Agile Six Sigma for Services (ASSS): a new approach to improve human activities efficiency

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Abstract: The present study analyzes the DMAIC-DMADV application to a service process. In particular, the aim of the work is to DEFINE, MEASURE and ANALYSE, and consequently IMPROVE and CONTROL (through a re-DESIGNING and VERIFICATION of the procedure), the time variability in field monitoring activities assigned to different operators. Main causes of variability have been pointed out, due both to errors in the "design" process rather than operative factors (different operators, technical problems, environmental conditions etc.). The application of Lean Six Sigma (LSS) tools to services and human activities needed a redefinition of the classical methodology, the need of "standardization" of procedures and the investigation of the required tools, because of the special output of the process, strongly linked to human factors. For those reasons, a new approach for the application of Six Sigma to Services is required, starting from the integration of modern management techniques: Lean Six Sigma and Agile Project Management: Agile Six Sigma for Services – ASSS. A characteristic of quality in manufacturing is generally tangible (size, weight etc..), instead for human activities, the service quality is more difficult to measure and the time of execution is one of the interesting parameters, as well as accuracy. Therefore, even if a service procedure should be considered as an operation, as well as in the considered case study (field monitoring activities), the strong presence of human factors and the constant interaction with internal and external variables, customers included, suggest a management as a recursive project we need to improve, where time or completion is expected and not deterministic.

Keywords: Lean, DMAIC, DMADV, Project Management, human activities, field monitoring

1.Introduction

A characteristic of quality in a manufacturing process is generally tangible (size, weight etc..), instead in a service process mainly characterized by human activities, it is more difficult to measure and the time of execution is one of the interesting parameters, as well as accuracy.
The present paper suggests a methodology to verify the goodness of the designed procedure for the execution of a service. In particular, the efficiency of a process of monitoring of many stations is studied and then re-designed, in order to realize a more correct assignment of resources, able to respect deadlines, to meet customer needs, to avoid problems.
The Six Sigma approach was developed by Motorola in 1987 and defined by Snee (2010) as a business improvement strategy. The benefits of Six Sigma can increase if the application of the method is combined with other improvement strategies, in particular with Lean Manufacturing and Agile Project Management (Atmaca and Girenes 2013; Cobb, C.G. 2011; Dahlgaard, J.J. and Dahlgaard-Park, S.M. 2006). The first approach is really designed for the improvement of operational business processes, while the second one generally assumes a context of project development and management (Di Bona et al. 2014). Anyway, it is possible to combine Agile-Lean-SixSigma, and consequently DMAIC and DMADV (Bañuelas and Antony 2002; Lynch et al. 2003; Gupta 2005).
The DMAIC cycle (Define, Measure, Analyse, Improve, Control), son of Deming's PDCA, is a methodology useful both to the operative phase and the design one (DMADV - Define, Measure, Analyse, Design, Verify), also for re-engineering processes. Frequently, the most common simulation applications are based on the principles of Lean Production and Six Sigma (Falcone et al. 2010; Falcone et al. 2011). The Six Sigma applications generally refer to productions, and rarely to services, in

order to manage and improve human activities (e.g. in Lee et al. 2008, in Antony 2006 or in Chen at al. 2010).

2.DMAIC vs DMADV

In the case of designing or re-engineering a process, the DMAIC approach becomes **DMADV**.
We can divide the approach into two parts:
DM-ADV
(Define+Measure=*ProblemSetting*_Analyse+Design+Verify =*ProblemSolving*)
The first activity consists in identifying (**D**EFINE) the whole process and all its phases. The second phase is the collection of all information and data able of describing the process (**M**EASURE).
Starting from the collected information and data, we have to link causes and effects (**A**NALYSE). The most effective tools to perform this phase are Brainstorming and Ishikawa Diagram or Cause-Effect Matrix. For each process phase, the possible causes are organized into five categories (M):

- Men;
- Machines;
- Materials;
- Methods;
- Mother Nature.

The methods can be divided into two sub-categories: working and measure, because of the importance of measurement errors (Di Pasquale et al. 2015). Subsequently, the next step is the improving phase (**D**ESIGN), based on the results obtained in the previous phases. In the final phase, it is necessary to check the goodness of the taken choices (**V**ERIFY). To support the study, statistical software can be used, more or less specialized (commonly Excel or Minitab – Fig. 1).

