considered great)



Process centered on the target (with a reduced dispersion of variables near the average) \bar{x} - values Y_i



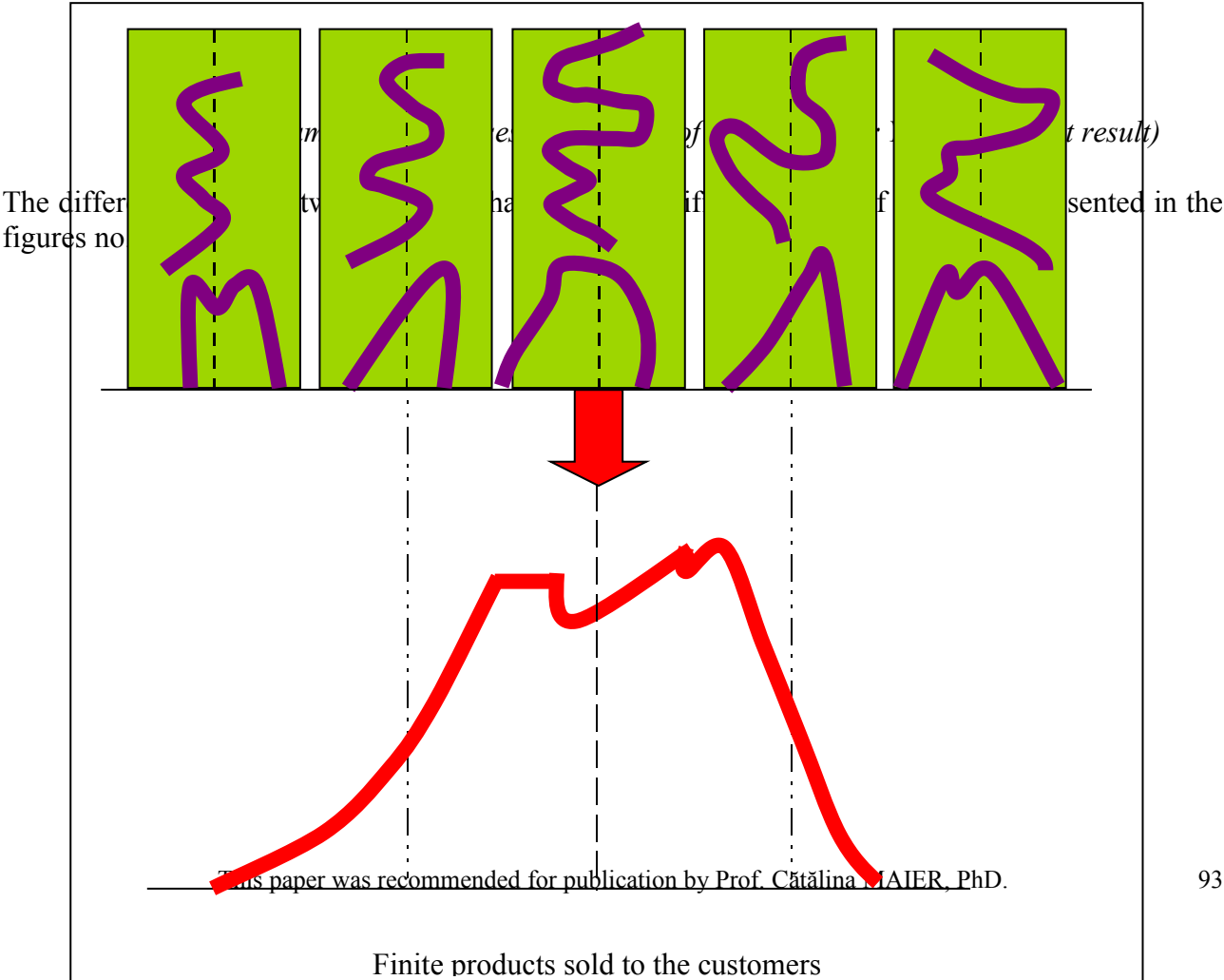


Fig. 2 – The values of Y parameters for a process focused by an instable control

In the following table, we emphasize the correspondence between a number given by sigma

and the number of deficiencies to one million of products. (Table 1)

