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Design of a Unit Department for the Administration and Execution of Technological and Innovation Projects: A Case Applied to Mechatronic Projects †

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Abstract: Currently, the administration of innovation and technology, and the execution of technological projects (in this case, mechatronic projects) is, for all types of organizations, a challenge that requires the use of the creativity and initiative of its professionals, investing or implementing processes, machines, products, and services in such a way that inventions, designs, and prototypes provide solutions to environmental problems and facilitate society. Therefore, in innovation projects, it should be considered that it corresponds not only to the application of new technologies, but also to the generation of an outcome that is useful for the objective, quantifiable, and productive segment, as applied to mechatronic projects. Therefore, it is necessary and relevant to carry out a process of orderly development in the following phases: identification of need, ideation, development, construction, and verification of the final solution of these mechatronic projects. The above is turned towards a comprehensive design process around the academy, which for the purposes of this research takes place at the Universidad Autónoma del Caribe, which, according to the indicators of technological development and innovation, is positioned among the top ten positions at a national level (over 350 measured universities) in the DTI-Sapiens ranking, published every two years since 2017 by the consulting firm Sapiens Research and recognized by the international IREG Observatory. The Unit Department for the Administration and Execution of Technological Projects and Innovation: A Case Applied to Mechatronic Projects aims to achieve a balanced technological offer in the universe of R&D&I projects in mechatronics, among economic and social scientific values. In this way, it will be possible to consolidate links with the socioeconomic environment for the transfer of existing knowledge in HEIs, its exploitation by stakeholders, and the increase in the development of R&D&I projects, strengthening capacities in the UEES relationship for the transfer of know-how to companies.

Keywords: business unit processes; technology; R&D&I; mechatronics; mechatronic projects; innovation; technological enrollment

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1. Introduction

At present, administration in innovation and technology, and the execution of technological projects (in this case, mechatronic projects) is, for all types of organizations, a

challenge that requires the use of the creativity and initiative of its professionals, investing or implementing processes, machines, products, and services in such a way that inventions, designs, and prototypes provide solutions to environmental problems and facilitate society.

Therefore, in innovation projects, it should be considered that it corresponds not only to the application of new technologies, but also to the generation of an outcome that is useful for the objective, quantifiable, and productive segment, as applied to mechatronic projects. Therefore, it is necessary and relevant to carry out a process of orderly development in the following phases: identification of need, ideation, development, construction, and verification of the final solution of these mechatronic projects.

The above is turned towards a comprehensive design process around the academy, which for purposes of this research takes place at the Universidad Autónoma del Caribe, which, according to the indicators of Technological Development and Innovation is positioned among the top ten positions at a national level (over 350 measured universities) in the DTI-Sapiens ranking, published every two years since 2017 by the consulting firm Sapiens Research and recognized by the international IREG Observatory.

This Unit Department for the Administration and Execution of Technological Projects and Innovation: A Case Applied to Mechatronic Projects aims to achieve a balanced technological offer in the universe of R&D&I projects in Mechatronics, among economic and social scientific values. In this way, it will be possible to consolidate links with the socioeconomic environment for the transfer of existing knowledge in HEIs, its exploitation by stakeholders, and the increase in the development of R&D&I projects, strengthening capacities in the UEES relationship for the transfer of know-how to companies.

2. Theory and Methods

2.1. Theory

Currently, it is important not only to emphasize that research and development projects require a social development component, but also to enable their materialization, secure resources for support, and, above all, exploit the resources invested. This is performed in such a way that, upon fulfilling the social component, but more importantly, at a general level, it can lead to economic returns for the stakeholders, including the business sector, the government, and, of course, the academic sector.

In the case of projects developed in the Mechatronic Engineering Department at the Universidad Autónoma del Caribe, they are based on a significant foundation, such as the Mechatronic Engineering Research Group (GIIM), framed within the following lines: bioengineering and biomedicine; intelligence and artificial vision; process optimization with nanotechnology and new energy sources; robotics and automation; and engineering education.

This is how these projects must be fully identified, classified, and, of course, promoted, so it is important to develop or implement a department for the management and technological execution of innovation responsible for these projects, considering the research lines mentioned earlier.

From the above, it was proposed that, for such research, agile methodologies would be used for the execution of mechatronic engineering projects. This approach not only aims to introduce new technological projects into society but also to provide innovative solutions capable of acknowledging opportunities for understanding, comprehension, and development at a general level and in various productive sectors.

