ARTIGO

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The Triple Helix in Aeronautics Command projects: analysis of the regulatory framework for ST&I

La Triple Hélice en proyectos del Comando de la Aeronáutica: análisis del marco normativo dirigido a CT&I

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Abstract: This research aims to analyze whether the regulation of the Air Force Command (COMAER) focused on science, technology, and innovation (ST&I) promote the effective participation of the Defense Industrial Base (DIB) in the development of technological projects of the Department of Aerospace Science and Technology (DAST). A bibliographical and documental review to identify the primary legislation outside and inside COMAER and semi-structured interviews with representatives of the Triple Helix were used as methodology. The results of the analysis of legislation showed the urgency of aligning and measuring goals and adjusting the definition of the term "project." This study found a poorly defined process to select the appropriate legal instrument for developing ST&I projects, affecting DIB participation criteria. The interviews highlighted points the scarcity of measurable goals in the legislation, multiple priority areas, lack of knowledge about technological contracting and cooperation instruments, and the difficulty of improving the governance of ST&I projects. COMAER regulations fail to promote the effective participation of DIB in the development of DAST technological projects.

Keywords: Legislations; BID; Aerospace technology; Innovation.

Resumen: El objetivo de esta investigación es analizar si la normativa del Comando Aeronáutico (COMAER) enfocada en Ciencia, Tecnología e Innovación (CT&I) promueve la participación efectiva de la Base Industrial de Defensa (BID) en el desarrollo de proyectos del Departamento de Ciencia. y Tecnología Aeroespacial (DCTA). La metodología consistió en una revisión bibliográfica y documental para identificar legislación externa e interna al COMAER, además de entrevistas semiestructuradas a representantes de la Triple Hélice (Gobierno, Industria y Academia). El análisis de las legislaciones reveló la necesidad de alinear y medir metas, y adecuar el término "proyecto". Se encontró que un proceso no está bien definido para seleccionar el instrumento legal para el desarrollo de proyectos de CT&I, afectando los criterios de participación de la BID. En las entrevistas, los puntos resaltados fueron la escasez de metas medibles, la existencia de múltiples áreas prioritarias, el desconocimiento sobre los instrumentos de contratación y cooperación tecnológica y la dificultad para mejorar la gobernanza de los proyectos. Se concluye que las normativas del COMAER son insuficientes para promover la efectiva participación de la BID en el desarrollo de proyectos tecnológicos del DCTA.

Palabras clave: Legislaciones; BID; Tecnología aeroespacial; Innovación.

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1 INTRODUCTION

The result of a military operation depends on the technological capabilities in the various domains involving battlefields, such as those for the aeronautics, space, and cybernetics (Brasil, 2020a). The very characteristics of these scenarios turn technologies into an inherent part of present and future military forces missions. A factor that deserves attention in technological development refers to the risk of international embargoes. It is unreasonable to simply acquire all military equipment abroad since international partnerships can be undone during conflicts of interest. Given this context, the Brazilian Air Force Command (COMAER) has been developing research and technology projects by its scientific, technological, and innovation institutions (STI)[1].

According to Etzkowitz (2008), the interaction between university, industry, and government is fundamental to grow innovation, and consequently, the economy. However, Leite (2022) observes that COMAER laboratories and institutes strategies have failed to appropriately promote interaction, partnership, and involvement of the private sector in offering technology to companies.

The Brazilian Federal Court of Accounts also disclosed that federal public incentives for ST&I have strategic planning flaws (Brasil, 2022a). Its audit indicated gaps in the governance structure, presenting the need to develop a long-term strategic framework for the use of public resources aimed at innovation.

Thus, seeking to establish a relationship between the entry of the Defense Industrial Base (DIB) in technological projects of interest to the Brazilian Air Force (FAB) and the COMAER regulations that address ST&I gave rise to the following research problem: how does COMAER legislation contemplate the participation of industry in the development of technological projects?

To answer this question, the general objective this study involved analyzing whether the COMAER standards aimed at ST&I promote the effective participation of DIB in the development of DAST technological projects.

This research can contribute to improving the interaction and cooperation between the elements of the Triple Helix (government, industry, and academia), requiring that ST&I COMAER standards constantly improve to promote greater participation of DIB in projects developed in DAST STI.

According to the Guideline of the Commander of the Air Force for the years 2023-2026 (Brasil, 2023a, p. 22, our translation), the "interdependence between the mission and ST&I" is fundamental, i.e., technological projects must be strategically aligned with the mission of the institution. "Aerospace Power is essentially a technological weapon" (Brasil, 2020a, p. 36, our translation).

In addition to this introduction, this study is structured as follows: Section 2 describes the methodology of this research; Section 3, the main themes that constitute the

1 COMAER has 13 STI distributed in its sectoral management bodies, the main ones being the Institute of Aeronautics and Space, the Institute of Advanced Studies, and the Aeronautics Institute of Technology.

theoretical framework—such as Etzkowitz's (2008) Triple Helix theories, highlighting the importance of the interaction between government, industry, and academia for technological innovation, and Mazzucato and Penna's (2016) Mission-Oriented Innovation Policy, which defends the importance of government strategies for technological innovation. Both theories advocate the participation of industry in ST&I projects. Section 4, the analysis of the legislation and the carried-out interviews; and finally, Section 5, the final considerations.

