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Risk Assessment in the Implementation of Resilient, Sustainable, and Smart Cities

Carlos Eduardo Cardoso de Souza
Department of Engineering, Universidade Católica de Petrópolis, Brazil. E-mail: cecs_kadu@hotmail.com

Raquel Machado Gomes
Department of Engineering, Universidade Católica de Petrópolis, Brazil, E-mail: raquelm_gomes@hotmail.com

José Cristiano Pereira

Department of Engineering, Universidade Católica de Petrópolis, Brazil, E-mail: josecristiano.pereira@ucp.br

Alexandre Sheremetieff
Department of Engineering, Universidade Católica de Petrópolis, Brazil, E-mail: alexandre.sheremetieff@ucp.br

The degree of complexity of a smart city project and the management of multiple technologies is expected to advance year after year. The project manager must manage technological resources, ensure their implementation and maintenance throughout the project, and provide all necessary training and documentation for the work team; the challenge is enormous. This study aims to conduct a risk assessment on implementing a smart city considering project management methodologies, highlighting the main organization topics, risks, and impacts for major stakeholders. The study also seeks to highlight different project management methodology guidelines, looking for an effective contribution to success in implementing such a sustainable and innovative project. As a methodological approach, the authors collected qualitative data from experienced field specialists and project managers. A matrix was used to list opportunities, risks, and impacts of the construction and implementation of a smart city project. As a result, the study shows vital information that can contribute effectively to project managers involved in smart city projects and help meet the requirements of time, cost, and quality. Although conducted in a specific city in Brazil, the study can be generalized to other cities and countries whose safety is affected by risk issues resulting in waste, rework, and unnecessary energy consumption. The study can change practice and thoughts of professionals dealing with risk assessment in implementing a smart city.

Keywords: Smart city, resilient cities, project management, risk management.

1. Introduction

Considering the advance of times, increased pollution, the emergence of the pandemic, the opportunity to emerge new technologies, the increasing application in the concept of recycling/ reuse, the need to contribute to the reduction of CO2 emissions, the need for Cost and resources optimization, increased reliability, need for resilience and integration, it is necessary to manage and manage risks in the implementation of a smart city, and use the best of project management methodologies and map the complexity of a Project of this nature, transforming a great differential of success.

When we talk about smart city, the concept becomes very comprehensive and it is necessary to diagnose the real needs of a municipality, neighborhood, or condominium where the necessary technologies should be evaluated, the problems to be solved, the real needs to meet a given type of service integrating multiple solutions into a defined scope. For this assessment the proposition is to use the case study of recently developed smart city projects that have the opportunity to be implemented in full on the horizon from 3 months to 2 years.

During this article, it is expected to answer the questions: 1- How applied risk management concepts and project management considering an extremely innovative and challenging topic can

contribute to the success of the project. 2- Diagnosis of complexity of a project in the perspective of the main stakeholders and how it can be determinant in the process design. 3- How the FMEA risk management methodology can effectively contribute to the implementation of a project.

In the next sessions we will explore the concepts of smart cities and the level of implementation in Brazil and worldwide as to technologies and stage of implementation. Increasingly, we will have the private initiative working together with the public initiative in private public partner models aiming at a win-win relationship with the improvement of the quality of services to the citizen and bringing integrated reliability and innovation and fostering an entire chain of strategic development, and can even act directly with class entities and the academic world. One of the world's great goals is how we can multiply and make this type of business scalable.

1.1. Concept of Smart City

According to the portal "The Guardian" in a recent article we have the following definition for smart city: "A city capable of becoming environmentally sustainable and attractive for citizens and companies requires a new type of intelligent infrastructure-Intelligent Technology-based open platform-open platform which can help prospective cities more predictably integrate a complex set of economic services and effectively, at rhythm and scale. " [1]

Considering article published on CNN.com [9], Smart Cities are spaces that use advanced technology to connect systems and services, in the search for a higher quality of life of their population. The housing experience in a fully connected city seeks to optimally develop mobility, energy distribution, education, health systems, and promote a sustainable lifestyle for the future. This concept, which transforms the infrastructure of an entire city, is part of the urban development planning of various countries around the world. In a global scenario of constant population increase in large urban centers, it is increasingly important to plan and implement solutions that improve the quality of life of the inhabitants and, moreover, that mitigate the impacts of our consumption on the environment.

According to the UN [10], 70% of the global population (more than six billions of people will live in cities, where to plan, manage and rule cities in a sustainable way, maximizing economic opportunities and minimizing environmental damage are major challenges that virtually everyone Countries will face in this new century. Public resources need to have better use and natural assets need to be exploited consciously and responsible.

