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Project Risk Management Methodology: A Case Study of an Electric Energy Organization

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Abstract

This paper presents the developed risk management methodology and the main risk management results of a pilot project in a Portuguese electric energy organization – EDP Distribution. Most of the project risks identified have external and technical sources, and most of the risks are rated as medium and high level. In the future, it is expected that this methodology can be used for similar projects and that a gradual standardization on the use of the risk management methodology can be achieved in the organization.

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Keywords: risk management; risk management plan; identify risks; risk assessment; plan risk response; risk monitoring and control

1. Introduction

Nowadays, projects are constantly under pressure, in consequence of the globalization's challenges and their innovative nature [1, 2] and project risk management is an area of great interest for organizations. Project risk management practices are more and more necessary, as they can provide a systematic process that aims to identify and manage risk in order to act if it arises, contributing to define different project objectives, improve project

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control, increase the chances of project success, improve communication between project participants, facilitate decision-making and prioritize actions [3].

EDP Distribution, the biggest electric energy organization responsible for the electricity distribution in Portugal, perceived the value of project risk management, and settled as a goal to define and implement a project risk management methodology in a pilot project of the organization. The main objective is to test the risk management methodology developed and extend the methodology to all similar projects in the organization.

In order to attain this important goal for EDP distribution, an action research project was required, which had established the following objectives:

- Design a risk management methodology adapted to the project characteristics, which includes the risk management planning, risk identification, risk qualitative and quantitative assessment, risk response planning and risk monitoring and control processes.
- Provide all the necessary templates for the risk management processes.
- Develop the project risk register.
- Adapt the risk management methodology to future similar projects.

EDP Distribution has defined quality and scope as the most important project objectives, since the variation of the budget and schedule is not acceptable. Therefore, the main concern about the project's risks is that they impact the project's quality. The quality is connected to the smart grid infrastructure or functionalities, and if something happens in this particular area, the project success becomes more difficult to achieve.

This paper presents the characteristics of this pilot project, the initial risk management plan and the results obtained until now, starting with a literature review on project risk management.

2. Project Risk Management

The term risk is defined in PMBoK®, from Project Management Institute, as an uncertain event or condition that, if occurs, has a positive or negative effect on project's objectives [2]. Although, PMBoK® defined risk as an uncertainty, there are differences between risks and uncertainties. A risk represents an event or condition for which the probability of occurrence is known, the ‘known unknowns’, susceptible to analysis. And uncertainty is an event for which the probability is not known, being the ‘unknown unknowns’, not susceptible to analysis [4]. During the project lifecycle it is common for project managers to find assessable risks and uncertainties that can't be assessed. As a result, they felt the necessity to improve project risk management practices by adopting broader perspectives in what concerns managing uncertainty, for instance, paying more attention to lack of knowledge that may bring uncertainty [5].

Risk management assures that almost all problems are discovered early enough so that there is time to recover from them without missing schedules or overspending the budget [6]. Leung, Chua and Tummala [7] argue that formal risk management approaches can provide a useful insight into the project and provide more information to improve the quality of investment decisions.

Elkington and Smallman [8] claim that project risk management is essential for the project's success. The authors carried out a study on a British utilities company to assess their project risk profiles. Based on the effects of risk, the authors developed a framework that might explain project success by: a) assessing the different kinds of projects' risks to measure the amount of risk management processes undertaken by a project manager, creating questionnaires to collect business risks, procurement risks, management risks and technical risks; b) assessing how and when the project manager applied risk management processes during the project; and c) determining the project managers' knowledge of risk management and their attitude towards it. A total of 10 of 20 questionnaires were responded completely by the project managers invited. They have identified that the most successful projects undertook more risk management practices. They also perceived that the earlier risk management is initiated, the more successful a project is.

A definition of a project risk management methodology normally enables risks identification, qualitative and quantitative assessment, response planning and monitoring, giving the project manager a set of tools and techniques which allow to increase the probability and impact of events that may appear as opportunities for the project and decrease the probability and impact of the ones that may cause negative effects on the project objectives [2, 9].

PMBoK® defines six risk management processes: plan risk management, identify risks, perform qualitative risk analysis, perform quantitative risk analysis, plan risk responses and control risks [2].