2 METHODOLOGY

Bibliographic and documentary research and field research by interviews with industry, government, and academia representatives were used in the methodology of this this applied qualitative research.

ST&I-related legislation external to COMAER was described, such as the National Strategy on Science, Technology and Innovation (ENCTI) and the National Innovation Strategy (ENI) from the Ministry of Science, Technology and Innovation (MCTI), the Ministry of Defense (MD) Ordinance no. 3.063, and the Strategic Conception between the MD and the MCTI. This description showed the goals related to the participation of DIB in ST&I projects, the effectiveness of public innovation policies, and their influence on COMAER legislation.

ST&I-related legislation internal to COMAER was also identified, such as the Air Force Command Plan (PCA 11-217), the Aeronautics Command Directive (DCA 400-6), the Aeronautical Command Manuals (DCA 17-1, 16-2 and 16-3), the Technological Order Manual (ETEC), and the Sectoral Standards (NSCA 80-1 and 80-2), which address the DIB participation in DAST technological projects. This raised the need to update the goals, taxonomy, contracting instruments, and criteria of the legislation.

The interviews with DIB, government, and academia representatives sought to investigate their perception of normative gaps that prevent greater participation of the industry in DAST projects. Representatives with direct involvement with ST&I and an institutional relationship with COMAER were chosen. Respondent selection considered a maximum of two representatives per institution and management, board, and/or leadership functions.

STI professors and researchers internal and external to COMAER were interviewed representing academia, aiming at greater representation of those who are involved in project execution, such as from the Aeronautics, Universidade Federal de Santa Maria, the Manufacturing and Technology Integrated Campus, and the Foundation Centers of Reference in Innovative Technologies. For the industry, a representative of an aerospace company (referred to as company A in this study to preserve the confidentiality of the information) was interviewed, as were representatives of the Brazilian Company of Industrial Research and Innovation and the Aerospace Industries Association of Brazil. Finally, MCTI, the Air Force General Staff (EMAER), and DAST representatives were interviewed to represent the government.

The interviews included semi-structured questions on the participation of DIB in DAST projects, as shown in Table 1.

Table 1. Semi-structured questions to respondents

	Questions
1	In general, how do you evaluate the MCTI National ST&I Strategy on the effectiveness of public innovation policies in the country?
2	Are these policies effective in promoting DIB participation in technological projects, specifically DTCA projects?
3	What are the main difficulties the industry faces to participate in DAST projects? Are these difficulties mainly normative in nature or are there other factors involved?
4	Do you believe that the COMAER ST&I standards are sufficiently clear and objective regarding industry participation in DAST projects? Are there points that could be improved in these standards to encourage greater participation of the industry?
5	Do you believe that the Ministry of Defense (MD) and COMAER have taken sufficient measures to encourage industry participation in DAST projects? What would be the possible actions the Ministry of Defense and COMAER could take to encourage DIB participation in DTCA technological projects?
6	How could the participation of industry in DAST projects be further encouraged by public policies and normative measures? What would be the possible solutions to overcome the identified regulatory gaps and promote greater participation of the industry in technological projects in the DTCA?
7	Is there any difference between the approach of COMAER standards the DIB participation in DTCA technological projects and the approaches of other government institutions? If so, what are these differences and what is their impact on the participation of the industry in technological projects?
8	What is the best phase of the Research and Development (R&D) process for the industry to enter a DAST ST&I project? Can industry participation from the outset bring additional benefits or is it more appropriate for industry to enter a project at later stages? What are the advantages and disadvantages of these approaches?

Source: elaborated by the author.

The content of the interviews was analyzed based on the four axes that stood out the most: legislation lacking measurable goals; multiple prioritized areas; lack of knowledge about newly created contracting and technological cooperation instruments; and improvement of the governance of technological projects.

It is important to highlight that this research focuses only on the participation of DIB in DAST STI technological projects, ignoring participation in projects of other Air Force Command sectoral steering bodies.

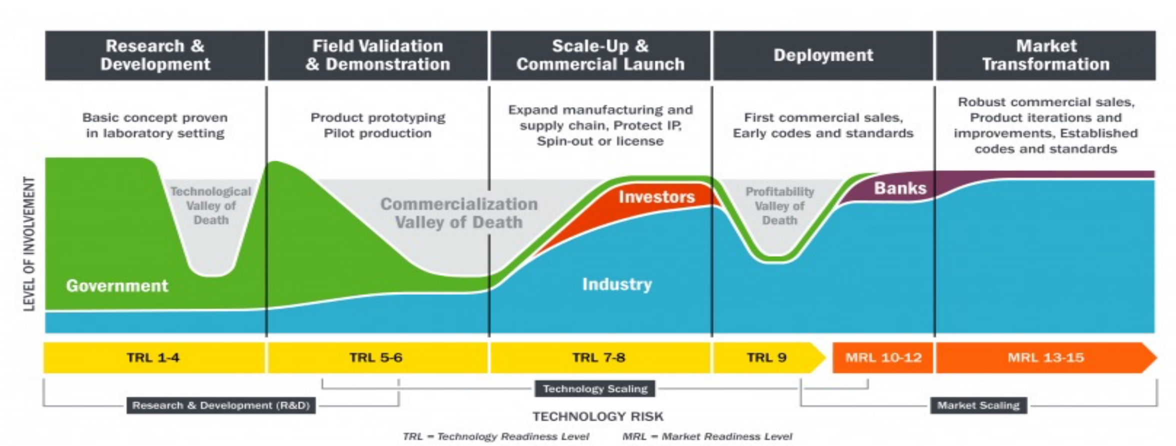
3 STATE, INDUSTRY, AND INNOVATIVE UNIVERSITY

According to Etzkowitz (2008), the competitive dynamics of the current market prohibit long intervals between technological development (expressed in patents) and their large-scale adoption by industry. When universities or STI make patents available, the technology is no often longer attractive to companies in the sector. Thus, it is essential to rethink the role of the university/STI capitalizing on knowledge, i.e., "when knowledge generates an economic added value" (Viale; Etzkowitz, 2010, p. 31).