The great challenges we will have in the coming years is to create projects that contribute to all the concepts of sustainability, considering reduced CO2 emissions, decarbonization concepts, "net zero", ESG using the best of biodiversity considering a migration To recycle, reuse and optimize the use of our planet's resources. In this trend comes the concept of intelligent cities or circular cities or resilient cities that are concepts that are increasingly improving technology and innovation.

With the advancement of time, solutions are increasingly necessary that contribute to a climate rebalancing and an adaptation to a new post - pandemic reality.

In addition to the concepts of sustainability, one of the major goals of an intelligent city is to use the best of advanced technology to meet the specific needs of a particular municipality or that population with quality improvement in the provision of services with cost optimization, using the concept of turn data into information.

Another very important pillar part integration with existing systems and technologies as a fundamental premise.

In the initial phase of a project, the Project Manager must work by making a mapping of all existing technologies and setting together with the Municipality the needs, priorities and time designed to implement the project, as well as an administration platform for all applications through a control room.

Considering the step by step in the implementation of a smart circular city as Business, we can see that one of the great missions will be to integrate the whole concept of urban infrastructure with systems and people, providing a better quality of life.

2. Objective

As one of the main objectives of this article, we have the key assessment of risk management methodology in the implementation of an intelligent city model and project management

considering since the first stage of discussion and conception with municipal leaders or private managers, until its real implementation.

We will seek to evaluate the impacts on the implementation of a smart city considering the project management methodologies highlighting the main organization topics, risks and impacts for the main stakeholders in the implementation of the respective project seeking to highlight the described in the different guides of management methodology guides Projects combined with the concept of reliability management and risk management, seeking an effective contribution to success in the implementation of such a sustainable and innovative project.

The proposed methodology will be to evaluate the scope of a base project originated from the intercession of project needs and solutions that encompass cities with a minimum of 80 k up to an average of 700 k inhabitants with mountain, rivers, islands and sea. To obtain a comprehensive ecosystem and at the same time that it can be replicated not only in Brazilian cities but also in the cities around the world, highlighting the role of the project manager in the success of the project.

In sessions related to the methodology and unfolding of discussions we will bring the answers related to the main questions, as follows:

(i) How applied risk management concepts and project management considering an extremely innovative and challenging topic can contribute to the success of the project.

(ii) Diagnosis of complexity of a project in the perspective of the main stakeholders and how it can be determinant in the process design.

(iii) How the FMEA risk management methodology can effectively contribute to the implementation of a project.

3. Methodology

With the focus of contributing to this work, we hope to describe and demonstrate how the project management methodology can and should be applied from the construction of the base project scope to the implementation phase with the identification of steps, objectives, opportunities, and management of Risks in its implementation, in addition to the contribution to major stakeholders.

When we talk about risk management, the big focus will be to build a process through FMEA so that each technology based on a multi -farm group analysis considering various levels of specific focus experiences, and involving potential customers' vision through of a sample research and also explore the main companies of both technologies and services. The risks around here may be categorized in hardware risks when we talk about technologies, cyber secondity risks since for a smart city one of the necessary assumptions is necessary to better use connectivity, quality risks in the provision of services where we should have A very strong focus on the management of people responsible for project execution and implementation, risks of changing legislation and regulation, quality risks and costs of necessary inputs, as well as the risk of demand and/or proper revenue for minimal profitability to investors, Cost reduction and benefits to the citizen.

One of the other opportunities that proposes to evaluate is how KPIs' reliability and management should be monitored and applied to the success of the project through project management exploited in the main guides. When we talk about project management methodology we will seek to evaluate how the main guides address in topics: organization, risk management, controls/monitoring, change management, impacts on major stakeholders and complexity assessment of a project.

3.1 FMEA Method

The selected method can be applied to the implementation of a new information system in the field of implementing a smart city in practice. If the new information system has to be functional and, at the same time, safe, it is undoubtedly a difficult and complex task, and it is necessary to integrate with all existing systems and processes. Preconceptions, lack of technical training, barriers and related risks can slow down,

compromise or even prevent the process of project creation and implementation. The FMEA method is considered a systematic procedure to identify possible failure conditions, its causes and consequences that affect product or process performance. Based on the evaluated project, we recognize structural analysis, process and the FMEA system. The procedure can be summarized in four main phases: preparation or planning phase, current situation evaluation, proposal of risk reduction measures, evaluation of proposed measures. [2]