The corresponding table between the number of sigma and the number of products with deficiencies in a process

- Table 1 -

Number of Sigma	The percentage of products without deficiencies (%)	The number of products with deficiencies to 1 million products
0,125	8,46	915.434
1	30,85	691.462
2	69,15	308.538
3	93,32	66.807
4	99,38	6.210
5	99,986	145
6	99,99966	3,4

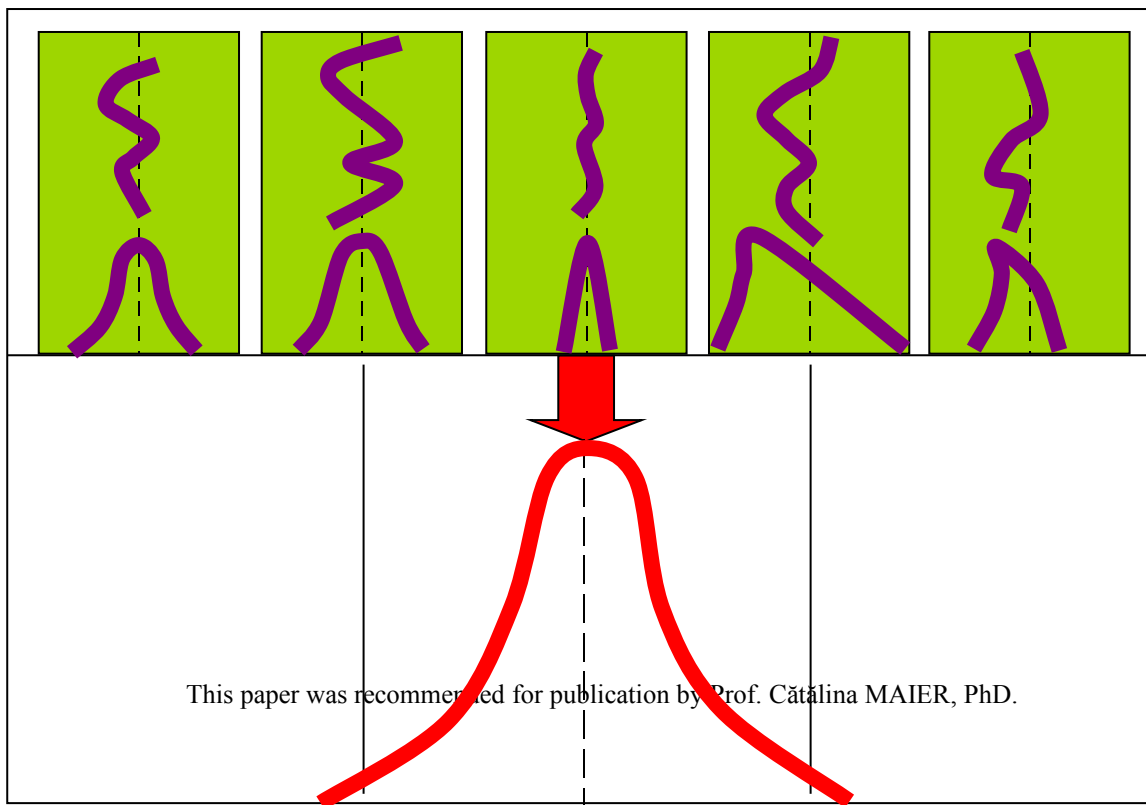


Fig. 3 – The values of Y parameters for a controlled process, focused on the target

It becomes obvious that in such an approach of quality improvement, it is necessary in the first place to determine the average of the Y parameters which have to be obtained and the limits of variation (USL and LSL), considered acceptable in accordance with this value (the interval of variation). If the process is capable of providing an average value or a very close one to the established Y nominal value than the desired ideal has been accomplished. Sigma (σ) measures the dispersion of the Y parameters values in comparison with an established average. The number of sigma concerning one process is represented by the percentage of products whose dimensions are in the interval of tolerance (USL, LSL).