Given this context, the so-called entrepreneurial universities play a fundamental role in the effectiveness of the Triple Helix since they promote technology transfer, incubate new companies, and lead regional renewal efforts (Etzkowitz, 2008). Stanford successfully exemplifies an entrepreneurial university, contributing to the emergence of companies such as Google, Cisco, among others (Viale; Etzkowitz, 2010).

These universities were able to face the challenge Etzkowitz (2008) emphasized in the broad innovation process: the gap between research, development, commercialization, and profitability, known as the "Valley of Death" (Figure 1).

Figure 1. The "Valley of Death": from Basic Research to commercialization



Source: Estados Unidos (2023).

Specifically, in the "Technological Valley of Death," with technology readiness levels 3-4 (TRL 3-4), the gap can be bridged by intense collaboration between business, government, and universities/STI.

Mazzucato (2013, p. 41) endorses Etzkowitz by asserting that "studies that showed a direct relationship between the market value of firms and their innovation performance as measured by R&D spending and patent success supported these policies". EMBRAER exemplifies a company that has invested in innovation, exploring the technological opportunities around it both by DAST institutes in São José dos Campos/SP and in partnership with universities and innovation institutes across the country (Leite, 2022).

Another national example that contributes to innovation, promoting connections between the various actors, is the São José dos Campos Technology Park in the state of São Paulo. It has a hub of innovation called Nexus, recognized in 2022 as one of the five best private business incubators in the world by UBI Global, a Sweden-based technological innovation intelligence organization (PQTEC, 2023).

In general, it is important that both industry and universities/STI rethink their interactions between the public and private sectors. It is essential that these sectors learn from each other, understanding the opportunities and limitations of each one to foster creativity and innovation (Mazzucato, 2013). Several connections are necessary, with industry being the key to production and the university being the key to knowledge.

3.1 The innovative State

Etzkowitz (2008) points out that the innovation policies governments implemented toward large-scale military projects obtained success. Thus, transformational public investments often resulted from "mission-oriented" policies that pursued lofty goals. Moreover, as Mazzucato (2013) points out, it is essential that governments exceed the role of mere project coordinators in the Triple Helix and reinforce their strategic importance in innovation policies, investing in bold initiatives that can boost the economy and society.

According to Mazzucato (2013), the Defense Advanced Research Projects Agency (DARPA) illustrates the strategic role of the U.S. government in promoting innovation. By investments in Research & Development (R&D), it has contributed to the development of technologies that have profoundly impacted society, such as the Internet, GPS, and stealth technology (Mazzucato; Penna, 2015). These technologies have been crucial to the global economy, driving the emergence of new businesses and services.

Table 2 shows that the FINEP, the Brazilian funding authority for studies and projects, has the largest number of collaborators and the second largest annual budget of all development agencies from other countries in the framework. However, countries with smaller ST&I budgets, such as Israel and the United Kingdom, spend more on domestic industry.

Table 2. Overview of Innovation Agencies

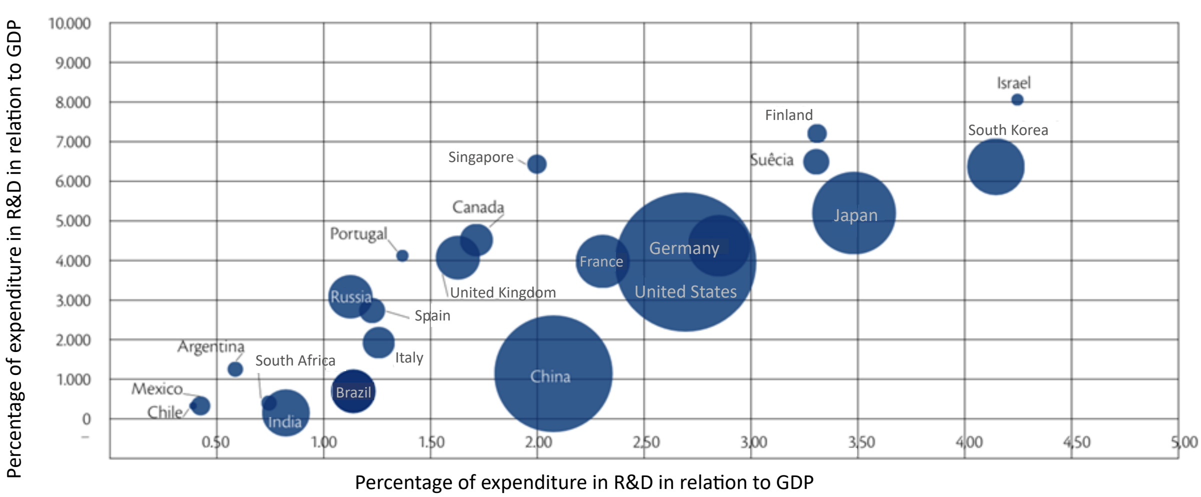
Agency, Country	Year of Creation	Number of Employees	Annual Budget	Industry Spending Budget
DARPA, EUA	1958	220	U$2.9 billion	Unavailable
FINEP, Brazil	1967	740	U$2.1 billion	37%
INNOVATE UK, United Kingdom	2007	300	U$ 870 million	84%