3.1.1. Preparation or planning

In this step we have the definition of the scope, the objective of the analysis and the composition of the team that works in the analysis. The purpose of the analysis is to determine the continuity of the individual activities of the process, identify barriers and risks in this process, describe their possible consequences, categorize failures in terms of probability of occurrence, severity of the consequence and probability of early detection, determine the severity of each failure and possible priority of their solution, propose measures to reduce risk factors in the process, evaluate residual risks. [2]

3.1.2. Evaluation of the current situation

To evaluate the current situation, it is necessary to define the sequence of the main individual steps of the process and then identify barriers in each step and/or possible flaws that threaten the success of the implementation of the process. The defined steps and barriers corresponding to the implementation of an intelligent city can be observed below in Table 1.

Table 1: steps, description and possible problems or barriers

Step	Description	Possible Problem or Barrier
A	Definition of the project scope, considering existing situation and future implementation	Incorrect interpretation of needs and lack of coverage in all software and hardware requirements
B	Service to political and non-technical agendas	Accelerate the project and overcome necessary steps due to a political window
C	Software definitions and integration with existing systems	Use software not able to manage all resources and integrate with existing systems
D	Creation of new systems	Create software without considering hardware requirements and technologies to be implemented
E	Hardware mapping and preliminary field analysis	Incorrect definition of the hardware
F	Sizing of teams for the project	Team sizing error based on the time planning needed to implement and maintain the entire project
G	Generation of ancillary revenues	Projection of accessory revenues for project coverage
H	Evaluate, test and commission both hardware and software before implementation	Manufacturing problems or definition of requirements that may be insufficient or problematic for the performance
I	Cyber security	Lack of protection or use of systems inadequate to Cyber Security

Considering the FMEA methodology, below in Table 2, we have the consequences related to the possible problems or barriers identified.

Table 2: Definition of consequences for possible problems or barriers

Number	Step	Description	Consequence
1	A	Definition of the s project scope, considering existing situation and future implementation	Non meeting the minimum customer requirements, system inefficiency, integration problem
2	A	Service to political and non - technical agendas	Omit relevant topics, increase in costs, lack of resources, installation problems, loss of revenue
3	B	Software definitions and integration with existing systems	Problems of reliability in information, system performance and lack of inertness of the project
4	B	Creation of new systems	Problems of effectiveness, rework and increase in costs with the need to develop/ adapt new applications
5	C	Hardware mapping and preliminary field analysis	Increased costs with installation/replacement of equipment, on additional cost by non-failed mapping items
6	C	Sizing of teams for project	Delay in project execution, increased cost, and loss of credibility
7	D	Generation of ancillary revenues	Lower profitability for shareholders and for sharing with the public administration
8	E	Evaluate, test and commission both hardware and software before implementation	Low performance, risk of failure and inoperability by hardware and software, loss of revenue, cost increase
9	F	Cyber security	Theft of information, lack of reliability, financial loss, judicial proceedings due to the general data protection law

Based on the FMEA method, possible problems or barriers are evaluated through three factors: the probability of occurrence (PV), the description of the consequences and their severity (n) and the probability of detection before we have the manifestation of negative effects (PO). By assigning PV and N to every possible failure, we can talk about risks (where we have that the risk is really defined by the likelihood of a negative phenomenon and the magnitude and reach of its consequence. [3]

Based on this description, we can determine the value of the consequence of the manifestations of individual disorders. Its values will be attributed in the range of 1 to 10. The occurrence of an error represents the likelihood of manifestation of a potential cause of the failure and is evaluated by a weight of 1-10, where the number 1 means the minimum and the number 10 means most likely. The meaning of the consequences of a failure is a factor that expresses the impact of customer failure discovery and is evaluated, as well as the occurrence of the failure. The probability of detecting a failure represents the probability that

the failure is detected before project implementation or the product has been applied and is evaluated with a weight of 1 to 10, where 1 means that the failure is always detected and 10 It means that the failure will not be detected. [4]
The resulting value of the risks is called a risk priority number (RPC), which can be calculated by the formula: RPC = PV * N * PO. We can observe in Table 3 the result of this analysis.