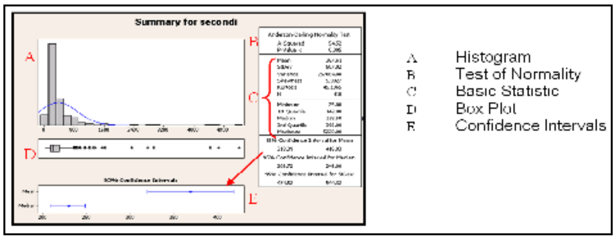

Fig. 1: Minitab output example

First of all, the statistical analysis allows identifying anomalous points among the population data, often responsible of a non-normal distribution and very common in the case of human activities. It is important to study and remove those anomalies to obtain a normal distribution, without compromising the statistical analysis. Subsequently, it is possible to study the history of data (STATISTICS), in order to forecast the future behaviour (PROBABILITY). In that way, it is possible to fix performance goals and to achieve them. Then, we can use control charts to maintain processes under control.

Thanks to the above statistical analysis, we obtain information on special causes and/or noises acting on our process. Therefore, it is possible to remove problems and to improve operative activities.

3.Integration of Lean Six Sigma and Agile Project Management

Lean Six Sigma (LSS) combines the business process improvement in terms of variation reduction with the principles of Lean Manufacturing, in terms of flow acceleration and wastes reduction (George 2002).
Agile Project Management (APM) can be used to control product development using iterative and incremental practices, with the advantages of a simple implementation. This methodology can significantly increase productivity and reduce time, facilitating adaptive and empirical systems development (Petrillo et al. 2018).
There are many aspects to consider in integrating Lean and Agile. LSS can help to improve the design/development/support processes. Through the voice of customer - VoC, we trie to deliver working features and measurable values, while reducing cost and time effort; those things are very important in the Agile world (Christopher & Rutherford 2004).

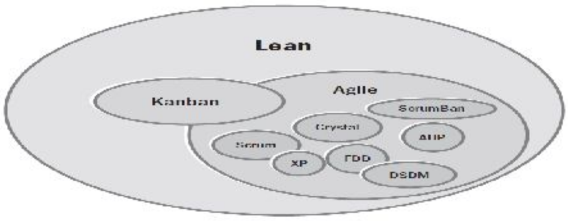

Fig. 2: Lean-Agile integration

Figure n. 2 shows Agile as a subset of Lean approach, according to PMI-PM BoK Guide, the 6th edition.
The main idea is the integration of three aspects: philosophy, framework and methodology (Fig. 3).

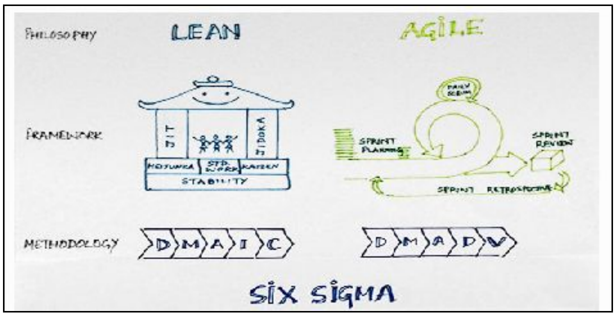

Fig. 3: Lean, Six Sigma and Agile integration

In practice, the five Lean principles with the four Agile values are integrated (Ben Naylor, J. 1999).

4.Case Study: Agile Six Sigma for Service

The effectiveness of the Agile Six Sigma approach becomes very interesting in the case of services based on human activities, where error and performance influence the service output and the possibility of standardization.

The approach followed has been called Agile Six Sigma for Services – ASSS; it suggests a way for designing in the correct way the service procedure.

The case study is an activity of monitoring of a number of stations.

In particular, it refers to the measurement procedure of gas consumption. The location of gas meters is in the southern part of Lazio, in the province of Frosinone.

The activity consists of three main tasks:

- to identify the gas meter;
- to read the gas consumption, leaving a notice for the customer;
- to transfer the reading data to the control panel.

Four different operators are involved, in two different periods of observation: January and April, 2019. The operators are free to organize their tour.

The considered case study presents general characteristics and different similar applications: measurements of utility consumption; survey of customer satisfaction; evaluation of equipment conditions and so on.