The risk management plan defines what activities should be done to deal with project risks:

- The risk identification allows identifying and documenting risks that may affect the project objectives.
- The qualitative analysis evaluates the possible consequences of the risks as well as their likelihood of occurrence, in subjective terms, in order to prioritize the risk.
- The quantitative analysis is recommended to be conducted for the most important project risks, considering their probability and impact resultant from the qualitative analysis. It should be conducted with rigor in quantitative terms to assess the probability and impact of the high priority risks.
- The risk response planning helps to develop actions to enhance opportunities and to reduce threats on project objectives [2, 10].
- Monitoring and controlling risks, which enables the project manager to keep track of the defined risks and identify new risks during the project and during the implementation of the risk response plans [2, 9, 10].
- The risk management plan should also include the definition of the tools and techniques suitable and available for each risk process, for a particular project or type of project.

Raz and Michael [11] performed a study about the tools and techniques most used by project managers during the project risk management. With their survey results they realized that the tools of the risk control group are perceived by project managers as low contributors for project success. These findings may be explained as a consequence of the management culture: project managers might be willing to invest time and effort in the earlier phases of risk management, which are carried out along with other project planning activities, and with the evolution of the project they become busier and are subject to resource constraints and time pressures, consequently neglecting the risk control phase, using the tools sporadically or not at all [11]. That is a tendency to avoid on this case study.

Some studies indicate that project risk management approaches are not widely accepted in project management as a result of the time necessary to use them, the difficulty of obtaining input estimates and assessment of risk probabilities, human/organizational resistance to change, difficulty in understanding and interpreting outcomes of the risk management process and finding suitable risk management methods [7]. However, a recently worldwide survey study from 2013, conducted by Fernandes, Ward and Araújo [12], found that from the 68 surveyed project management tools and techniques, the areas of knowledge: risk, scope, time, communication and integration assume a high relevance amongst the most useful PM practices, each with at least three PM practices on the top 20 of the list. For example, under the risk management practices were identified: ‘risk identification’, ‘risk response plan’ and ‘qualitative risk analysis’. Curiously, none of the tools from the area of cost or quality, related usually to the project's objectives, were in the top 20 of the list.

Alhawari [1] recognizes that lack of knowledge among project team or lack of knowledge sharing during project progress can influence the effectiveness of project risk management practices, and at an extreme case confine the project to failure. This knowledge can be described as a mix of framed experience, values, contextual information and expert insight, that provides a structure for evaluating and integrating experiences and information [1]. Other aspect that should be pointed out is that there is no perfect knowledge about the future state of an environment, and error will always occur even with the attempts of correction [10].

Given all this, we can face the project risk management as an essential part of project management, that manages the uncertainties and known risks of the project and, as a result, provides information that may be used to optimize the decision making process.

3. Distribution Automation Pilot Project at Batalha

The EDP distribution automation pilot project has the main objective to implement a smart grid system on the electric grid of a restricted area (Batalha). It represents a huge technological innovation for the local electric grid. Given the technological aspects and the expected quality, this project deals with great uncertainties and there is no historic data to know what could be expected with the project evolution in general and in particularly the related risks. This project has also some other particularities:

- It is a partnership between EDP Distribution and its main supplier: the supplier gives the technological equipment and software, and the organization gives the means to execute the project.
- The project management is done by two project managers, one that manages all EDP Distribution activities, and another that manages all the main suppliers' activities of the project.
- Neither EDP Distribution nor the supplier involved use standard or systematic risk management approaches.
- The implementation of the project risk management methodology described in this paper was started after the pilot project's implementation phase was initiated.

Consequently, to develop the risk management methodology adapted to this particular pilot project, the researchers needed firstly to understand the project and the organization's project management practices and try to achieve an effective risk management methodology, using action-research.

4. Developing the Risk Management Methodology

The development of the risk management methodology had the main theoretical foundation PMBoK® [2] and the particular Practice Standard for Project Risk Management [9] also from Project Management Institute. These standards were selected because PMBoK® is the most well-known body of knowledge, with the primary focus upon task execution [13]. Organizations have several benefits using an internationally-recognized BoK/standard to guide them in the development of the organization's project management and in this case a risk management methodology. These include: 1) the assurance that the organization is using what is considered to be 'best practice'; 2) demand from external customers that a recognized methodology is used; 3) assistance with external recruitment; and the availability of suppliers of the methodology for training and support [14]; and 4) removes to some extent the barriers to design/development of project management or risk management methodologies as BoKs are recognized as 'best practices' [15].