It is evident that by positioning knowledge as a relevant asset for social and economic development, it becomes necessary to have a detailed relationship with reliable indicators of institutional, relational, and human capabilities for knowledge generation and appropriation, technological development, and innovation. Thus, research and innovation have

become increasingly significant components of higher education, representing major pillars of transformation and serving as a focal point for dialog with the environment.

The proper interpretation of economic evolution is a useful tool for improving business decision making. Companies do not operate in a vacuum but rather in a changing, unstable, and unpredictable environment with various dimensions, the economic dimension being one of them. Understanding the economic environment in which businesses operate is essential because it conditions future business prospects, and this can also be related to academia as a solid enterprise.

However, all the above presents certain obstacles, and one of them is the meaning of various economic concepts commonly used by economists and analysts to determine "how the economy is doing". This is not a simple task, as the economy, like any science, has its own "language". Secondly, the rapid evolution of economic events requires companies to invest significant effort in understanding their environment not only on a national but also on an international level. This alters business forecasts and leads to projects that were once profitable becoming unprofitable, and vice versa. Hence, the management of basic concepts used by analysts is a necessity within the company. It is not coincidental that business plans incorporate an analysis of the environment, and this analysis is not solely economic [1].

Additionally, competitive advantage refers to the characteristics or attributes that a product or brand possesses, giving it a certain superiority over its immediate competitors. This superiority, wherever it exists, is of a relative nature, referring to the competitor best positioned in the product market. It is then referred to as the most dangerous competitor or the priority competitor [2].

While readiness refers to the process by which strategic, commercial, and financial attributes of a technology are identified and validated for promotion and negotiation with third parties interested in it, technology must have sufficient technical validations for readiness. These validations should be considered in projects undertaken by a research group such as GIIM, but above all, its structuring, formulation, solution, verification, and implementation must be organized. This ensures that the final products can be commercialized [3].

On the other hand, commercial management encompasses all actions that lead to the transfer of technology to another entity. These actions include the identification of commercial prospects, presenting the technology and its benefits, and transfering conditions to third parties. This process is concluded by the subscription of a transfer agreement or by abandoning the process due to a lack of interest in technology [3].

Regarding business units, especially those originating from universities, Spin-Off Colombia is the result of the leadership and work of various higher education institutions (HEIs) and entities within the Science, Technology, and Innovation System of the country (SNCTi). Its purpose is to strengthen the capacities of the actors and achieve the effective implementation of the technology transfer mechanism called Spin-Off. This is achieved through the design of institutional policy frameworks, pre-incubation, and incubation, and the establishment, launch, and acceleration of academic Spin-Off technology-based companies [4].

Considering the foregoing, it is proposed to design a unit or department for the administration and execution of technological and innovation projects. This proposal specifically focuses on mechatronic projects.

2.2. Methods

The object of study focused on technological developments generated in the specific case of the Mechatronic Engineering Research Group (GIIM) at the Universidad Autónoma

del Caribe. GIIM is endorsed, recognized, and categorized by the Ministry of Science of Colombia. Many of these developments are not currently being commercialized, and a significant portion lacks the appropriate technological maturity (TLR) and commercial readiness (CLR) to enter the market, let alone the possibility of manufacturing them (MLR).

To achieve the set objectives, a descriptive study with a mixed research approach was defined, combining both qualitative and quantitative approaches in the same study. This combination provided a broader and deeper perspective to the research by collecting and presenting data gathered from the state of the art and the implementation of a technological surveillance process to understand market behavior. The study's nature was descriptive as it initially sought to diagnose the current technological developments generated in the specific case of the Mechatronic Engineering Research Group (GIIM) at the Universidad Autónoma del Caribe, with a focus on designing a unit for the administration and execution of technological and innovation projects, specifically applied to mechatronic projects.

Since there was no intentional manipulation or random assignment of variables, the design was non-experimental, given that the research's purpose was observational, analyzing data from variables collected over a period for the GIIM at the Universidad Autónoma del Caribe, where high-impact technological developments have been generated.

Regarding the units of analysis, a diagnosis of the current situation of the technological developments of the GIIM Research Group was conducted. Additionally, developments from other universities, offices of research results transfer (OTRIs), spin-offs, and startups engaged in technological readiness and commercial management were analyzed.