Agency, Country	Year of Creation	Number of Employees	Annual Budget	Industry Spending Budget
OCS, Israel	1974	100	U$ 450 million	95%
VINNOVA, Sweden	2001	205	U$ 355 million	30%

Source: Adapted from Glennie and Bound (2016, p. 14).

Although Table 2 shows that the country invests considerably in ST&I, an Organization for Economic Cooperation and Development survey shows that Brazil remains far from the most advanced countries regarding R&D spending and the involved human resources (Figure 2).

Figure 2. R&D expenditures and human resources



Source: Brasil (2016a, p. 64).

On the other hand, despite the few investments in relation to its gross domestic product, according to Mazzucato and Penna (2015), EMPRAPA and PETROBRAS represent success stories in Brazil that led innovation programs, focusing on achieving their missions. Such initiatives were implemented at a time when Brazil faced extremely severe budget constraints stemming from huge oil and food imports and required disruptive innovation to remove obstacles to long-term growth. In this context, public funding configured the main source of funds that drove these programs, enabling state-owned companies to become pioneers in their areas of operation and generating benefits for society as a whole.

In any case, according to Mazzucato and Penna (2015, p. 9), "Those regions and countries that have succeeded in achieving smart innovation-led growth have benefited from long-term visionary mission-oriented policies."

Additionally, it is important to highlight that innovative solutions may require new supply chains and business models, which no company can develop individually (Mazzucato; Penna, 2015), thus necessitating new alliances and investments to drive innovation and overcome challenges. Moreover, Mazzucato (2013) argues that innovation policies should be directed toward clear objectives, which can mobilize resources and skills from several actors and sectors by a collaborative and cooperative approach.

Therefore, as per Mazzucato and Penna (2015), the government should—rather than limiting itself to financing innovation—play an active role in guiding change. An example mentions the Brazilian space market, which has faced the lack of incentives in ST&I in recent years. This lack of strategic priorities in the space area has resulted in few effective advances for the sector in Brazil (Matos; Ferreira, 2020).

By contrast, DARPA, other innovation agencies, and U.S. universities have constituted a crucial component of the defense innovation system toward building R&D capability for projects with military applications (Squeff, 2014).

Mazzucato and Penna (2015) also ratify the importance of governments adopting an ambitious approach to ensure the success of innovation policies, requiring the establishment of clear priorities and directions and the adoption of a broad perspective that encompasses the entire innovation process.

Regarding the aerospace sector, according to Viale and Etzkowitz (2010), public intervention is essential to support the relationship between industry and academia. However, improving innovation in the Brazilian defense area requires a more centralized governance since the three branches of the armed forces still manage ST&I directly and independently (Squeff, 2014).

Considering the above, it is essential to review the legislation of the Air Force Command regarding the participation of DIB in DAST technological projects. As responsible for the largest technological center in Latin America, the institution faces the challenges inherent to ST&I, which involve contributing to the growth of the economy and playing a relevant role in ensuring the sovereignty of Brazilian airspace by aerospace technological products.

4 DESCRIPTION AND ANALYSIS OF RESULTS

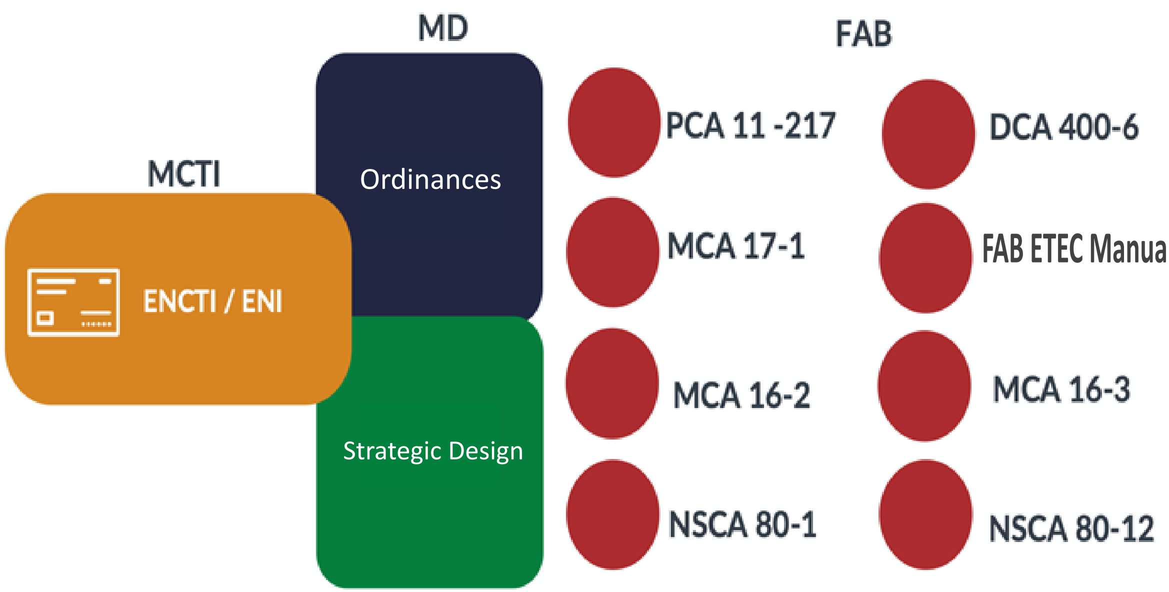
This topic analyzed and discussed the results of this research, categorizing them into two subtopics according to the objectives of the work: Analysis of the Legislation and Analysis of the Interviews.