4.1. Risk management plan

The development of the risk management plan is the most valuable activity on project risk management, because it establishes all the activities that the project management team need to handle to manage the risks and uncertainties of the project. It works like a guide that provides procedures, tools and techniques and document templates that the project management team should use during the management of the project.

The risk management plan contains the project's information and risk management objectives, the guide for identify, assess, plan responses and monitor and control risks, the nomination of risk owners and who they have to report in order to communicate modifications on their risk behave, and the risk management documents (risk breakdown structure, risk register and templates). Table 1 summarizes the information contained on the project risk management plan.

The main output of the risk management plan is the risk register. It collects all the information about the identified risks, qualitative and quantitative evaluation, risk response and status during the risk monitoring and control. Risk management is an iterative and continuous process [16], and the risk register must be regularly updated in order to identify new risks and control others that may occur [9]. These reviews may happen during the risk control activity. Table 2 summarizes the defined project risk register structure.

4.2. Risks Identification

The risk management plan defines the inputs, tools and techniques to use and the outputs to identify the project risks (Table 3). Along with this activity, the risk qualitative analysis is also made, as well as the identification of risk potential responses, in order to provide a better understanding of the risks that are being identified.

The reviewing of all project documents allows to understand the project reality, all project management practices, and also to identify the project's weaknesses and strengths.

Table 1. Information contained on the project risk management plan.

Project description	Project's objectives	
	External dependencies	
	Stakeholders identification	
Risk management scope and objectives	Thresholds	
	Prioritization of project objectives	
	Weights and other parameters	Unacceptable Threats
		Unmissable opportunities
		PxI matrix and probability scales
		Selection criteria
Risk activities	Risk identification	
	Risk qualitative evaluation	
	Risk quantitative evaluation	
	Risk response plan	
	Risk monitoring and control	
Responsibilities and functions	Risk owners	
Risk management documents	Risk breakdown structure	
	Risk register	
	Templates	

Table 2. Project risk register structure.

Identify Risk	**Qualitative Analysis**		**Quantitative Analysis**	**Plan Risk Response**		**Risk Monitoring and Control**
ID	Probability		EMV	Risk possible results		Monitoring and control status
Description	Impact	Cost	Risk decision trees	Risk owners		Risk audit
Classification		Chronogram		Entities involved on the risk		Risk management learned lessons
Phase expected to occur		Scope		Type of action to risk response	Preventive	
Frequency of occurrence		Quality			Contingency	
		Total			Corrective	
	Matrix Probability x Impact			Risk response	Avoid/Explore	
	Prioritize risk				Mitigate/Enhance	
					Transfer/Share	
					Accept	
				Plan risk response		

Table 3. Inputs, tools and techniques, and outputs defined to use on identifying risks.

Input	**Tools and Techniques**	**Output**
Reviewing all documents of the project, e.g. meeting's records, work breakdown structure, contracts, project description, etc.	Brainstorming meetings	Risk register Risk breakdown structure
	Audio or audiovisual recording of meetings	
	Decision tree analysis	
	Documental revision	

Brainstorming meetings require preparation, for both, meeting's moderator as for the participants. An agenda for the meeting is required. This agenda should explain the meeting's subject and purpose, the set of objectives to achieve and related concepts. Additionally, it should be presented to all participants beforehand, so they can prepare themselves, come up with some ideas to share and doubts to clarify.

The audio or audiovisual meetings' recording facilitates the future information consulting, as many times as needed, to fill of the risk register template.

In order to improve the process of identifying risks and their consequences, the decision tree analysis is recommended. This tool facilitates the process of thinking about the decisions and consequences that can occur due to a risk, and eventually helps finding some possible secondary risks.

The risk breakdown structure organizes the risks identified by their classification in terms of types of sources: external, commercial, project management and technical.

All the information collected must be filled up on the project risk register.

4.3. Qualitative risk analysis

As noted in the previous section, qualitative analysis is accomplished in parallel with the identification of the risks. In qualitative risk analysis the probability impact matrix (PxI matrix) is recommended. Each risk is classified with subjective probabilities for the probability of occurrence and impact of the risk on the project objectives, through the matrix, resulting in the risks rating as low, medium or high impact on the project. The risk level is defined with a color code: green for low, yellow for moderated and red for high impact risks.

The risk probability scale, risk impact scale and PxI matrix defined for the project are presented on Table 4, Table 5 and Table 6, respectively.

Table 4. Probability scale used on the pilot project [2].