3. Results

The main objective of technological and innovation projects, specifically those carried out in the Mechatronic Engineering Department at the Universidad Autónoma del Caribe, is defined as the development, research, and high-level innovation of knowledge in the areas of robotics and automation, artificial vision and intelligence, optimization of processes with nanotechnology and new energy sources, and bioengineering and biomedical engineering. This involves the experience, adaptation, appropriation, and creation of knowledge, contributing to the training of excellent professionals and researchers who impact both the academic and industrial sectors. The aim is to conduct research (formative, basic, and applied) and innovation in line with the needs of the environment, the UEE relationships, the training of human resources for science, technology, and innovation (CTI), the generation of new knowledge, and the social appropriation of knowledge. The results are intended to be endorsed by social and business fabric, returning to academia and allowing for the continuous redesigning of the curriculum and research training activities.

Certainly, with the aim of establishing a unit for the administration and execution of technological and innovation projects, specifically applied to mechatronic projects at the university, and considering the main objective, an analysis is presented through a SWOT matrix (Table 1) to assess the importance of its creation.

Similarly, several higher education institutions at the local and national levels were analyzed, serving as a foundation and support through a market study with related institutions (See Table 2). This study aims to highlight the research level of each institution and subsequently compare the projects and products produced, juxtaposing them with the Mechatronic Engineering Research Group (GIIM) at the Universidad Autónoma del Caribe.

In relation to the market segment targeted for the commercial management of technologies developed in the GIIM, and considering market levels, the focus is on national companies or organizations, particularly in the department of Atlántico and its Caribbean region, engaged in functions related to strategic areas of technological development and

innovation. The target audience should possess the interest, need, and capacity to afford specialized services, consulting, and advisory services.

Table 1. SWOT Matrix—Universidad Autónoma del Caribe.

Weaknesses	Opportunities
1. Economic resource limitations for technological development. 2. Lack of knowledge among some researchers regarding maturity levels of designed products. 3. Absence of implementation of economic incentive policies for researchers at the national, local, and institutional levels. 4. Reduction in research staff. 5. Insufficient specialized personnel in intellectual property. 6. Lack of internal communication.	1. Monetization of research production, as well as associated products. 2. Participation in calls at the regional, national, and international levels. 3. Positioning of the research group. 4. Involvement in governmental and private entities in addressing established problems. 5. Support and implementation of solutions in the social sector.
Strengths	**Threats**
1. Trained and educated human talent in areas of interest. 2. Portfolio of technological developments implemented by the research group. 3. Well-trained research seedbed. 4. Infrastructure capacity. 5. Portfolio of capabilities in Research and Development (R&D) and innovation. 6. Research group categorized by the Ministry of Science and Technology (MinCiencias).	1. Low monetization of designed products. 2. Positioned competition among recognized research groups. 3. Positioning of the academic program in mechatronic engineering in the country. 4. Obsolescence of designed products and prototypes.

Table 2. Comparative Table of Research Production in Various Universities at the National Level (Colombia).

Entity	*Financial Capacity*	*Prototyping Laboratory*	*Top-Tier Research Groups*	*Research Seedlings*	*National Alliances*	*International Alliances*	*Knowledge Generation Capacity*	*Knowledge Transfer Capacity*	*Result*	*Position*
Universidad Simón Bolívar	3	4	2	2	4	2	4	3	24	2
Universidad del Norte	4	4	2	2	4	4	4	3	27	1
Universidad de la Costa	3	2	2	3	2	3	4	2	21	3
Universidad Autónoma del Caribe	1	2	2	2	2	2	4	2	17	4

For the rating scale, the following were used: Major Weakness = 1; Minor Weakness = 2; Minor Strength = 3; Major Strength = 4.

This target audience is intriguing due to its growth potential, as an increasing number of companies or organizations receive constant support from the national government for entrepreneurship and competitiveness, making it an attractive and viable market. The Unit Department for the Administration and Execution of Technological and Innovation Projects: A Case Applied to Mechatronic Projects should leverage this support to establish itself and position itself in the market for its excellence and capacity in developing various projects that benefit many economic and social sectors of the country. These projects have the potential to transform into highly equipped laboratories with the best emerging technologies.