DMADV Steps:

1 - DEFINITION of the service process;

2 - MEASUREMENT of service data, in particular monitoring times;

3- ANALYSIS of criticalities of the procedure;

4 - DESIGN of service process through the application of Agile Improvement Cycles (Sprints);

5 -VERIFICATION of performances after redesigning.

4.1 Step 1 - DEFINE

In applying Agile Six Sigma for Services, we started from the following adapted four Agile values:

- attention to front-office operators;

- focus on adopted procedures and methods;

- interaction among operators and with final customers;

- management of variable conditions.

According to the DMADV approach, the whole process of monitoring was analysed, in order to re-design the procedure and realize a more predictable and efficient job.

In order to identify the "core" phase of the process, an Ishikawa Diagram was constructed (Fig. 4), using the 5M that in the case study become:

1. technical and logistical equipment;
2. operators;
3. working methods used;
4. data processed;
5. environmental conditions.

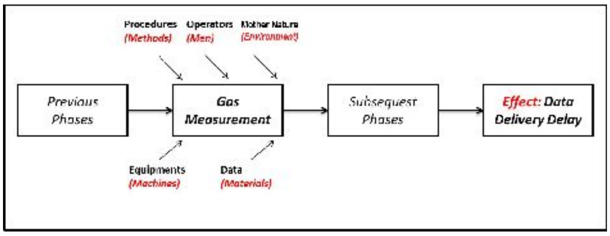

Fig. 4: Cause and Effect (Ishikawa) Diagram of the monitoring process

The construction of Ishikawa Diagram allows to clarify how the reading phase is the "core" of the service process and the most responsible of the "value" for the end customer. In particular, it is necessary to pay attention to organizational strategies chosen by operators. In fact, the operator doesn't follow a predetermined path to organize his reading tour, according to an appropriately designed and structured planning. Often, to make different readings along the same street, they often go back and forth, with time and cost losses.

Identified the "core value", in order to apply the five Lean principles, the other DMADV phases were developed.

4.2 Step 2 - MEASURE

Initially, the data of two working weeks in the winter season were collected and analyzed; in particular, the execution times of the reading process as described previously and realized by only one operator, named A. The registered time goes from the starting point of a new measurement activity, gas meter identification, up to its ending point, transfer of reading data to control panel. In the case of reading problems, a note is transferred to the control panel and the time not considered. The confidential data have been normalized in the study.

As shown in the following table n. 1, using Minitab, positional parameters of the data distribution (mean, median, first and third quartile) have been evaluated, for each day (corresponding to each line).

Tab. 1: Minitab Worksheet of positional parameters - January

C3	C4	C5	C6
Mean1	Q1_1	Median1	Q3_1
99,16	19,00	35,0	72,50
73,79	10,00	14,0	47,00
573,88	164,00	420,0	902,50
440,93	27,00	114,0	268,00
618,03	208,00	445,5	809,00
474,60	55,50	379,0	748,50
483,65	200,00	377,5	674,00
518,21	244,50	369,0	854,50
1036,86	256,00	802,5	1412,25
505,25	127,25	294,5	1094,00

It is possible to notice some anomalies. In the red box we have the highest values. Instead, for the first and second day, we have the lowest values. In the case of human activities, that characterize a service process, the presence of anomalous values and a great variability of data are very common. So we need to investigate those anomalies in order to understand the possible evolution of the process and the reasons of its deviation.

There are three sources of variability in task completion times:

- the task procedure;
- the worker performing the task;
- the environment where the task is performed.

Although all those sources might play a role, the models of variability in task completion times, typically assume that the most significant sources are the task itself or the environment where the task is performed. Doerr, K.H., Arreola-Risa, A. (2000) suggest to investigate the notion that the worker performing the task may be the most significant source of variability in task completion times, and propose a modelling approach for this situation. In the present work all the three sources of variability are investigated.

4.3 Step 3 - ANALYSIS

In order to verify the effects of those anomalies and to identify any possible outlier, a Normality Test was performed (Fig. 5 - MINITAB function: Graphical Summary).

