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Structuring the Technological Innovation Center and Performance Indicators for Innovative Development and Extension in a Company in the Nuclear Sector

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Abstract:
This work aims to create the structuring process for the Technological Innovation Center (NIT) a company in the nuclear area. This research presents two instruments that help structure and strengthen NIT management. It includes a theoretical review on the concepts of innovation, innovation system, triple helix; strategy focused on innovation, performance indicators for innovation, innovation funnel and organizational culture for innovation. The qualitative prescriptive research strategy was chosen, appropriate to understand the various situations about the object of study, applying the Design Science Research methodology with the objective of studying, researching, investigating and generating knowledge that is applicable and useful for the solution of the problem. The Design Thinking and Balanced Scorecard (BSC) tools were used in the development of the research to generate alternatives. The use of performance indicators, segregated from the perspectives of the BSC, allows a assessment of the effectiveness of actions, monitoring and strengthening of processes and management activities. The contribution of this research to the structuring of the NIT is evidenced in the systematic view of the innovation management process, based on the innovation funnel, a recognized tool helped the decision-making process of innovation, as well as in its proposed administrative organization through the Internal Regulations .

Key Word:Technological Innovation Center; Innovative Extension, Nuclear Industry; Key Performance Indicators Design Thinking.

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I. Introduction

Innovation within an organizational context is a key factor for economic growth and a sustainable and effective source to ensure competitive advantage[1]. In Brazil, in order to leverage the country's competitiveness through the promotion of innovations and the interaction between the academic, public and private sectors, Law 10,973 or Innovation Law, was regulated in 2004, which imposed, from then on, that Scientific, Technological and Innovation Institutions (ICTs) should create internal bodies to, among other things, manage their innovation policies, intellectual property and technology transfers, called Technological Innovation Centers – NITs[2].

The well-done establishment, structuring and functioning of NITs is extremely important, since they can be actors of change within ICTs and facilitators for the dissemination of research and the formation of partnerships, mainly with the productive sector[3].

The company, object of this work, called company "A", for reasons of confidentiality, is categorized as an ICT, combined with the Ministries of Science, Technology, and Innovation - MCTI and Education - MEC. It's objective is to explore and promote the nuclear and defense sectors, identifying needs and continuously seeking solutions for the consolidation of these industries in the country.

For this, innovation management, operationalized through the NIT, has become an important instrument for the company to create solutions and develop new technologies. Furthermore, it should be noted, that it is essential to measure innovation and discuss the results associated with it[4].

Thus, this work intends to explore the concepts of innovation management for the creation of innovation performance indicators (KPI's) based on the innovation funnel, segregated in the perspectives of the Balanced Scorecard (BSC).

This work seeks to answer the following research question: Which performance indicators can help in the process of structuring the NIT in a company in the nuclear area?

The general objective of this paper was to develop a framework of innovation performance indicators for the NIT, based on the innovation funnel, segregated in the perspectives of the BSC, as a mechanism to strengthen and define the management processes, and thus, help the process of the Nucleus' structuring.

II. Literature Review

The concept introduced by Federal Law No. 10,973/2004 was amended by the Federal Law No. 13,243/2016, now displaying the following wording: introduction of novelty or improvement in the productive and social environment that results in new products, services, or processes or that comprises the aggregation of new functionalities or features to an existing product, service or process that may result in improvements and effective gains in quality or performance[5].

The general definition of innovation can be understood as a product or process that is new or improved, or a combination of both, regarding its characteristics or intended uses, or even the implementation of new or significantly improved methods or processes[6].

The concept of Innovation System considers a network of participants involved in the innovation process and the relationships established between them during the creation and diffusion of new technologies and economically useful knowledge[7,8].

The term innovation system refers to a synergistic system, such as the sum of the parts is greater than the whole, the author emphasizes the importance of interaction between actors, their processes and results[9] .

Considering the Triple Helix model, in the model the interaction between university, industry and government is the key to innovation and growth in a knowledge-based economy[10].In addition, in this approach, ICT is an important link, as it involves generation and capitalization of knowledge[11].