Occurrence	Very low (VL)	Low (L)	Moderate (M)	High (H)	Very High (VH)
Probability	0,1	0,3	0,5	0,7	0,9

Table 5. Impact scale used on the pilot project [2].

Project objectives	**Very low (VL)**	**Low (L)**	**Moderate (M)**	**High (H)**	**Very High (VH)**
	0,05	0,1	0,2	0,4	0,8
Cost	Insignificant increasing	<5% cost increasing	5-10% cost increasing	10-20% cost increasing	>20% cost increasing
Chronogram	Insignificant delay	<5% total delay on the chronogram	5-10% total delay on the chronogram	10-20% total delay on the chronogram	>20% total delay on the chronogram
Scope	Almost unnoticeable scope reduction	Minor scope areas are affected	Relevant scope areas are affected	Unacceptable scope reduction	Unsuitable final product
Quality	Almost imperceptible degradation	Only more demanding application affected	Quality reduction requires client authorization	Quality reduction unacceptable to the client	Useless final product

Table 6. PxI matrix defined for the pilot project, according to the project team risk tolerance.

Probability	**Impact**				
	0,05	0,1	0,2	0,4	0,8
0,9	0,05	0,09	0,18	0,36	0,72
0,7	0,04	0,07	0,14	0,28	0,56
0,5	0,03	0,05	0,10	0,20	0,40
0,3	0,02	0,03	0,06	0,12	0,24
0,1	0,01	0,01	0,02	0,04	0,08
Color code constraints	between	0,00	and	0,05	
	between	0,06	and	0,14	
	between	0,15	and	1	

The risk localization in this matrix allows the project management team perceived the type of responses that must be considered on the identified risks for planning the risks' responses, reducing their impact, diminishing their level of impact on the project, or avoid them (see Table 7).

Table 7. Relation between the project risk impact and the adequate risk response.

	Project impact	**Monitoring**	**Response**
	High	Urgent attention	Preventive: Avoid
	Moderate	Periodic risk revision	Contingency: Reduce/Mitigate
	Low	Control	Corrective: Mitigate/Accept

But, this does not mean that the project management team just has to provide one response plan for each risk. It is useful for the team to have a backup plan, if the first response plan does not achieve the expected result.

4.4. Quantitative risk analysis

The risk management plan specifies that the quantitative analysis is not mandatory for all project risks identified. The quantitative risk analysis is done if the risk in the PxI matrix is classified above 0.14, and the risk owner is a representative of EDP Distribution. If the risk owner is a project supplier, even if the risk has a high

rating, the responsibility is of the supplier, therefore EDP distribution does not take any further actions in what concerns quantitative analysis. In addition, even if EDP distribution wanted to quantitatively assess the risk, they would not have the necessary information. During the quantitative risk analysis, the expected monetary value (EMV) should be evaluated for each alternative of action.

Figure 1 illustrates an example of the use of the decision tree technique during the conduction of quantitative analysis of the project risk - *the mismatch of customer/final client expectations for a sub product functionality* - which got a qualitative evaluation of 0.15, and the risk owner was EDP distribution.

For this particular risk, the goals defined were the maximization of the customer satisfaction and the minimization of the cost of the technical changes. A 1-10 scale was used to represent the customer satisfaction. The cost in euros was converted to this common scale, using equation (1), a minimization linear function.

$$y(x) = \frac{Max - x}{Max - Min} \times 10 \tag{1}$$

Then a global score for each alternative was evaluated using equation (2).

$$Global\ Score\ = 60\% \times Costumer\ Satisfaction + 40\% \times Cost \tag{2}$$