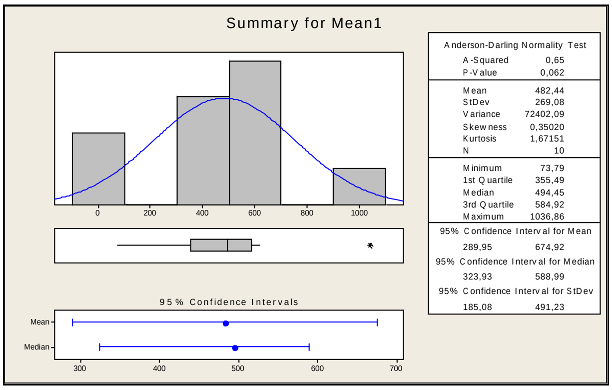

Fig. 5: Graphical Summary of means - January

Thanks to the statistical analysis, it is possible to identify an outlier, anyway the P-value of the Normality Test confirms a normal distribution, in fact as shown in the figure n. 5, the value of 0.062 is slightly greater than the limit of 0.05. Therefore, we can affirm that the average values are normally distributed as well as the whole population of reading times.

The other positional parameters of the same dataset have been studied (median value, first and third quartile). P-values for all investigated parameters confirm a normal distribution.

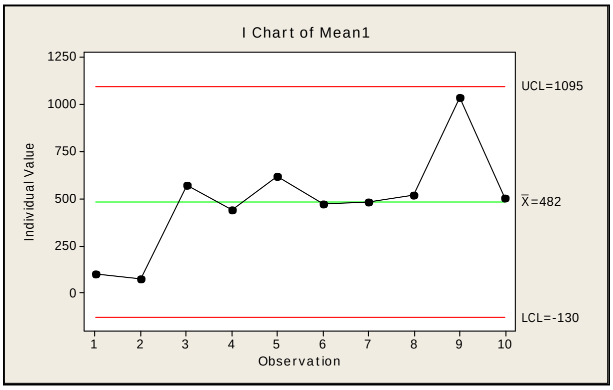

Fig. 6: Xbar-R Control Chart of the mean values - January

We collected continuous data and not discrete, therefore even if they are not so big because of the difficult of obtaining confidential information by the service company; we can consider them enough to analysis the problem. Then, we represented Xbar-R control charts (Fig. 6 - MINITAB function: Control Chart Continuous). Even if the process seems to be normal distributed according to Normality Tests with an enough degree of confidence, we can observe a growing trend for all investigated parameters. In particular, analysing the distribution of mean values, we observe many data over the average line and also near the upper control limit. Therefore, the process is probably out of control, non-predictable and with a great variability.

4.4 Step 4 - DESIGN

Therefore, to optimize the service, it is necessary to re-engineering the process.

At this point, the DESIGN step was developed through the introduction of Agile Improvement Cycles (Sprints) (Sutherland, J. 2005). At any cycle a statistical analysis of reading times performed by operators has been carried out.

4.4.1 First Sprint

To re-engineering the reading phase, we decided to introduce a new upstream phase: the planning of reading activities, considering Contract Management and Quality Control.

After the sharing and the implementation of the proposed procedure, a new set of data and a new analysis, previously conducted in January, were repeated in April (Tab. 2), considering four weeks and 19 working days referred to three different operators.

Tab. 2: Minitab Worksheet of positional parameters - April

C3	C4	C5	C6
Mean1	Q1_1	Median1	Q3_1
88,355	27,5	50,0	93,50
93,237	24,0	49,0	95,50
101,710	31,0	63,0	100,00
71,800	23,0	46,0	83,00
107,140	32,0	64,0	113,50
66,348	25,0	41,5	70,75
74,153	26,0	44,0	73,00
90,100	27,0	54,0	105,00
86,682	23,0	49,0	93,00
99,545	28,0	54,0	106,00
180,584	45,0	83,0	142,00
109,161	35,0	67,0	108,75
95,731	23,0	49,0	96,00
95,996	27,0	55,0	101,00
101,650	27,0	58,0	105,00
92,361	29,0	61,0	104,00
81,729	28,0	51,5	90,00
162,623	34,0	68,0	134,00
118,619	36,0	58,0	93,50

