UTILITY MODEL, TECHNOLOGICAL MATURITY, AND DUAL USE IN THE BRAZILIAN DEFENSE INDUSTRIAL BASE: AN ANALYSIS OF PATENT BR 202014017157-1 IN LIGHT OF TRL

MODELO DE UTILIDADE, MATURIDADE TECNOLÓGICA E EMPREGO DUAL NA BASE INDUSTRIAL DE DEFESA BRASILEIRA: UMA ANÁLISE DA PATENTE BR 202014017157-1 À LUZ DO TRL

MODELO DE UTILIDAD, MADUREZ TECNOLÓGICA Y USO DUAL EN LA BASE INDUSTRIAL DE DEFENSA BRASILEÑA: UN ANÁLISIS DE LA PATENTE BR 202014017157-1 A LA LUZ DEL TRL

https://doi.org/10.56238/sevened2026.008-183

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ABSTRACT

This study analyzes intellectual property (PI) management in the Brazilian Defense Industrial Base (BID), focusing on the underutilization of the Utility Models (MU) compared to invention patents. The main objective is to characterize patent BR 202014017157-1, related to a gas-powered pistol modification, a component of a shooting simulator, from the perspective of technological maturity (TRL) and dual-use potential. Through a qualitative and documentary approach, the research demonstrates that the MU is the most suitable instrument for incremental innovations at intermediate readiness levels (TRL 4 to 6), positioning them close to practical application. The analyzed technology shows high strategic versatility, enabling cost reduction and increased safety in both military training and in civilian and recreational contexts. The analysis outlines three strategic scenarios for managing the asset: restrictive, focused on national autonomy and maximum protection of sensitive secrets; Partial Opening, aimed at achieving scale and licensing to civilian markets and selected international partners; and hybrid, which combines patent protection with trade secrets to allow selective technical cooperation. It is concluded that the full exploitation of this asset requires robust institutional governance to manage power asymmetries in negotiations and maximize technological spillovers. Strengthening the BID depends on integrating the MU into mission-oriented incrementalism, ensuring sovereignty and industrial competitiveness.

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Keywords: Utility Model. Technological Maturity. Defense Industrial Base. Dual-Use Technology. Incremental Innovation.

RESUMO

Este estudo analisa a gestão da propriedade intelectual (PI) na Base Industrial de Defesa (BID) brasileira, focando na subutilização do Modelo de Utilidade (MU) em comparação às patentes de invenção. O objetivo central é caracterizar a patente BR 202014017157-1, relativa a uma modificação de pistola acionada por gás, componente de um simulador de tiro, sob a ótica da maturidade tecnológica (TRL) e do potencial de emprego dual. Por meio de uma abordagem qualitativa e documental, a pesquisa demonstra que o MU é o instrumento mais adequado para inovações incrementais em níveis intermediários de prontidão (TRL 4 a 6), situando-se próximo da aplicação prática. A tecnologia analisada evidencia alta versatilidade estratégica, permitindo a redução de custos e o aumento da segurança tanto no adestramento militar quanto em contextos civis e recreativos. A análise delineia três cenários estratégicos para a gestão do ativo: (i) restritivo, focado na autonomia nacional e proteção máxima de segredos sensíveis; (ii) Abertura Parcial, voltado ao ganho de escala e licenciamento para mercados civis e parceiros internacionais; e (iii) híbrido, que combina proteção patentária e segredo industrial para cooperação técnica seletiva. Conclui-se que a plena exploração desse ativo exige uma governança institucional robusta para gerenciar assimetrias de poder em negociações e maximizar transbordamentos tecnológicos. O fortalecimento da BID depende da integração do MU ao incrementalismo orientado a missões, garantindo soberania e competitividade industrial.

Palavras-chave: Modelo de Utilidade. Maturidade Tecnológica. Base Industrial de Defesa. Tecnologia de Emprego Dual. Inovação Incremental.