The Innovation Lawdetermines that each ICT must have its own NIT or be associated with other ICTs in order to manage its innovation policy[12]. This law also establishes the minimum competencies required of an NIT: a) to ensure the maintenance of the institutional policy to encourage the protection of creations, licensing, innovation, and other forms of technology transfer; b) to evaluate and classify the results arising from research activities and projects; c) to evaluate an independent inventor's request for adoption of an invention; d) to opine on the convenience and promote the protection of the creations developed in the institution; e) to give an opinion on the convenience of disclosing the creations developed at the institution, subject to intellectual property protection; and f) monitor the processing of requests and maintenance of the institution's intellectual property titles;

Recently, Law 13,243, of January 11, 2016, expanded the attributions of the NIT, adding other activities: g) to develop studies of technological prospection and competitive intelligence in the field of intellectual property, in order to guide ICT innovation actions; h) to develop studies and strategies for the transfer of innovation generated by ICT; i) to promote and monitor ICT's relationship with companies; and j) to negotiate and manage ICT technology transfer agreements.

The role of the NIT is to foster and mediate relations with the productive sector and the government, stimulating entrepreneurial and innovative activities and productively managing the technologies developed[13].The NIT's action is required to promote the creation of an environment favorable to the transfer of generated technologies and the protection of knowledge.

The study of NITs and their administrative processes, as well as understanding the effectiveness of their managerial actions, is extremely important and contributes to the elaboration of their management structure[14]. The NIT should create indicators for measuring results and performance in order to review and improve the Center's innovation management process[15].

One of the ways to carry out this evaluation is to measure performance through metrics known as key performance indicators (KPI) or key performance measures[16].

The performance indicators in the NITs allow an assessment of the effectiveness of the actions taken and contribute to the definition or redefinition of strategies, in addition to contributing to decision-making, planning, the visualization of current and future scenarios, and the results of the NIT's actions[17].

For[18], in addition to analysis and strategic choice, there must be monitoring and evaluations to efficiently reallocate project resources. One of the main aspects of innovation management is the ability to measure the level, capacity and performance of initiatives[19].

A fundamental principle of the Oslo Manual is that innovation can and should be measured. Consistently measuring innovation and using innovation data in surveys can help policymakers understand economic and social changes, assess innovation's contribution to social and economic goals, and monitor and evaluate the efficiency and effectiveness of their innovations. and policies[6].

As for the innovation process, any process originates from an initial idea that adds a series of other ideas over time; therefore, it is concluded that innovation is a process permeated by ideas in all its forms and phases[20].

For example, a new product project aims to transform an idea or concept into a final product through well-defined and structured phases[21].

A tool called Innovation Funnel was developed with the aim of generating ideas for the development of a product or service[22]. The funnel provides a development tool with the following characteristics: generation and review of alternatives, sequence of critical decisions and nature of the decision.

For[23], the innovation funnel is a way of visualizing risk and uncertainty variations throughout the product development process. It is, in essence, a decision-making process. As it is a complex and long process, the author states that subdividing it into a few steps facilitates development quality control.

The BSC Designer proposes an innovation funnel that starts from the generation of ideas and ends with the development of the product and builds a system for measuring and managing innovations through performance indicators segregated from the perspectives of the Balanced Scorecard (BSC), as proposed of this research (Figure 1).

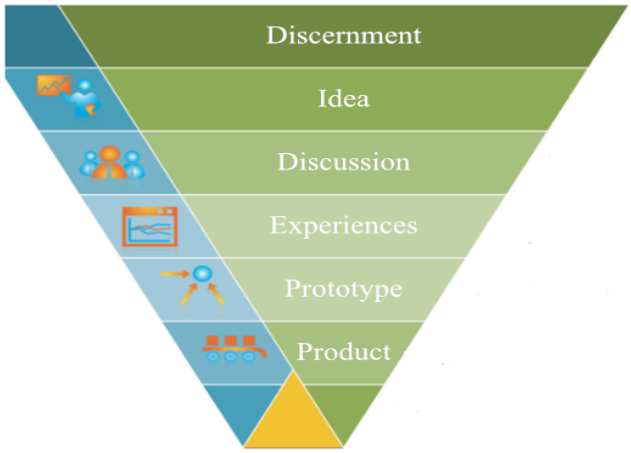

Figure 1. Innovation funnel for generating ideas and developing products based on the BSC[24].