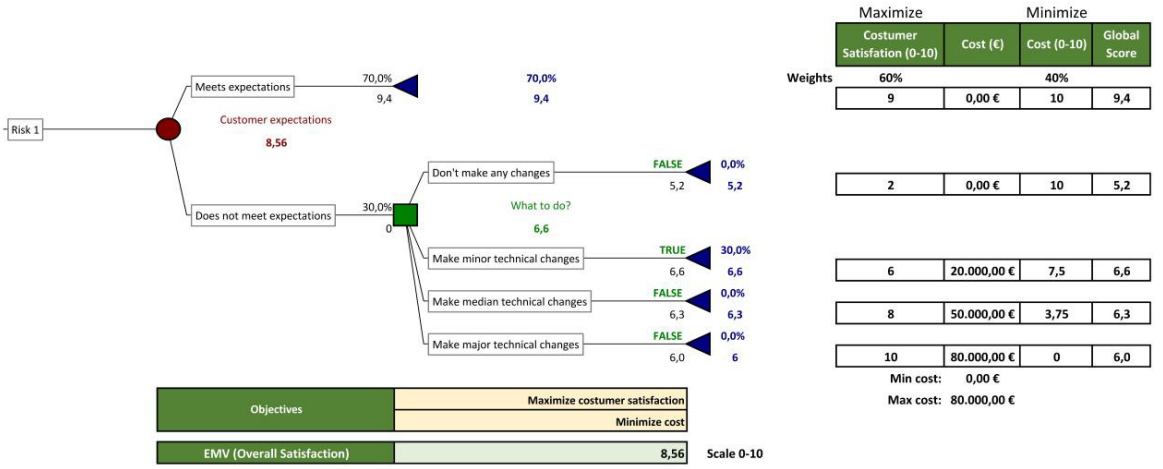

Fig.1. Pilot project's risk decision tree for risk 2.

The Expected Monetary Value (EMV) was 8.56 and the best solution, considering the objectives, was - *to make minor technical changes*. This solution corresponds to a cost of 20000€. This kind of analysis allows the organization to decide what to do if risks occur and evaluate how much the organization might need to spend to respond to the risks. Nevertheless, we have to be careful because the values used are estimates that should be further analyzed if the risk really occurs. A sensibility analysis might also help on this analysis.

4.5. Plan risks response

A risk response plan should be identified for all risks, even if the response is *accept*, i.e. do not take any action. The risk response plan has the following information, and it should be attached to the project risk register, having one record of risk response for each individual risk:

- Risk ID and description.
- Assumptions that involve the risk, such as the risk causes.
- Possible risk results on scope, quality, schedule, and costs.

- Risk responsibility: identify the risk owner and entities involved on the risk occurrence and response.
- Intervention action: all the actions to be taken to risk response are described; the resources needed are estimated, as well as the costs and the delays of every response.
- Communication: the communication moments along the risk responses are defined.
- Risk and responses interaction: identification of the secondary risks that may arise as a consequence of a response to the primary risk.

The risk response planning has as main input the risk register, and as the output the risk register updates and one document with the risk response plan for every risk, in order to facilitate the consulting of the records, when this information is needed.

4.6. Risk monitoring and control

The risk monitoring and control has the follow inputs, tools and techniques and outputs defined in Table 8.

Table 8. Inputs, tools and techniques and outputs of risk monitoring and control.

Inputs	**Tools and Techniques**	**Outputs**
Risk register	Risk audit	Risk register
Plan risk response documents		Lessons learned report

The risk audit has the purpose to evaluate the way that the risk management rules are being carried out and if they are adequate for controlling the project risk, and must happen every time that a risk occurs on the project. Table 9 shows the structure of the risk audit document.

Table 9. Structure of the risk audit document.

Risk Audit	Risk Management Audit
ID and description of the risk	Accomplishment of the risk management plan processes and tools and techniques used on the risk
Action date of the response plan	
Causes that made risk happen	
Responses in action	Lessons learned
Observations made about the responses	
Communications made	Good practices description
Results of the response plan	
Actions and mechanism that should be improved	

During the project control progress or when the first response plan is activated, the information about the status of the risk is collected on the risk register. The risk status is assessed in four steps: irrelevant (if the risk is far from the horizon of the project activities), controlled (if its time of occurrence on the project chronogram is being tracked), requires attention (if is perceived that the occurrence is near and response plans are on the move), and critical (if it is already happening or it is inevitable and the response plans are not resulting on avoiding or reducing the risk impact on the project). This assessment is done in order to control the evolution of the risk over time, and anticipate its behavior before the actual occurrence.

All lessons learned in every risk audit must be collected in a single document to facilitate the access to the information, in order to avoid the same mistakes or misjudgments all over again during the project risk management process, and to provide know-how for future projects.

5. Risk Management Results of the Pilot Project

During the implementation of the risk management methodology twenty-one risks were identified: twenty threats, five of them secondary risks; and one opportunity.

After the risks identification, the risk breakdown structure was developed, providing the project management team the sense of what types of risks can occur in the project. It was found that the major part of the identified risks had external or technical sources. This indicated to the project management team the area of intervention that needs more attention. The technical source was an expected result, since this project implies a large use of new

technical components, namely related to the automation equipment and the software platforms needed to manage and control the smart grid functionalities.