As a next step, and with a focus on the design of the Unit Department for the Administration and Execution of Technological and Innovation Projects: A Case Applied to Mechatronic Projects, the scientific production of the Mechatronic Engineering Research Group (GIIM) at Universidad Autónoma del Caribe over the last 3 years, 2021, 2022, and 2023, is analyzed and highlighted. In summary, the following achievements are emphasized:

- A total of 120 software registrations to date. Registered and endorsed by the National Directorate of Copyright (DNDA) of the Ministry of the Interior of Colombia.

- A total of 32 research projects endorsed by the Directorate of Research and Transfer (DIT) of Universidad Autónoma del Caribe.
- The design of 60 prototypes, endorsed and filed in the researchers' CvLac, as an integral part of the product or machine design phase. CvLac is an application where the resumes of individuals participating in science, technology, and innovation activities are recorded.
- The protection of 15 trade secrets between the Mechatronic Engineering Research Group (GIIM) at Universidad Autónoma del Caribe and companies in the sector.
- The establishment of Research, Development, and Innovation (R&D&I) units in productive companies in the energy and automation sector.
- The generation of new knowledge through significant contributions to the state of the art in a knowledge area, which have been discussed and validated for incorporation into scientific discussion, research activities, and technological development, and can be a source of innovation.
- The publication of scientific articles in indexed journals.
- Training in human talent at the undergraduate and postgraduate levels.

It is important to highlight that in Colombia, there has been an increased interest in technology transfer, particularly in the generation of business units, administrative units, or spin-off companies that promote technological developments, innovation, entrepreneurship, and competitiveness. The GIIM Group at Universidad Autónoma del Caribe recognizes laws such as Law 29 of 1990 [5], Law 1014 of 2006 [6], and Law 1286 of 2009 [7], among others.

Acknowledging Law 29 of 1990, which promotes scientific research and technological development and obliges the state to incorporate science and technology into strategic and development plans, conditions have been created for generating scientific and technological knowledge, stimulating innovation in the productive sector, guiding the selective import of technology, strengthening support services for research and development, and organizing a scientific information system. Therefore, it is necessary to formalize a unit for the development of such products at the mechatronic engineering level.

Simultaneously, Law 1014 of 2006 establishes a general framework for promoting the culture of entrepreneurship and, consequently, the promotion of entrepreneurship and training in the necessary competencies for this purpose. Law 1286 of 2009 strengthens the National System of Science, Technology, and Innovation (SNCTI), incorporating science, technology, and innovation as cross-cutting axes of the country's economic and social policy and transforming Colciencias into an administrative department to increase the country's investment in this area, aiming to achieve the socioeconomic results that leading countries in the field have attained. Finally, current projects seek to establish a framework for understanding and operation regarding entrepreneurship and technology transfer, especially regarding spin-offs, and enable certain aspects that are currently restricted by the law.

Similarly, there is the IDIC 2020, which corresponds to the Departmental Innovation Index for Colombia, adapting the methodology used by the Global Innovation Index (GII) to the national context. This index presents performances regarding the innovation capabilities and results of all departments in Colombia. Each score is associated with a position within the ranking (1 to 31) and a performance group: high, upper-middle, middle, lower-middle, and low. The aggregation of each of these constructions is calculated based on the simple average of each of the elements that compose it. In other words, within the index aggregation process, no differential weights are assigned [8].

Hence the proposal for the design of the Unit Department for the Administration and Execution of Technological and Innovation Projects: A Case Applied to Mechatronic

Projects, understanding that these are developed through high-level research and innovation. They stem from the fields of robotics and automation, vision and artificial intelligence, optimization of processes with nanotechnology and new energy sources, and bioengineering and biomedical engineering. This involves experience, adaptation, appropriation, and the creation of knowledge, contributing to the training of excellent professionals and researchers impacting both the academic and industrial sectors [9–13].

This is how the Unit Department for the Administration and Execution of Technological and Innovation Projects: A Case Applied to Mechatronic Projects is based and grounded, as shown in Figure 1, and enables the following:

1. A unit for technological readiness.
2. A unit for the commercial management of technologies developed by the GIIM.
3. A business unit for technological readiness.
4. It will enable the commercial management of developed technologies.
5. It will provide specialized services, consulting, and advice based on the conducted study.
6. A unit for continuous and specialized training.
7. A unit with applied research, technological development, and innovation that allows products with a TRL (technology readiness level) of 2 to 9.
8. A unit that enables and enhances new certified or validated products, industrial secrets, product, service, or process innovations, and licensing, among others.