In addition, it should be noted that the BSC was developed as a management model with a strategic focus, through a structure of objectives, targets and performance vectors that interact within a cause and effect logic, measuring organizational performance from four perspectives : financial, customer, cause and effect, measures organizational performance from four perspectives: financial, customer, internal processes and learning and growth, thus becoming not a control tool, but a communication tool[25].

The application of the BSC implies a series of benefits, such as the integration of financial and non-financial measures, the guarantee of organizational focus and alignment, strategy communication and feedback, linking strategy with planning and budget, and others[26].

III. Methodology

This study is classified as qualitative, prescriptive research. Thus, bibliographical research, documental research, and qualitative prescriptive research were used in this work.

The approach to the problem is qualitative, adequate to the need to understand the different situations related to the object of study. For [27], the following are characteristics of qualitative research: emphasis on the subjective interpretation of individuals; delineation of the context of the research environment; importance of the conception of organizational reality; and proximity to the studied phenomenon.

Although the emphasis of the study is on the application, the first stage is characterized by the literature review regarding the proposed theme: bibliographical research. The bibliographical research consisted of a bibliographic survey of the main concepts of innovation and its management, as well as references on the management of the NIT in an ICT.

Documental research, in addition to bibliographical research, was used as a technique, with the characteristic, according to [28], that the source of data collection is limited to documents, written or not, constituting a source of primary research. In this work, official documents and administrative publications of the institution were used as sources. The documentary research involved the study of a set of existing documents and information in the company, and the qualitative prescriptive research aimed to obtain more information about the problem in question, describing it.

Design Science Research (DSR)

The adoption of the "Design Science" research method is appropriate in a research project when there is the creation of an artifact to promote improvements in the present or future real world, applied in a context of cooperation or not with the actors involved, with the effectiveness of the artifact in achieving such improvements being the focus of the study[29].

For [30], unlike the tradition of the natural and social sciences, which seek to understand phenomena in the world, design science is based on the tradition of design itself, in which the idea of developing artifacts to change and improve the world is often expressed in a prescriptive way. "Artifact" is defined by [31] as everything that is not natural, something constructed by man. Knowledge is generated about and from these artifacts, contributing to those involved with problems of similar characteristics and contexts[32].

According to [33], while exploratory, descriptive, or explanatory research problems emphasize the study of problems, explaining the real world retrospectively, the "prescriptive" approach of Design Science emphasizes the proposition and iterative evaluation of solutions.

According to[34], Design Science Research involves the generation of one or more artifact alternatives for the solution of the identified problem, and this process begins with the understanding of the problem and develops until the evaluation stage, resulting in the conclusions of the research (Figure 2).

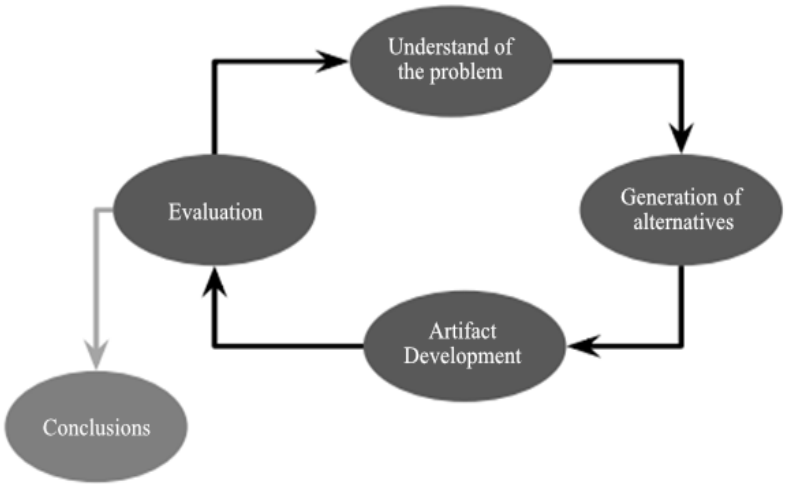

Figure 2. Cycle of research stages in Design Science Research - DSR used in the research[29].