The qualitative analysis rated most of the risks as having a medium and high impact on the project, indicating that almost every identified risk may jeopardize the project success. Consequently, risk monitoring and control needs more care and attention concerning the risk development and requires close supervising. Table 10 shows the identification number of the project risk on the PxI matrix. For example, risk 7.1 is the risk of the subcontracting teams not being able to meet the deadlines for executing the project activities.

Table 10. Probability-Impact Matrix with the identification of the pilot project risks by their ID number.

	Consequence				
Probability	**VL**	**L**	**M**	**H**	**VH**
VH			1.1		14
H			3, 4, 15	14.1	
M			7.2, 8, 9, 11, 12, 16, 7	2, 7.1, 10, 13	6
L		9.1		5	1
VL					

Table 10 indicates that is mandatory for the project management team to apply avoidance response plans to the nine risks with high impact on the project, on the red zone, and guarantee to them urgent attention, so they can be avoided or become residual risks with minor impact on the project. To handle the eleven risks with moderated impact, yellow zone of the table, periodic supervising and mitigation response plans are needed. The project management team decided to apply to this risks avoidance and mitigation response plans. The one on the green area, a risk with low impact on the project, only required monitoring and control.

During the quantitative analysis, three risks were identified by EDP Distribution representatives. One has commercial activities as a source, and the other two have technical origin. The example given at section 4.3 is from a commercial source risk.

During the risk response planning several plans were established: fifteen preventive response plans (one for exploring an opportunity), ten response plans for mitigating project risk's impacts or probability, two for transfer the impact or responsibilities, and eleven to accept the risk occurrence. Therefore, we can say that EDP Distribution is committed to avoid risks or at least reduce their impact on the project by investing in prevention and mitigation plans as a response for the risks occurrence. The risk response acceptance is allowed if preventive and mitigation response plans fail. Currently, there is only one risk identified, that acceptance is the given response plan.

The risk monitoring and control phase already started, however only one iteration was done. For more reliable information of the risks' evolution, more time is needed. Presently, there are ten risks being classified as irrelevant, which do not require much attention, eight that are in control, three of them with already activated risk response plans: two plans of avoidance and one for mitigation, and three risks require attention, but only two of them are with the response plans activated (for the other one no response plan could be activated). Three of the risks with active response plans are on the red area marked on the PxI matrix, and two on the yellow one (table 10).

6. Conclusion

This paper presents the risk management methodology defined for a pilot project under execution. During project evolution and risk management revision processes, changes that are proven to be more effective to the plan may occur, together with some gradual increase of the risk management's assessment, monitor and control parameters.

The risk management methodology proposed for the project was developed having as basis the PMBoK® [2] and the particular Practice Standard for Project Risk Management [9]. The risk management methodology was developed for this particular pilot project context. However, this methodology could be adapted to other similar projects of EDP Distribution.

One of the main concerns during the development of this risk management methodology was the degree of effort necessary for its usage by the project team. As argued by Fernandes, Ward and Araújo [17], the ‘perceived ease of use’ is a key embedding factor for the embeddedness of a project management practice, in this particular

case, the risk management methodology.

The risk management methodology proposed was applied to the pilot project case study. The results from the risk identification, qualitative and quantitative risk analysis, risk response planning and monitoring are summarized. Since the results of risk monitoring and control resulted from just one iteration, it is not possible to conclude about the result or impact of this methodology to the current pilot project.

This research found some setbacks such as:

- The project risk methodology is new for the project management team, so first should be assured that project team understands the project risk management plan and is committed to follow it.
- The project had already started when the risk management plan was defined, once the ideal timing for establishing the risk management plan is along with the project management plan, when the project is defined and characterized, so it is easily accepted along with the other project management practices.
- The information collection process from the project management team took more time than expected. The reasons for this can be related to: a) the inability to perceive the relevance of risk management practices for the project success; b) the fact that the project was already started; c) the team being involved in other tasks, and c) lack of risk management knowledge.
- Difficulty in understanding and interpreting the outcomes of project risk and response plans.
- Difficulty in influencing the project team to dedicate more time to risk management activities.

It is expected that during the risk monitoring and control phase, the collection of more data about the risks and about the risk management plans implemented will improve gradually the risk management plan, and establish confidence on risk management practices among the project management team and administration.

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