2. The mathematical basics of the Six Sigma

Alan Larson, the ex quality manager from Motorola, related the fact that the simplicity of

this approach represented one of its great advantages: "it is really a mathematical system, not a statistical system. What's interesting is that all you have to know is to multiply, to add and to divide, you needn't be a statistician". The Six Sigma method tends to reduce the number of deficiencies to zero. The deficiency represents every circumstance or event in which the product or the process doesn't succeed in accomplishing the needs of one client. The sigma levels are expressed by means of "number of deficient products to one million", indicating how many variations (errors) will appear if an activity were repeated million times. In the data determination from this table, we started from the premise that in the majority of the companies, a process produces in average 6.000 – 6.210 deficient products/1 million products, which corresponds to a level of 4 sigma. We will obtain a spectacular percentage of 3,4 deficiencies/1 million of products outputs at a level of six sigma.

In daily life, such a passage from 4 sigma to 6 sigma would produce important achievements. (Figure 4)

4 sigma	6 sigma
20.000 lost letters per hour by the post services	7 lost letters per hour
2 missed landings per day in the main airports	1 missed landing in 5 years
200.000 fallacious drugs prescriptions per year	68 fallacious drugs prescriptions per year
54 hours of non-availability of the informative system per year	2 minutes of non-availability per year

Fig. 4 – Qualitative differences of the processes from 4 sigma to 5 sigma

One of the most significant contributions in Motorola Company was the change of quality discussion from one in which quality was measured in percents (parts to one hundred) to a discussion in parts to one million or even parts to one billion. Motorola showed that modern technology was so complex that old ideas

concerning the "acceptable qualitative levels" wouldn't be available. Modern businesses require almost perfect levels of quality.

Tables of precision of the sigma levels were emitted:

Table of precision regarding the sigma level

- Table 2 -

Process centered on the target	C_p	LSL	USL	Deficiencies for the right side of the
--------------------------------	-------	-----	-----	--

				distribution (ppm)
1 σ	0,33	$m - \sigma_1$	$m + \sigma_1$	158.655
2 σ	0,66	$m - 2 \sigma_2$	$m + 2 \sigma_2$	22.750
3 σ	1	$m - 3 \sigma_3$	$m + 3 \sigma_3$	1.350
4 σ	1,33	$m - 4 \sigma_4$	$m + 4 \sigma_4$	31,686
5 σ	1,66	$m - 5 \sigma_5$	$m + 5 \sigma_5$	0,287
6 σ	2	$m - 6 \sigma_6$	$m + 6 \sigma_6$	0,001

We can observe that if you take into consideration for example the elements from the right side of the contribution, we can obtain:

- 22.750 to 1 million products are outside the 2 σ average interval;
- 1394,96 to 1 million products are outside the 3 σ average interval;
- 31,686 to 1 million products are outside the 4 σ average interval;
- 0,28715 to 1 million products are outside the 5 σ average interval;
- 0,001 to 1 million products are outside the 6 σ average interval;

In the case of the 6 sigma method, we reduce the variation of the process.

$$C_p = (12 \sigma / 6 \sigma) \rightarrow C_p = 2$$

We say that a process is capable if $C_p = 1$. The greater C_p is, the more the process will accomplish the specifications if the process average reaches the m target value.

In the case of this method, C_p offers the indication if the process is or not potentially capable of accomplishing the specifications. C_p doesn't offer the indications if the process accomplishes effectively or not the specifications. Thus, C_p reflects if the variation of the process will be or not acceptable for a process which is perfectly controlled from a statistical point of view. In order to describe how good the process has proved its

conformity with the specification and how close it has approached from the central point of the specification, we use the C_{pk} indicator. If the value of C_{pk} is equal to 1 or greater then 1, few products will be outside the specification.