This cycle can be performed in a prescriptive way by the researcher, based on their perspective on the problem[29]. Given the prescriptive approach of this method, it is necessary that the understanding of the problem is not reductionist, requiring a systemic emphasis[35].

In Figure 3, a framework for the application of procedures and relevant steps applied in this research, based on the DSR method, stands out. It is worth mentioning the procedure used to generate ideas, "Design Thinking." [36] refers to this as an abductive thought. In this type of thinking, one seeks to formulate questions through an apprehension or understanding of the phenomena, that is, questions that can be answered from the information collected during the observation of the universe that permeates the problem.

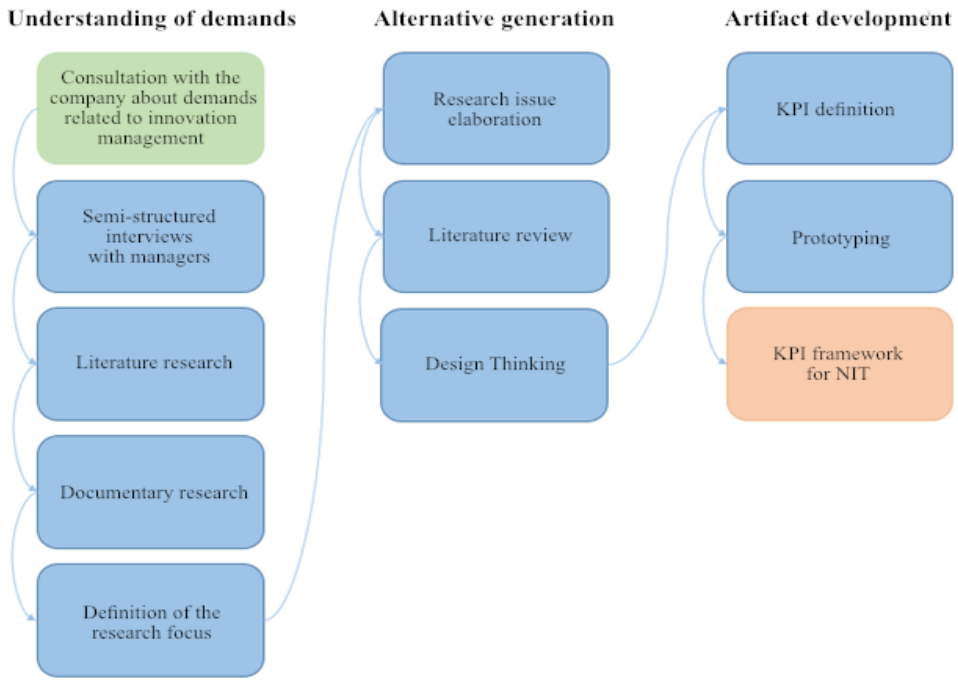

Figure 3. Framework for applying the DSR method in this research. Source: authors (2022).

For [37], to think abductively is not to think of a solution directly through the problem, but rather to use modal reasoning in which one aims to imagine and think about the possibilities of what may be true for the problem.

As the focus is on the human being, design thinking emerges as a tool to assist design made for people [38].It's in this way that empathy emerges as one of the main precepts of the tool.According to [39], the Design Thinking process revolves around three fundamental phases: inspiration, ideation, and implementation. During these phases, problems are questioned, ideas are generated, and answers are obtained.

IV. Results and Discussion

In this context, the stages of the development of the artifact are presented, such as technical and technological products; in this case, the framework of performance indicators for the innovative extension, based on the innovation funnel, is segregated in the perspectives of the BSC, adding the proposition of indicators for measurement of a favorable environment.

The results follow the steps of the DSR, with phase 1: Understanding the problem, phase 2: Generation of alternatives, and phase 3: Development of the artifact. Table 1 lists the procedures used in each phase.Table 1 shows the three phases of the DSR.

Table 1. Procedures carried out in the first three phases of the DSR and their connections with the research.

PHASE 1 UNDERSTANDING THE PROBLEM	PHASE 2 GENERATION OF ALTERNATIVES	PHASE 3 ARTIFACT DEVELOPMENT
Semi-structured interviews Literature Research Documentary Research	Literature Review Design Thinking	Prototyping

Source: authors (2022).