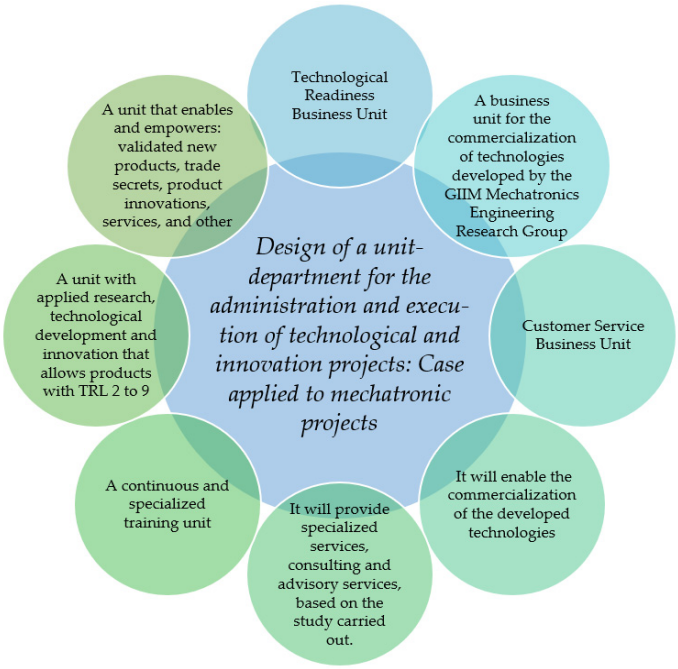

Figure 1. Rationale and Foundations of the Unit Department for the Administration and Execution of Technological and Innovation Projects.

The Unit Department for the Administration and Execution of Technological and Innovation Projects: A Case Applied to Mechatronic Projects will be encompassed within a comprehensive technological readiness model proposed at Universidad Autónoma del Caribe. This model aims to initiate projects of various kinds and application sectors, originating from different academic programs and their research groups, as depicted in Figure 2 [14–18].

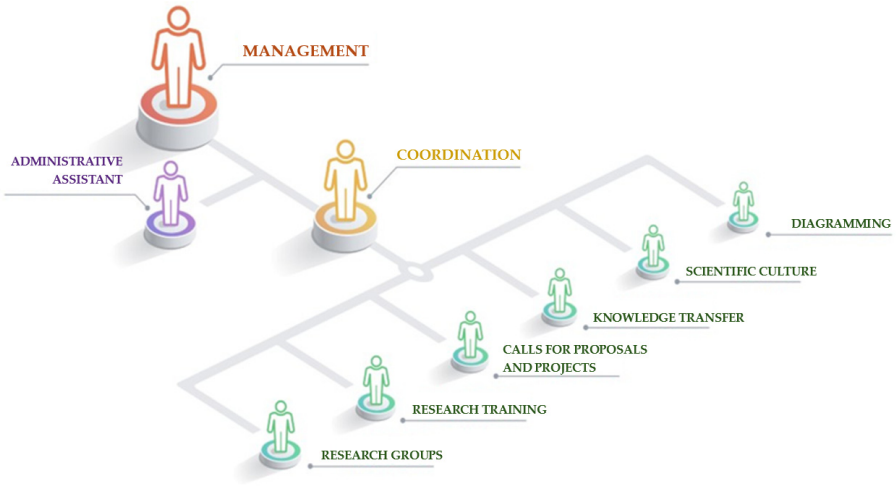

Figure 2. Model for the technological readiness proposed at Universidad Autónoma del Caribe.

From the model for technological readiness proposed at Universidad Autónoma del Caribe, the Unit for the Administration and Execution of Technological and Innovation Projects: A Case Applied to Mechatronic Projects will provide a space for reflection, updating, and meeting for executives, teachers, students, and researchers from different disciplines at the Universidad Autónoma del Caribe. Through analysis and experimentation, it allows the deepening of projects and applications in various sectors, enhancing current development in information and communication technologies, biotechnology, nanotechnology, and new materials, as these have significant implications for long-term economic transformation and the achievement of set goals [19–21].