RESUMEN

Este estudio analiza la gestión de la propiedad intelectual (PI) en la Base Industrial de Defensa (BID) brasileña, centrándose en la subutilización del Modelo de Utilidad (MU) en comparación con las patentes de invención. El objetivo central es caracterizar la patente BR 202014017157-1, relativa a una modificación de una pistola accionada por gas, componente de un simulador de tiro, desde la perspectiva de la madurez tecnológica (TRL) y del potencial de uso dual. A través de un enfoque cualitativo y documental, la investigación demuestra que el Modelo de Utilidad es el instrumento más adecuado para innovaciones incrementales en niveles intermedios de preparación (TRL 4 a 6), situándose cerca de la aplicación práctica. La tecnología analizada evidencia una alta versatilidad estratégica, permitiendo la reducción de costos y el aumento de la seguridad tanto en el entrenamiento militar como en contextos civiles y recreativos. El análisis plantea tres escenarios estratégicos para la gestión del activo: (i) restrictivo, enfocado en la autonomía nacional y la máxima protección de secretos sensibles; (ii) apertura parcial, orientada a lograr escala y licenciamiento para mercados civiles y socios internacionales; y (iii) híbrido, que combina protección patentaria y secreto industrial para cooperación técnica selectiva. Se concluye que la plena explotación de este activo requiere una gobernanza institucional robusta para gestionar las asimetrías de poder en las negociaciones y maximizar los derrames tecnológicos. El fortalecimiento de la BID depende de la integración del MU al incrementalismo orientado a misiones, garantizando soberanía y competitividad industrial.

Palabras clave: Modelo de Utilidad. Madurez Tecnológica. Base Industrial de Defensa. Tecnología de Uso Dual. Innovación Incremental.

1 INTRODUCTION

The Brazilian Defense Industrial Base (BID) has been consolidated as a strategic pillar for national sovereignty, especially after the regulatory framework of Law No. 12,598/2012.

This ecosystem is based on the search for technological autonomy and the ability to convert incremental innovations and dual-use technologies into assets of security and economic development (VERGUEIRO, 2023).

However, there is an asymmetry in the management of Intellectual Property (IP) in the sector: while invention patents dominate innovation agendas, the Utility Model (MU) institute remains underexplored (LIMA; GOMES, 2022). Yu (2009) highlights that property should serve the collective well-being and the development agenda, preventing excessive "constraints" from impeding subsequent innovation.

This movement does not occur in a legal vacuum, it was forged by the expansion of intellectual rights that transform inventions into goods of exclusive commercial use. According to Law No. 9,279/1996, the MU is the title dedicated to protecting functional improvements linked to the objects, that is, alteration in the three-dimensional configuration aimed at functional improvement, precisely aligning with the nature of many technological trajectories of the BID. Therefore, the utility model patent protects the object's adaptations with a focus on its functional performance, which contributes to an incremental technological learning dynamic.

Despite the relevance of incremental innovations, there is a gap in the national literature regarding the integration between the legal regime of MUs, the levels of technological *readiness (*TRL) and the concept of *dual-use technologies* within the context of defense (SOUZA; PINHEIRO, 2021).

According to Silva and Gomes (2021), this fragmentation makes it difficult for companies and regulatory bodies, such as the Ministry of Defense (MD) and the National Institute of Industrial Property (INPI), to make strategic decisions about which type of protection is most appropriate to the stage of maturity of a sensitive or critical technology. In this sense, a fundamental question stands out about the role that the utility model can play in stimulating technological and economic development in the country, both for the spillover of dual technology to the market, and in the assimilation of foreign technology to adapt it to the national context. Incremental cumulativeness can enclose an evolutionary strategy that may imply the emergence of more radical technological proposals, however, the limitation of the utility model patent being associated with functional improvement through the configuration of the object's form is highlighted.

Faced with this challenge, this article proposes the following research question: how is the MU BR 202014017157-1 patent characterized in terms of technological maturity and dual employment, and how does this asset fit into the IDB's strengthening strategy? And also, to elucidate IP strategies that can contribute to foster technological development strategies in reinforcement of Brazilian sovereignty.

The general objective of this study is to analyze the patent as an instrument of incremental and dual innovation, correlating its technical specificities to the Brazilian regulatory and institutional framework.