In phase 1, the company's managers and directors were consulted through semi-structured interviews, which allowed the interviewee freedom of expression and the maintenance of the interviewer's focus [40], in which the main characteristics of the performance of the NIT were highlighted, highlighting the importance of its structure for the company as it is an internal body that can boost the achievement of the organization's strategic objectives.

The interview script had directed questions, based on §1 and Art. 16 of Law 10.973/2004, for understanding the projects and activities being carried out by the NIT, the existing relationships with other institutions, the available documentation, the demands, and the main needs and difficulties faced.

Afterwards, bibliographical and documentary research was carried out through the analysis of current legislation and available documents, such as bylaws, internal regulations, strategic planning, and the institutional development plan.

When analyzing the management reports, prepared annually, for the 27 (twenty-seven) performance indicators monitored by senior management, only three (three) indicators related to innovation were identified. After understanding the context of the organization's needs, the focus of the research was defined: the need to structure the NIT and expand the performance indicators for monitoring and promoting innovation management in the company.

Phase 2 started with the definition of the research question. Next, a bibliographic review was carried out aimed at defining the performance indicators and the existing tools. Then, the Design Thinking tool was applied, based on the pillars of empathy, collaboration, and experimentation, in which we sought to idealize the paths and solutions that guided the development of performance indicators for each perspective.

In phase 3, the innovation KPIs for the NIT were defined, and prototyping was carried out, which, according to [36], consists of transferring ideas from the conceptual scope to reality and, thus, validating the ideas generated in phase 2. Finally, the process was concluded with the effective creation of the KPI framework for the NIT based on the innovation funnel and the perspectives of the BSC.

Performance Indicators for Innovation

Taking as a starting point the innovation funnel [41], according to Figure 1, the performance indicators were defined and segregated based on the four perspectives of the BSC: learning and growth, finance, internal processes, and customers, adding the proposition of indicators for measuring a favorable environment. The innovation funnel was the basis for the development of KPIs for internal processes, according to the standards for each perspective, as shown in Table 2:

Table 2. basis for the development of KPIs for internal processes.

LEARNING AND GROWTH	Number of innovations trainings; Number of innovations conferences; Number of records in lessons learned; Number of studies developed; % of employees trained; % of senior management participation in training; % meetings with the innovation agenda over the total number of senior management meetings; Number of registered patents.
FINANCE	Funds spent on innovation; R&D budget; Budget for experiments; Budget for generating ideas; Budget for prototypes; Revenue generated by innovations; Revenue for new projects; Return on investment (ROI) of projects.
INTERNAL PROCESSES	% ideas discussed over the total number of ideas; % ideas tried out over ideas discussed; % prototyped ideas over tried out ideas; % ideas implemented over number of ideas tried; Number of projects focused on innovation and institutional development; Number of projects running as ICT; Number of technology transfer agreements.
CUSTOMERS	Value for external customers; Value for internal customers; Number of stakeholders that can generate ideas for innovation.
FAVORABLE ENVIRONMENT	Number of suggested ideas in a period of time; % of ideas turned into experiments; Number of innovative initiatives that were successful in a period of time; Number of spin-offs generated.

Source: authors (2022).

In this context, the indicators are presented in a framework in order to identify the relationships with the stages of the Innovation Funnel, as related by the BSC perspectives. The framework developed is a static representation of the connections between the funnel stages and their indicators, allowing the organization and its stakeholders to quickly understand it (Figure 4).