4.1 Analysis of the Legislation

COMAER belongs to the National System of Science, Technology and Innovation and the National Innovation System, which has the Ministry of Science, Technology and Innovation (MCTI) as its central link. The Brazilian MD, via COMAER, is essential for the National System of Science, Technology and Innovation, considering the DAST STI and its infrastructure of laboratories and researchers.

Thus, some legislations, even if external to COMAER, may influence the participation of DIB in DAST technological projects. These legislations based the COMAER internal ST&I standards (Figure 2).

Figure 3. ST&I Legislation External and Internal to COMAER



Source: elaborated by the author.

The ENCTI version for 2016-2022 highlights its objective of promoting the capacity to use aerospace resources and techniques in solving national problems and of fostering research and product development (Brasil, 2016a). It establishes the objectives and the need to promote the participation of DIB in aerospace technological projects but offers no measurable goals.

Moreover, to replace the new ENCTI version for 2023-2030, MCTI Ordinance no. 6,998, of May 10, 2023 establishes the guidelines for preparing the new Strategy. The ordinance defined the structuring axis of Reindustrialization and Support for Innovation in Companies (Brasil, 2023b), which will possibly result in greater interactions between DIB and Air Force STI.

In addition to ENCTI, ENI, an instrument of the National Innovation System, contains thematic action plans and offers well-defined objectives, with indicators and metrics to be achieved. In the thematic axis of Development, for example, ENI determines Action #1004 of initiative F575, to create a Center to discuss and structure the creation of a ST&I Agency for Defense, increasing the development of projects of interest to Defense (Brasil, 2021a).

Thus, the MCTI legislation guides the actions of the MD related to ST&I. In 2003, the Strategic Conception between the Ministry of Health and the MCTI was launched: ST&I in the interest of national defense. And, in 2021, the agency issued, by ordinance MD no. 3,063, the specific objective of "prioritizing innovative projects that have the participation of technology-based industry in areas of interest to Defense" (Brasil, 2021b, p. 2, our translation).

Following its strategic alignment with the MD, COMAER reissued its ST&I Plan (PCA 11-217) in 2021, which aimed to "guide the actions to be developed by the ST&I area of the Air Force, presenting the priorities and strategies to be followed in the management of the aerospace sector" (Brasil, 2021c, p. 9). The plan signals, within the scope of the institution, other legislation that guides the participation of the industry in DAST technological projects.

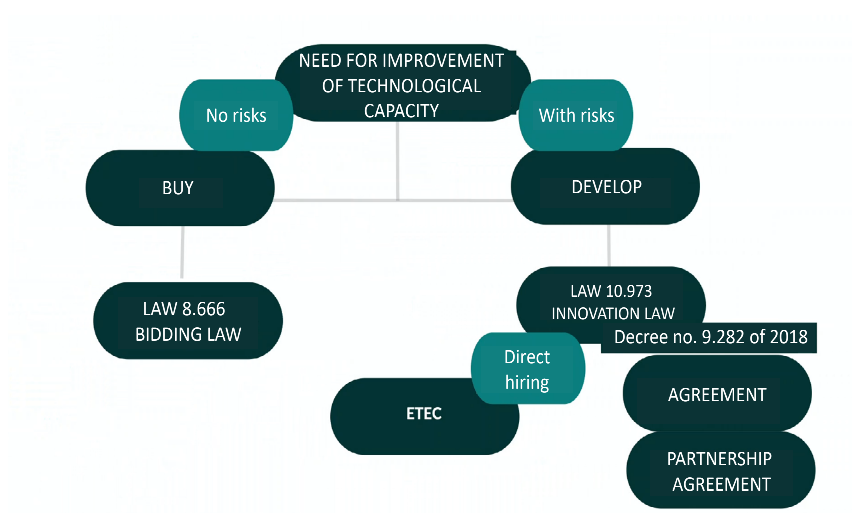
The PCA exhaustively highlights, with objectives but without goals, the importance of DIB participation in COMAER ST&I projects by guiding "the integration between the teams of educational institutions, R&D, and their industrial partners by the joint realization of technological development projects that include industry since the conception stage" (Brasil, 2021c, p. 26, our translation).

The Aeronautics Command Directive (DCA 400-6), which addresses the Life Cycle of Materials (Brasil, 2007) fails to specify whether the option to develop refers to Acquisition or ST&I Projects. On the other hand, the Aeronautical Command Manual (MCA 17-1), which aims to "elucidate processes and disseminate good Project Management practices" (Brasil, 2021d, p. 9, our transalation), mentions that in the Project Opening Phase referenced by DCA 400-6, one can choose to acquire or develop the product "in the case of development, preferably, the concept of Technological Order (ETEC)" (Brasil, 2021d, p. 20, our translation) will be used.