To this end, the research proposes to characterize the asset from the perspective of the TRL (NASA, 2013), identify its potential for civil-military application and discuss the viability of the MU as a tool for economic sustainability and national security.

This effort is justified by the pressing need to align the governance of sensitive knowledge with the demands of productivity and export control in force in the international scenario.

2 THEORETICAL FRAMEWORK

2.1 UTILITY MODEL AND INTELLECTUAL PROPERTY IN BRAZIL

The protection of intellectual property through the Utility Model (MU) patent is governed by Law No. 9,279/1996 (Industrial Property Law - LPI), which establishes:

"Article 9 - An object of practical use, or part thereof, susceptible to industrial application, which presents a new form or disposition, involving an inventive act, which results in functional improvement in its use or manufacture, is patentable as a utility model.

Article 10. The following are not considered inventions or utility models:

I - discoveries, scientific theories and mathematical methods;

II - purely abstract conceptions;

III – commercial, accounting, financial, educational, advertising, lottery and inspection schemes, plans, principles or methods;

IV – literary, architectural, artistic and scientific works or any aesthetic creation;

V - computer programs themselves;

VI - presentation of information;

VII – rules of the game;

VIII – operative or surgical techniques and methods, as well as therapeutic or diagnostic methods, for application in the human or animal body; and

IX – the whole or part of natural living beings and biological materials found in nature, or even isolated from it, including the genome or germplasm of any natural living being and natural biological processes."

In this sense, the purpose of the MU is to protect functional increments in the shape of the object, therefore, it requires a less rigorous requirement of inventiveness than the invention patent, due to its own incremental nature. In this sense, the analysis of obviousness seeks to assess the incremental inventive effort involved in the functional improvement of the form of the already existing object. Thus, these changes in the shape of the object to give it better performance in its functions cannot be obvious and evident to a technician in the area, being ideal for short technological cycles. Although the criterion of inventiveness is less rigorous, such increments in form must always be associated with a concrete technical effect, either in the performance or in the manufacturing process of the object (POLAR; KONETZ, 2025).

While the invention patent has stricter criteria regarding inventive step, being more robust and covering, as a rule, new technical solutions with a high degree of originality (WIPO, 2023), which makes it more complex to obtain when compared to MU. The choice for UM allows you to reduce costs and exam times, offering protection in line with crucial functional adjustments for the operability of equipment at BID. According to Boyle (2008), IP should avoid the "tragedy of the anti-commons", ensuring that technical protection does not stifle the public domain necessary for the progress of mind and industry (Boyle, 2008, p.179-204).

In Brazil, the term of validity of the MU is 15 years from the filing, lower than that of invention patents, which is 20 years. Such a difference reflects the incremental nature of the institute and its vocation for shorter technological cycles (ELOY et al., 2022).

From the perspective of innovation management, according to Eloy et al. (2023), the MU is particularly suitable for sectors in which competitive advantage depends on successive improvements in ergonomics, operational performance, reliability, or integration of components in already known systems, a recurring situation in defense products that undergo continuous processes of modernization and technological updating.

In terms of intellectual property strategy, MA (2023) and Jee (2024) collaborate that the choice of MU allows for a reduction in costs and examination times compared to an invention patent, in addition to offering protection more aligned with functional adjustments, which often would not reach the inventive level required for the invention category, but are crucial for the operability of equipment in the Defense Industrial Base (BID).