C_{pk} is defined by:

where: USL = the superior limit of the specification

\bar{m} = the process average

3σ = half of the process capability

If for example, the process average has moved from the m target value to the right with a distance of 1,5 σ (which is actually six sigma according to the quality experts, the number of deficient products will be of only 3,4 to 1 million. (Table 3) The method reason is the following: in real life, even if a process is under control, there are many situations in which the process average moves from the target average with 1,5 σ . If this happens, in the worst case, the application of the 6 σ philosophy will guarantee that it won't be obtained more than 3,4 deficiencies to 1 million.

In the most cases of companies, a process produces in average 6.000 of deficient pieces to 1 million, which corresponds, according to the sigma metrics to a level of approximately four sigma.

The metrics for six sigma

- Table 3 -

Process average $\bar{m} = \frac{USL - LSL}{3\sigma}$	Standard deviation of the process	C_{pk}	Deficiencies for the right side of the distribution (ppm)
1 σ	3 σ	- 0,16	691.464
2 σ	1,5 σ	0,16	308.536
3 σ	Σ (cash)	0,5	66.807
4 σ	0,75 σ	0,83	6209,66
5 σ	0,6 σ	1,16	232,67
6 σ	0,5 σ	1,5	3,4

To work with six sigma means to work with a value of C_{pk} of 1,5. For the application of the six sigma method, the sample used must be enough significant.

3. Six sigma – a methodology in five stages

The improvement methodology of six sigma processes has five successive stages: definition, measure, analysis, improvement and control.

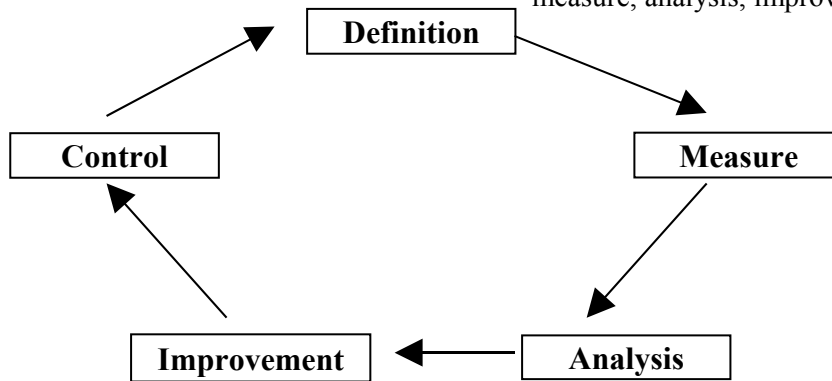


Fig. 5 – The stages of Six Sigma Methodology (DMAIC)

Definition – is the stage in which we identify the problems that are to be improved. The objectives are defined in connection with clients' requirements. The reference data are analyzed and their impact on clients is estimated. There are established the persons responsible for applying the objectives and the main deadlines of the project. At a superior level, the objectives may be of a strategic nature. (e.g. market share increase). At the operational level, the objectives are more concrete (e.g. the performance increases of a department). At the project level, the objectives may be the decrease of the deficiencies rates and of the production cycle. In order to identify the opportunities, the comparative analysis of data will be done.

Measure doesn't mean to estimate randomly or to formulate intuitively concerning the client's necessities. Measure proposes as an objective the research of measurable data which characterizes the respective process and the measure of the existent results. Data from different sources are collected in order to determine, for example, the promptness used to respond to clients' demands, the types and the frequency of deficiencies, the information return from clients regarding the way in which processes respond to their demands, the way in which clients appreciate the processes in time etc. It is verified the fact that measure shouldn't be a major source of error. There are remarks on the difference between the imposed objectives and the applied measures. One can use as instruments in this stage: the capability calculations, cause-effect diagrams, diagrams of statistical analysis.