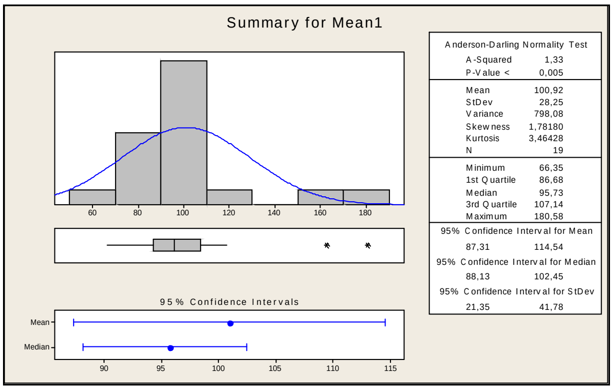

Fig. 7: Graphical Summary of means - April

A non-normal distribution of the mean values was obtained, in fact there are two outliers in the relative boxplot, corresponding to two specific days: 11 and 18 (Fig. 7). Subsequently, we focused on each of the three operators working during the considered period of observation, named B, C, D.

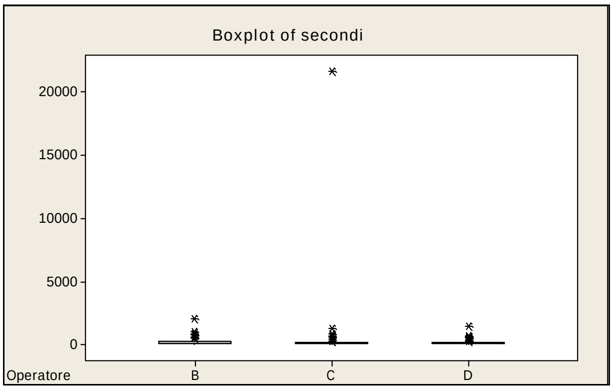

Fig. 8: Boxplot of cycle times sorted by operator

The variability of B and D is smaller than C, because of isolated high values of reading, due to the time breaks of some hours, probably caused by a traffic accident, rather than a technical fault of the handheld used by the operator for recording readings, or an authorized break of the operator (Fig. 8 - MINITAB function: Boxplot). The performed analysis allowed to understand and remove those anomalies, obtaining a consequent normal distribution, with a smaller variability than before of the re-engineering phase. The same result is obtained for the other positional parameters.

4.4.2 Second Sprint

At this point, it is possible to graph all collected measures (Fig. 9). We can notice a great variation shifting from January to April.

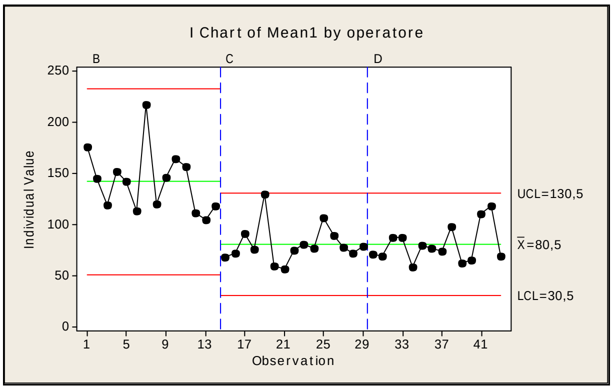

Fig. 9: Control Chart of the reading times of all operators

In January, only the operator A worked, except for one day when the operator B was working; instead in April, the operators B, C and D worked together every day. To verify if the cause of the greater variability is the operator A, we have realized a data stratification, considering only the reading times of the operator B during both months. The plot line confirms a great difference in time reading for the operator B too, not due to the operator A. Even if, we noticed a greater variability in reading activities for the operator B, with less experience and younger than the other operators (Fig. 10 - MINITAB function: Line Plot).

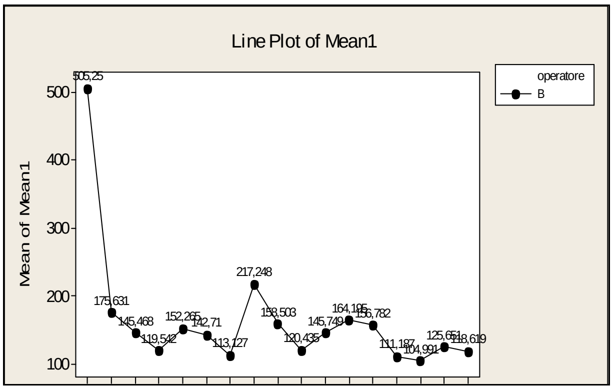

Fig. 10: Line Plot of the reading times of the operator B

4.4.3 Third Sprint

Then, it was possible to compare the mean values of reading activities for the two different datasets collected in January and April (fig. 11). A single control chart was realized, combining the mean values of the two months. We can observe a growing trend in January, absent in April, and a substantial greater variability in the measurement process in the same month.