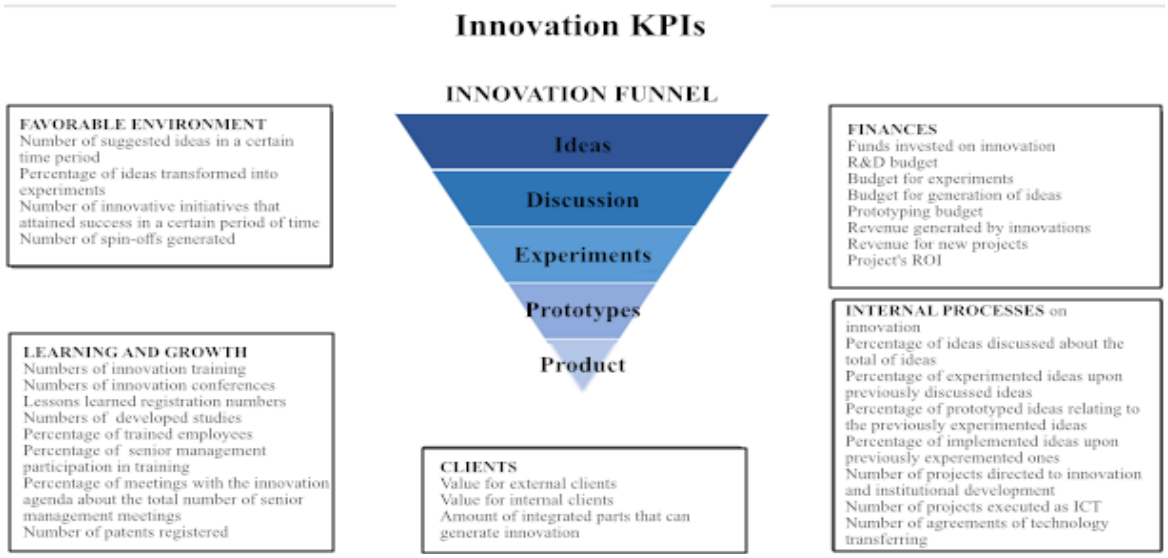

Figure 4. KPI's framework for innovation and its interactions with DSR and Design Thinking applied to research. Source: authors (2022).

With the completion of this phase, the objective of this research was to develop a framework of innovation KPIs for the NIT of a company in the nuclear area, based on the innovation funnel.

The framework has the purpose of quickly communicating with the organization's agents and portrays the relationship between the indicators and the funnel. The funnel establishes a decision-making process from ideas to the development of a new or significantly improved product or service. Indicators are a management tool that allows for the measurement of performance levels, indicating which processes require improvement and, as a result, more attention from managers. The BSC allows the segregation of indicators into financial and non-financial perspectives, which guarantee the body's multidimensional focus.

Therefore, it is worth highlighting the importance of each tool applied in the framework and the integration of these tools with the objective of communicating the NIT strategy and promoting the strengthening of its management.

As a next step, it is suggested that a prioritization technique, such as the GUT matrix, be used to define the indicators that will be managed by the organization in this first moment, in order to improve the organization's consistent evolution of the NIT's goals and purposes.It is also proposed that the review of the application and expansion of the indicators should be carried out annually.

With this, the work assumes the construction of a solution for structuring and strengthening the management of the NIT in the context of the nuclear area.

V. Conclusion

This work presented a solution, through qualitative prescriptive research, to the need that was evident for a company in the nuclear area to structure the NIT, an internal body that favored the reach and responses of the strategic objectives in the organization.

The proposed indicators constantly help to understand the competences and their main activities, significantly contributing to the elaboration of their structure.

The KPIs were presented using a framework that establishes the relationship with the innovation funnel and divides them into perspectives that allow the NIT effort to be directed in a multidimensional way in its actions in a harmonious and strategic way.

The semi-structured interviews and documentary research were crucial to understanding the environment, opportunities for improvement, the context, and existing processes in the company, and thus contributed to the focus of the research and the artifacts produced.

It was noted, as a result of COVID-19, that greater collaborative interactions were impaired; however, the DSR methodology supported the prescriptive nature of the research and provided a way to present the solution to the company.

It was noted that the action of the NIT is necessary in the sense of favoring the creation of a favorable environment to promote the culture of innovation. As a result, it is included in the "favorable environment" perspective as a guiding mechanism of this competence for the NIT.

The concepts sought in the literature were fundamental to supporting the empirical research and, above all, innovation, the innovation system, the innovation funnel, the BSC model, and performance indicators. They

allowed the creation of the knowledge base to develop the research cycle, present indicators of performance from the perspective of the BSC, relate them to the innovation funnel, and interconnect them in order to propose an innovation management process and monitor the Center's activities.

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