ETEC is one of the seven public procurement options for innovation according to the Innovation Law by selected characteristics (Brasil, 2022b). COMAER has an ETEC Manual that describes the process of performing the instrument (BRASIL, 2020b). However, the documentation fails to standardize the basic criteria for selecting candidate companies.

Regarding ST&I development, the Innovation Law facilitated DIB participation in technological projects by legal instruments, reducing bureaucracy in the macro-process of developing ST&I (Figure 4).

Figure 4. Develop innovation by purchase, Technology Partnership Agreement, or Agreement



Source: elaborated by the author.

However, the MCA 16-2 fails to contemplate the participation of the DIB in these projects. The legislation aims to "establish the rules for the prioritization process of Strategic Projects supervised by EMAER" (Brasil, 2018a, p. 9, our translation). It is important to emphasize that the Manual "establishes a methodology to prioritize existing projects with the purpose of making their score feasible according to pre-established criteria" (Brasil, 2018a, p. 15, our translation).

Grouped into the technical, financial, and conjunctural categories, they have the following criteria with the greatest weight: adherence to strategic design capabilities, support to institutional compliance, operational capacity, logistics shortage, financial risk, adherence to norms and standards, project urgency, waiting risk, opportunity risk, training and availability of human resources, compensation agreements (offset), and effectiveness.

In addition to ignoring criteria on DIB participation in ST&I projects, it fails to separate the criteria for acquisition projects from criteria for ST&I Projects. For example, a potential risk of embargo, a criterion absent in the legislation, is essential to analyze whether a project should be by acquisition or by ST&I.

Similarly, MCA 16-3 has no DIB-related parameters. The manual aims to "establish precepts to classify COMAER projects and their respective levels of responsibility for monitoring, according to their relevance and complexity" (Brasil, 2018b, p. 9, our translation).

As MCA 16-2, MCA 16-3 is aimed toward existing projects. Thus, the legislation classifies projects into categories to meet strategic objectives and into monitoring levels, which define the responsibility of EMAER and that of the sectoral management bodies. The Manual classifies, for example, space projects in category A and ST&I projects, in category C. The absence of a more appropriate taxonomy raises the question of whether a space project in ST&I should fall in category A (space) or in category C (ST&I).

The Aeronautical Innovation System Standard NSCA 80-1 ratifies the importance of DIB in technological projects (Brasil, 2018c). In the Standard, the Innovation Management Center, currently the Innovation Management Coordination (CGI), must support STI in their relationship with research support foundations and promote and monitor the relationship of STI with companies (Brasil, 2018c). The NSCA has objectives related to the participation of the DIB in technological projects but no measurable goals.

Similarly, i.e., without measurable goals, NSCA 80-12 aims to establish "the general procedures for formalizing partnerships between COMAER STI and public or private institutions for the execution of joint Research, Development, and Innovation (R, D&I) activities or projects" (Brasil, 2020c, p. 11, our translation).

Table 3 shows that a relevant factor refers to PCA 11-217 coming into force in 2021. The other analyzed FAB legislation precedes the PCA. Considering the "superior position" of the Plan over other legislation, this temporal discrepancy results in a desynchronization between the documentations.

Table 3. Summary of internal legislation to COMAER related to ST&I

Legislation	Purpose	Year	Goals	Taxonomy	Instrument	Criteria
PCA 11-217	ST&I strategy	2021	None	Adequate	Not mentioned	None
DCA 400-6	Life Cycle	2007	None	Inadequate	Not mentioned	None
MCA 17-1	Project Management	2021	None	Inadequate	ETEC only	None
MCA 16-2	Project Prioritization	2018	None	Inadequate	ETEC only	Inadequate
MCA 16-3	Project Classification	2018	None	Inadequate	Not mentioned	Inadequate
NSCA 80-1	Aeronautical Innovation System Standard Attributions	2018	None	Adequate	Not mentioned	None
NSCA 80-12	Procedures for Technological Partnerships	2020	None	Adequate	Partnership	None
Manual de ETEC	Procedures at ETEC	2020	None	Adequate	ETEC	None

Source: prepared by the author.

In general, the searched legislation has clear objectives but fails to specify goals, hindering the management of the obtained results. Another issue involves the used taxonomy. Most documents fail to differentiate between acquisition projects and ST&I projects, hindering the elaboration of parameters to select ST&I projects and the participation of DIB in such projects.

Acquisition Projects follow the Brazilian Bidding Law, requiring industry contracting. On the other hand, ST&I projects follow regulatory instruments under the Brazilian Innovation Law. The absence of a well-defined process in the FAB legislation (Figure 5) to select which instrument, such as ETEC, agreements, or partnership agreements, contributes to the lack of criteria for the participation of industry in DAST projects.

Figure 5. Connections between the deficiencies in COMAER ST&I legislation

Source: elaborated by the author.

Briefly, the described points show a connection. Outdated legislation based on PCA 11-217 causes desynchronized objectives, causing scarce goals and an inadequate taxonomy. This conceals the need for a well-defined process to select regulatory instruments and, consequently, the absence of criteria for the participation of DIB in DAST projects.