Analysis is the stage that allows data organization, the identification of problems and process opportunities. This stage allows for the identification of the differences between the

current performances and the objectives proposed, the definition of the improvement priority opportunities, the identification of the variation sources and the causes of the problems due to processes. This way of approach is supported by a series of instruments such as: the techniques of statistical analysis, multivariable analysis etc. Improvement has in view the revision of the used processes, offering solutions, both creative and obvious. It is necessary to develop innovation and technologies in order to find innovative solutions by correcting the main causes. The proposed solutions will be tested.

Control consists in the survey and evaluation of the results obtained and of the way in which the implied variables solve the problems. The standard indicators are established in order to maintain performance. One can use the instruments of performance had in view and the board tables. The stages don't succeed each other mechanically. Thus, when the team starts the measures, they realize that it is necessary to redefine the processes and when they analyze the causes, they realize that it is preferable to collect other data.

4. Improvement in six sigma

The instruction and improvement in six sigma cover a series of stages. The instruction in one day offers the possibility to those interested to appreciate the role six sigma plays in accomplishing the strategic objectives of a company, the management representing the key of success of such an approach. A next stage is represented by the instruction of the specialists in six sigma, those "management seniors" who succeed in uniting the metrics and the culture necessary for the process and who should help the organization to maintain a succession of improvement importance.

Franck Welch from General Electric has sent to improvement courses within the techniques of the six sigma, the managers from the ten departments of the company (plane motors, lighting products, electric equipments, industrial systems, railway products, communicators, services towards other companies). Many quality managers from different domains have received a complete instruction that allowed them to apply a specific organization within the company they work. The persons instructed are the guarantees of the method and are called "Master Black Belts" (MBB). Quality managers who are totally dedicated to the Six Sigma method, who work on projects or improvement programs in different services are the so called "Black Belts" (BB). All the co-workers of the company who can dedicate 20-30% of their time to work for improvement projects appear in the last stage. Five days of fundamental instruction are dedicated that offer the possibility of the insight in six sigma and professional team work in order to analyze the source of causes, to make the necessary measures and to apply controls to professional levels. The activity program in the black belt delivers the philosophy, the theory and the Six Sigma method necessary for the application in the company. Each course week is separated from other three weeks of activity in the company that has a Six Sigma project. Every Green Belt will be instructed two sessions of one week for a project that has to be applied and for the target.

5. The launching in the "Six Sigma" program

Eight responsibilities that have to be adopted in the first stages of the process are important for the managers of a company. These responsibilities will be based on:

- **The development of a strong motivation.** The leaders of a company should be able to describe- first for themselves and then for the others- why the "Six Sigma" should be necessary, what benefits it would bring to the whole company.
- **The planning and the participation to the implementation.** The plan and the strategy of such an approach must include other questions as well, for example: Which should be the first steps? Does the company budget allow for the implementation? How many people will have to participate to the instruction, to what level and when? The initiation and then the implementation presuppose the leaders' co-working with experts in the domain.
- **The elaboration of the vision and of the marketing plan.** The vision declaration can be adopted under the form a slogan as it follows: "the building of a big and strong company", "the creation of a culture of

continuous renewal". The vision declaration of General Electric is: "the complete satisfaction of customers' needs in a profitable way. What is important in the slogan elaboration is sending a clear positive message which should inspire and have synergic effects on the implementation effects of the Six Sigma.

The marketing plan must take into consideration the internal and external beneficiaries of the undertaken efforts; they must adopt the best measures in order to obtain positive reactions from the potential customers, to elaborate the best communication strategy, to specify the measures that must be taken in view to counteract the negative reactions.

The marketing plan for **Six Sigma** must be strong and interesting and also realist.