Applied research projects are based on conventional methodologies such as the PMI standard, and in many cases, they use agile methodologies such as scrum, kanban, a blend of them (scrumban), and long tail, among others. These methodologies allow articulation in the projection, analysis, design, implementation, validation, and completion of technological development projects in mechatronic engineering [22–24].

The Unit Department for the Administration and Execution of Technological and Innovation Projects: A Case Applied to Mechatronic Projects comprises stages or phases as evidenced in Figure 3.

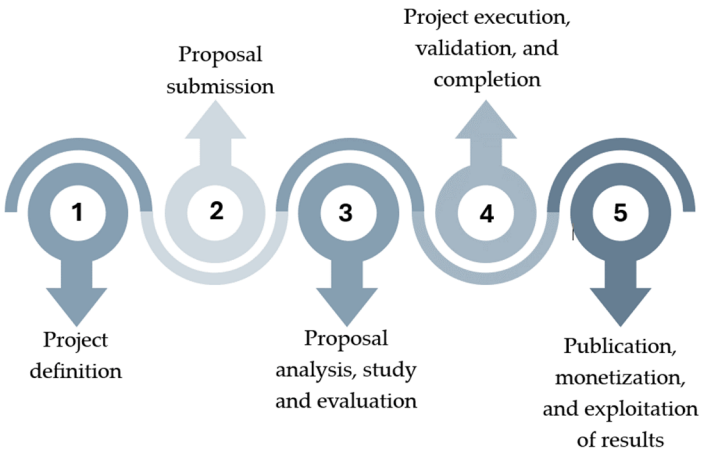

Figure 3. Model for the Unit Department for the Administration and Execution of Technological and Innovation Projects: A Case Applied to Mechatronic Projects.

Finally, the Unit Department for the Administration and Execution of Technological and Innovation Projects: A Case Applied to Mechatronic Projects at UAC will be operated with high standards, allowing it to be strongly positioned in various competitive business

environments. It will be a unit managed with high-profile and talented human resources, with a quality management approach for processes and designed products. This will validate entrepreneurship properly, accompanied by timely financial management, ensuring it is not confined to a single structure but complies with sector-specific regulations [25,26].

4. Conclusions

With the design and creation of the Unit Department for the Administration and Execution of Technological and Innovation Projects: A Case Applied to Mechatronic Projects at UAC, not only were the processes related to effective project management and evaluation organized, but also a structured approach to providing solutions to the context and related problems were presented. This enables continuous and improved support for the institution, positioning it at a higher level of competitiveness among other higher education organizations.

This unit achieves a balanced technological offer in the universe of R&D&I projects in mechatronics, considering scientific, economic, and social values. As a result, it will be possible to strengthen ties with the socioeconomic environment for the transfer of existing knowledge in higher education institutions (HEIs), its exploitation by interested parties, and the increased development of R&D&I projects, thereby enhancing capacities in the relationship between HEIs for the transfer of know-how to companies.

The above is directed towards a thorough design process within the academic sphere. For the purposes of this research, the focus is on the Universidad Autónoma del Caribe, which, according to technological development and innovation indicators, ranks among the top ten nationally (out of three hundred fifty-eight measured universities) in the DTI-Sapiens ranking. This ranking is published every two years since 2017 by the consulting firm Sapiens Research, recognized by the international IREG Observatory.

Most of the proposed actions and procedures for the Unit Department for the Administration and Execution of Technological and Innovation Projects: A Case Applied to Mechatronic Projects at UAC stem from studies carried out and projected from the field of business administration and the experiences of projects designed in the Research Group in Mechatronic Engineering (GIIM) at the Universidad Autónoma del Caribe. This proposes a strategic direction, which is responsible for managing the strategic, tactical, and operational aspects of the business unit through commercial planning and the application of corporate strategies. It aims to develop its potential, manage, and create business formats, business alternatives, competition analysis, and commercial strategies that allow the institution's knowledge and capabilities to be valued in companies and society.

Likewise, under the coordination of strategic, tactical, and operational aspects that enable the functioning of the research and transfer management process in compliance with the institution's objectives, monitoring and control will be carried out for the activities developed by the research groups. This will be in line with institutional guidelines and current legal regulations, managing the transfer of scientific and technological knowledge, dissemination, and administrative and financial management. It will provide support, monitoring, and administrative and financial control of the proposed or ongoing services of the business unit.

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