4.2 Analysis of the Interviews

Analyzing the content of the interviews found the four main factors that may lead to the reduction or absence of industry participation in COMAER ST&I projects, opposing the Mission-Oriented Innovation Policy and the Triple Helix theory. Table 4 shows these separately analyzed factor:

Table 4. Main factors for the reduced presence of DIB in ST&I projects

Item	Factor	Consequences for DIB participation	Interviewees' Suggestions
1	**Scarce legislation with measurable goals**.	Prioritization of basic research to the detriment of innovation.	DIB primarily participating in ST&I projects with TRL 3 or above.
2	**Multiple prioritized areas.**	DIB struggles to find and offer joint solutions	Creation of high-level, executive, and technical committees for each prioritized area.
3	**Lack of knowledge about the recently updated contracting and technological cooperation instruments.**	Lack of clear criteria for DIB participation in ST&I projects.	Creation of an independent agency for defense innovation and technology transfer
4	**Difficulty improving ST&I project governance.**	Ineffective coordination of the government with DIB and academia in ST&I projects.	Creation of an independent agency in the management of defense technological projects.

Source: prepared by the author.

4.2.1 Legislation without measurable targets

One of the main points interviewees describes refers to the general absence of measurable goals in the legislation, including the objectives related to the participation of DIB in technological projects.

Representatives of the Aerospace Industries Association of Brazil stated that ENCTI 2016-2022 failed to promote the implementation of the established objectives. The Universidade Federal de Santa Maria academia representative endorses this opinion by stating that the legislation required a lot of effort without a noticeable return in innovation to society.

In turn, the MCTI government representative explained that differences between government and state policies (lack of continuity in the established objectives) influenced the ENCTI, resulting in poorly effective participation of industry in ST&I projects. Within the COMAER scope, the EMAER government representative commented that the legislation is unspecific regarding technological development during the "Valley of Death," which impacts the participation of industry in projects.

The academia representative from ITA mentioned that ENCTI prioritized science and technology to the detriment of innovation. Although the research at DAST is recognized for its quality, most of it is yet to be converted into technological products (innovation). To explain this aspect, it is important to emphasize that, according to Guimarães (2002), CAPES and CNPq generally prioritize basic research scholarships (TRL 1 and 2).

A contributing factor to this situation, as per the representative of Company A, refers to the lack of goals established in the ST&I strategies for DIB participation in projects, in coordination with the strategies of the Ministry of Education and Culture, the Ministry of Development, Industry, Trade and Services and the MD. At the same time, the MCTI FINEP has the responsibility of financing technological projects. However, the lack of clear metrics and criteria in legislation makes it difficult to select projects, resulting in an appreciation of basic research. This lack of clarity is evident, for example, in the classification of a project as TRL 3, which makes it difficult to determine whether it is considered basic or advanced. This offers the possibility of financing from several funding sources (CAPES, CNPq, and FINEP), which, in turn, makes it difficult for DIB to participate in these types of projects.

The MCTI, Foundation Centers of Reference in Innovative Technologies, EMAER, and CIMATEC interviewees suggest prioritizing the participation of industry in ST&I projects from TRL 3 onward. The Company A representative suggests following the positive example of the Brazil-Sweden Cooperation Agreement in Aeronautics in ST&I, specifically by the Air Domain Studies group, in which academia and industry jointly suggest all new project proposals to EMAER. After the internal processing and approval, financial resources are sought from the development agencies.

However, the EMAER representative highlighted a certain immaturity in the criteria and stages of cooperation between academia, industry, and government in the COMAER legislation related to ST&I projects, making it difficult to select and strategically align this type of project and necessitating the establishment of clear guidelines and well-defined processes.

4.2.2 Multiple Prioritized Areas

Interviews highlighted the distribution of government-funded resources, covering multiple priority areas at ENCTI. This made it difficult for DIB to identify priorities and to thus plan in the field of ST&I.

A SENAI CIMATEC representative mentioned that the legislation failed to focus on the priorities Brazil need and highlighted the importance of "technological supremacy" in certain ST&I areas, rather than just "technological sovereignty." The term "technological supremacy" suggests the search for complete technological independence in the selected areas, considering the risks of embargo in specific international contexts.

The Universidade Federal de Santa Maria interviewee argued that ENCTI offered no adequate mechanisms to map and diagnose the existing problems in innovation. This lack of diagnosis has made it difficult to identify and effectively address the gaps and challenges that must be overcome.

The Brazilian Company of Industrial Research and Innovation representative also noted that not all areas identified as strategic received adequate support. She stressed the importance of a clear policy that guides companies on which directions to take. Only 2.9% of the DAST patents had the participation of DIB (Leite, 2022). Another important aspect refers to time mismatch, i.e., when the technologies become patents, their capacity is no longer interesting not only for the market but also for the operational application at FAB.

To minimize the impact of the wide distribution of priority areas, the Association of Aerospace Industries of Brazil representative suggested the participation of DIB in decision-making processes. The creation of committees with representatives of the Triple Helix for each priority area should provide government coordination in innovation management. An example is the management at Air Domain Studies, which only prioritizes projects in unmanned aircraft, the administration of which stems from committees at three levels (high-level, executive, and technical), enabling greater interactions between Triple Helix actors.

4.2.3 Procurement and technological cooperation instruments

The third aspect the interviews identified concerns the instruments for contracting and cooperation in ST&I that have been recently updated by the Brazilian government. Various possibilities the Innovation Law and the new Bidding Law offer require legal and administrative knowledge for DIB to participate in ST&I projects.