- **The continuous and convincing promotion of improvement necessity of the Six Sigma system.** Keywords will be used such as: the launch, expansion, and constant continuous support.
- **The planning of clear objectives** according to the type and direction of efforts from the respective company. The objectives should be easy to understand, challenging, meaningful and possible.
- **The correlation of efforts and responsibilities concerning the implementation with the stimuli assigned to the results obtained.** Other stimuli and bonuses will be assigned for every stage of progress registered.
- **The establishment of well determined indicators** that should clearly reflect the changes brought by the Six Sigma system.
- **The results communication** remains a main condition of progress in this approach. The clear presentation of successes and the recognition of those who have contributed the most to them determines trust and enthusiasm to go on.

6. The use of Six Sigma method in human resources selection

The strategic recruitment and selection are fundamental processes within the function of human resources in an organization. Six Sigma methodology may be applied if not like a institutionalized system, then at least like a frame of work principles. The stages of a process from the Six Sigma perspective can be applied to the process of recruitment and selection. The five methods (**DMAIC**) can be also used in the domain of recruitment and selection¹:

Definition: of abilities, competences and requirements that characterizes the job. The definition of a performance profile with all those

¹ "Biz", no. 64/2003, pages 60 – 61

involved and interested in the process of recruitment and selection will be associated with talents research.

Measure: the definition of abilities, competence and requirements must be measurable in the process of recruitment and selection. The choice of the most suitable measure methods of the elements set that define the performance profile is a key element in success assurance, in recruitment and selection.

Analysis: after the candidates' evaluation it is realized an analysis of their profile and a comparison with the performance profile required in the vacant job. The analysis can also be seen as a post-selection and placement, in the sense of an efficiency evaluation of the recruitment and selection process.

Improvement: represents the stage in which, after the potential errors have been identified in the process, the solutions for their improvement are searched.

Control: represents the pursuit in time of performances, both of that one who realized the process of recruitment and selection and proposed its improvement and of the candidate's performances, as a measure of recruitment and selection efficiency. The signs referring to the first interview passing, to which the candidate must be careful, are:

- the questions about the candidate's availability of attending another possible meeting in the future;
- the "thank you" messages on e-mail for the service;
- the questions sent subsequently on e-mail;
- the demand of completing an application file with other documents.

To the second interview, we verify the motivation, the psychological profile, the reactions in limit situations and the compatibility with the future boss. Generally, the employer also participates to this interview. He has in view the way in which the candidate speaks freely, the coherence of his discourse. He asks cross questions, introduces another person for the interview in order to verify the responses from this situation with those previously given. Elements like: psychological tests, professional testing, references checking, can occur in this stage. Beside the interviews, the selection process can also contain: behavior analysis, simulations (e.g. preparing and presenting a marketing plan, a repositioning, a launch and argumentation of a new promotional message), resources negotiations, etc.

In conclusion, Six Sigma represents a paradigm of processes improvement in an organization from beginning to the end whose implementation depends on the organizational culture and the calculation of ROI (return on investment). This stage can be applied to: the stage concerning the sources of human resources recruitment, the

selection process and the post-placement pursuit. If these under-processes can be measured and analyzed, then they can surely be improved.

7. The Strengths of the Six Sigma Methodology

The passion and the trust in the Six Sigma system even to the top management have proved to be unchallenged in companies like General Electric, Bombardier, Allied Signal.

Oliver Reitz, quality project manager to General Electric Capital Equipment Finance from France said: "the Six Sigma method allows the problems quantification, the evaluation of the non-quality costs. It is a team work technique that encourages the employees' responsibility and implication; this is what we called leadership."² Six Sigma is a business system used in order to reach and sustain the success by focusing on the customers. The best Six Sigma practitioners place the elimination on long term of internal barriers as one of the most important elements. Some successes are not sufficient to decree the system's victory. That's why the process management is primordial for Six Sigma system. The companies in which Six Sigma is implemented must establish very high levels for learning and support these standards by means of necessary financial and time investments in order to help the employees to reach them.

Six Sigma offers results both in production and especially in the service and transactional processes. According to some estimations, it surpasses by its effects even TQM (Total Quality Management).

² "Adevarul economic", no. 41/2000