Table 3: RPC calculation according to methodology and prioritization of problems or failures

Number	Step	Failure Description	PV	N	PO	RPC	Priority
5	C	Hardware mapping and preliminary field analysis	6	9	7	378	1
9	F	Cyber security	8	8	5	320	2
8	E	Evaluate, test and commission both hardware and software before implementation	7	7	6	294	3
4	B	Creation of new systems	4	8	8	256	4
7	D	Generation of ancillary revenues	6	7	6	252	5
1	A	Definition of the scope of the project, considering the existing situation	5	9	5	225	6
3	B	Software definitions and integration with existing systems	3	8	8	192	7
2	A	Service to political and non-technical agenda	4	7	6	168	8
6	C	Sizing of teams for the project	5	6	5	150	9

Table 3 (Continued)

3.1.3 Proposed risk assessment and failure mitigation

Advancing with the application of the methodology we have the main problems that were identified in analysis of the implementation team and in the table below we have identified the mitigation actions to reduce risk according to prioritization.

Table 4: Mitigation actions for prioritized failures

Number	Step	Failure Description	Mitigation Actions
5	C	Increased costs with installation and replacement of equipment, additional overcustom by failed mapping items	Creation of basic project with field visits and validation of expectation with the customer. Technical meetings with manufacturers and service providers for scope validation
9	F	Theft of information, lack of reliability,	Firewall implementation, hiring specialized

Table 4 (Continued)

		financial loss, judicial proceedings due to the general data protection law	services, cloud backup system, defining alarm procedures and insulation of systems in case of invasion.
8	E	Low performance, risk of failure and inoperability by hardware and software, loss of revenue, cost increase	Evaluation of the integration of hardware and software previously implementation, hiring Back to Back guarantees based on executive project
4	B	Efficiency problems, rework and cost increase with the need to develop new applications or adaptations	Throughout the development of applications and integrations, stress tests and validation should be performed with users in order to anticipate possible problems and be more assertive
7	D	Lower profitability for shareholders and for sharing with the public administration	Creation of business plan with proposals from companies with experience in the field of accessory revenues to be explored considering a minimum payment, performance indicator and possibility of recess due to problems and delivery and/or quality in the provision of services

Table 4 (Continued)

1	A	Non complaint with the minimum customer requirements, system inefficiency, integration problem	Project design based on previous experience and customer validation and their respective user areas ensuring documentation through records
3	B	Problems of reliability in information, system performance and lack of inertness of the project as a whole	During hiring the scope, the interface development criteria should be defined and guarantee the integration of existing systems ensuring prior validation with the customer of the minimum requirements of existing systems
2	A	Omit relevant topics, increase in cost, lack of resources, installation problems, loss of revenue	Use of project management implementation methodology and making it clear that the political agenda will impact on cost and time, requiring project redesign and critical path
6	C	Delay in project execution, increased cost and loss of credibility	Upon approval of the project, the executive project should be created and the necessary resources properly sized. when hiring companies to provide services there must be rules and back to back and penalties for non - compliance with deadline and quality

3.1.4 Evaluation of applied measures

After applying mitigation actions, the FMEA method should be taken again and check if the RPC calculation results are at acceptable levels. If we have any failure with higher RPC we must create new mitigation actions until we calculate the RPC below the acceptable limit.

Based on the observed results and FMEA analysis made, we can observe that the role of the project manager and the use of project management methodologies is fundamental at all stages of the project, from its conception/creation to its implementation. In the following sessions we will discuss the advantages of applying the concepts.

4. Conclusion

In addition to answering the questions described in previous sessions, as expected results, we have the proposal of a matrix with the identification of opportunities, risks and impacts with the proposition of a model that can be implemented in the light of the current regulation and bringing the whole concept of Sustainability to the center of the solution contributing to the other benefits already highlighted. Additionally, according to the objective of the activity in the project management discipline, the role of the project manager, their respective activities and risks in the implementation based on the project management methodology was highlighted.

In response to the questions we aim at a matrix with the FMEA methodology with the main risks in the construction and implementation of an intelligent city project and how effective it can be and contribute effectively to the project manager to be successful in their mission, besides, besides Successful in the effective management of risk and success in the project meeting the deadline, cost and quality requirements.

Based on all the discussions carried out throughout the document, we were able to observe that for the future of smart cities, it is necessary to use bold methodologies for management, from the first stage of conception to the stage of post-implementation control and monitoring. The project manager has a relevant role and when he successfully accomplishes his mission, applying the best of existing methodologies, it is possible to scale and build new smart cities contributing to sustainability, innovation and technology.

5. Future works

As future works, we have the possibility of applying the FMEA matrix and the complexity questionnaire to other stakeholders in order to identify the necessary actions for each type of smart city, remembering that it is very specific and has its particularities.

Another suggestion is based on the outputs of interactions with stakeholders and applying success cases, creating a script for implementation, plans creation and control and monitoring of KPIs based on project management methodologies.

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