Thus, the Foundation Centers of Reference in Innovative Technologies representative commented on the lack of knowledge of the administrative instruments in ST&I provided for in the innovation and bidding laws, such as ETEC, competitive dialogue, agreement, partnership, among others. This makes it difficult to determine criteria for DIB participation in ST&I projects, hindering technological innovation, since academia remains trapped in a vicious cycle in which it works alone and faces delays and long development periods.

The EMAER representative commented that DIB resents a greater participation in DAST projects and ratified the need to update the institution ST&I legislation toward greater interaction with the industry.

The MCTI representative suggested the creation of an office in defense to promote and regulate innovation by transparent criteria and ensure legal certainty for both DIB and government decision-makers. This office should also seek resources external to the MD and prospect innovation by marketing and advertising strategies, following an approach similar to that adopted by independent North American law firms Small Business Innovation Research and Small Business Technology Transfer.

Within the COMAER scope, the DAST creating the CGI in 2017 featured as an office to promote innovation. Initially, CGI focused its efforts on technology transfer by patents. However, according to the CGI representative, to increase DIB participation in ST&I projects at DAST, the controllership has sought to interact with industry, seeking to establish partnerships not only for ongoing projects but also for new ones. Initiatives with technology parks, such as São José dos Campos, among other initiatives with the DIB, were discussed.

4.2.4 Governance of technological projects

The interviews highlighted the difficulty of improving the governance of government-funded ST&I projects, especially in defense. In this context, the absence of an advanced agency in ST&I project management was mentioned.

The SENAI CIMATEC representative, among others, stressed the need for an innovation structure different from the current one, suggesting the creation of an agency along the lines of DARPA, known for its efficient and independent performance in the management of ST&I projects in defense and benefiting civilian applications. This proposal aims to promote technological independence of Brazil in specific areas of national security.

At COMAER, the CGI representative suggested adjustments in the organizational structure to improve interactions between the activities of the DAST Project Management Office and CGI. This approach will enable CGI to track the performance of ST&I projects in development, enabling the search for solutions and improvements by interactions with industry and funding agencies.

Thus, the factors the interviews described—which generally led to the absence of objectivity in the promotion of industry in DAST ST&I projects—agree with the Mission-Oriented Innovation Policy theory, when they evinced the need for more well-defined missions.

Respondents' answers also highlighted the importance of a strategic governance approach with effective collaboration following the Triple Helix theory, which, by the adjustments indicated in the survey, tend to boost technological innovation.

5 CONCLUSION

This study aimed to analyze whether the COMAER ST&I standards promote the effective participation of DIB in the development of DAST technological projects. This research described the external and internal COMAER ST&I-related legislation and that which addresses the participation of DIB in technological projects. In addition to documentary analysis, this study investigated the perception of representatives of DIB, the government, and academia on regulatory gaps that prevent greater participation of the industry in the ST&I projects developed at the DAST.

The results of this research pointed to the absence of measurable goals at ENCTI and in other ST&I legislation of MD and COMAER regarding the participation of DIB in technological projects.

Along with the absence of measurable goals, some COMAER legislation is outdated regarding the ST&I Plan (PCA 11-217), resulting in desynchronized objectives until the conclusion of this study. Moreover, the used terminology requires adjustments, especially regarding the concept and generic use of the term "project" in legislation. Generally, the word has been associated with procurement projects, which follow the regulations of the Brazilian Bidding Law. On the other hand, ST&I projects adopt the Brazilian Innovation Law. This conceptual lack of definition requires a better-defined process for selecting the appropriate legal ST&I instrument, which directly influences the criteria for the participation of DIB in technological projects.

Moreover, the analysis of the interviews with representatives of the Triple Helix showed the scarcity of legislation with measurable goals, multiple priority areas, the lack of knowledge about the contracting and technological cooperation instruments recently created by the government, and the difficulty of improving the governance of ST&I projects. These factors were the most relevant for the insufficient participation of DIB in ST&I projects.

The interviews offered suggestions for actions to mitigate this situation, especially prioritizing DIB participation in ST&I projects from technological readiness level 3 onward. Moreover, they proposed priority technology areas as in the Brazil-Sweden Agreement on Aeronautics, with the participation of industry, academia, and the government and by high-level, executive, and technical management committees. Participants also suggested establishing an independent defense technology transfer agency and another agency dedicated to managing advanced ST&I projects following the DARPA model.

Specifically, the DAST Innovation Management Coordination and the Project Management Office have been created in recent years. These initiatives have improved the corresponding activities and consequently increased DIB participation in ST&I projects.

In the light of the Triple Helix theory, greater interactions between government, industry, academia, and the Mission-Oriented Innovation Policy, in which the government must focus on specific objectives, requires an urgent review of institutional legislation. The factors the interviews mentioned and the data collected in this research show evince that the current COMAER regulations related to ST&I insufficiently foster greater participation of DIB in technological development projects in the evaluated military institution.

As a suggestion for future research, the potential of COMAER to obtain external funding by its infrastructure of laboratories and researchers in its STI is highlighted. The Electronic Manual for the Celebration of Partnership Instruments of COMAER, for example, can be a starting point for this analysis. Therefore, it is recommended that further research evaluates partnership mechanisms and identifies opportunities for collaboration between COMAER and other entities to enhance fundraising and boost research, development, and innovation in the area.

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