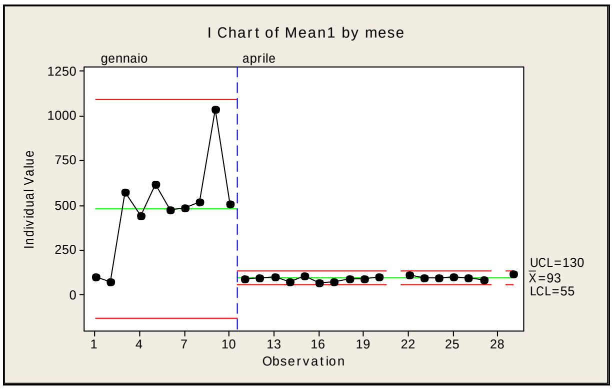

Fig.11: Control Chart of the mean values - January and April

We noticed there are two points in January comparable to the April data population. Making a more detailed study, we were able to identify the real cause of the problem: a different type of activity. In April, the three operators worked mainly in an urban area with a reading plan (a massive task related to many houses close to each other). In January, however, the activity of reading is massive during the first two days, but changes during the remaining days of the month: the operator A worked in a sub-urban territory without a reading planning (spot activities related to distant addresses).

At the end of the improvement of the reading activity through the re-Design of the procedure, we suggested to divide the initial procedure of reading in two different ones: Massive or Spot Procedure, linked to urban and sub-urban areas, that can't be managed in the same way. In the second case, a more detailed evaluation of paths and addresses is necessary. Subsequently, we can assign a different distribution of mean reading times to each procedure, based on historical data collected and constantly double checked by the company. Subsequently, it is possible to evaluate a more correct number of operators required to realize the monitoring activity.

4.5 Step 5 - VERIFY

After the adoption of the re-designed procedure of reading, based on a previous defined plan, we can realize the control chart of the figure n. 12.

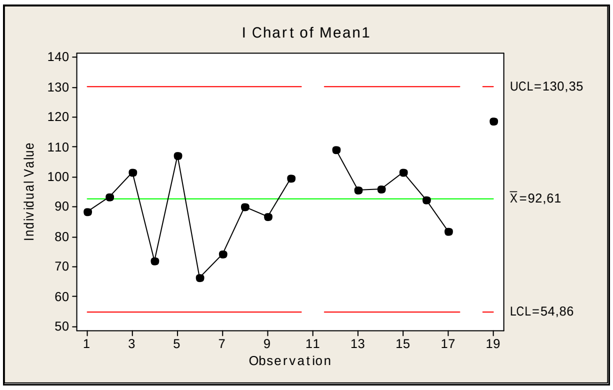

Fig.12: Control Chart of the mean values - April

Observations nn. 11 and 18 correspond to the above removed anomalies, are not present in the graph.

At the end, we can observe an under control process.

5. Conclusions

In the present work, a methodology called Agile Six Sigma for Services, has been proposed, based on the integration of Lean and Agile approaches (DMAIC vs DMADV) and the recursive application of six sigma tools. The main outcome is the definition of an improvement cycle, starting from the analysis of human operations in order to re-design and to improve the related service procedure. The variability of execution times often depends on a wrong design of the procedure, as well as on operator training or environmental conditions. The incorrect design of the procedure causes a great variability of the process and its unpredictability. The paper suggests a methodology to verify the goodness of the service procedure and then to allow its reengineering. The objective is a more adequate allocation of resources, able to respect deadlines, to satisfy customer and to avoid problems. In particular, a monitoring activity was investigated, highlighting the differences in working conditions (young or expert operators; long or short distance; winter or spring seasons), at the basis of the execution variability.

The suggested approach can be generally applied to activities realized by many operators in different conditions. In conclusion, a standard procedure for the statistical evaluation of information about human activities is suggested, in order to study their distribution, variability and predictability.

The strong presence of human factors and the constant interaction with internal and external variables, including customers, suggest a management as a recursive project we need to improve, where time of completion is expected and not deterministic. Continuing the integration of different tools, the future step will be the application of other project management tools, such as PERT, in order to calculate the probability of completion in case of particular deadline, mixing different information.

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