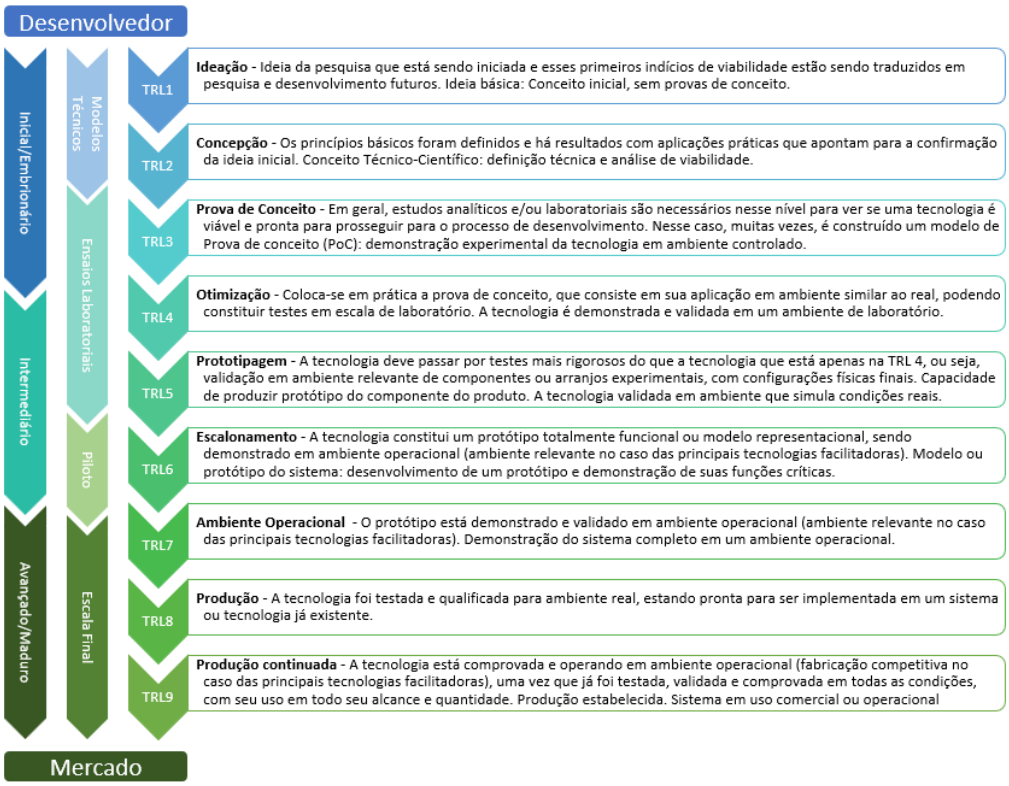
The utility model patent can contribute to a technological learning trajectory. This incremental route through the search for functional improvement, adaptations, can stimulate or favor the constitution of skill and technical competence, which are essential in issues involving technology transfer in the area of defense. In the case of the dual use of technology, this form of protection for incremental innovation creates a barrier to copying by competitors, stimulating the search for greater inventiveness, whose accumulation of knowledge can favor the emergence of more radical technologies.

2.2 TECHNOLOGY MATURITY LEVEL

The *Technology Readiness Level* (TRL) is a methodology developed by the National Aeronautics and Space Administration (NASA) to recognize and assess the maturity of technologies, ranging from basic research to operational implementation, with distinct levels that support innovation management decisions and the Research, Development and Innovation (RD&I) of complex systems (NASA, 2013). In the area of defense, the TRL guides strategies for intellectual protection and technology transfer according to the stage of development. Figure 1 presents the TRL levels and summarizes each stage.

Figure 1

TRL Scale



Source: INPI (2026).

It should be noted that basic research and conceptual formulation of a system occur in the initial TRLs, from 1 to 3. The intermediate levels, TRL 4 to 6, are intended for the validation of components and prototypes in a laboratory or relevant environment, while the upper levels, TRL 7 to 9, correspond to the demonstration and operation of the system in a real context, characterizing the products available for purchase or off-the-shelf (NASA, 2013).

According to Olechowski et al. (2020), this methodology was progressively absorbed by the United States Department of Defense (DoD) and other government organizations, which began to use it as a tool for technological risk management, RD&I resource allocation, and decision-making in military capability acquisition processes.

In the field of innovation, the TRL has been adopted as a cross-cutting indicator of technology readiness for different sectors, allowing comparability between projects and alignment between public and private actors in R&D portfolios (NASA, 2013).

In the area of defense, GAO (2020) corroborates that the application of TRL is articulated with the need to ensure that critical technologies reach adequate levels of maturity before their integration into weapons systems or sensitive infrastructures, mitigating performance and operational safety risks. In addition, the TRL guides intellectual protection and technology transfer strategies, according to the stage of development reached.

2.3 DEFENSE INDUSTRIAL BASE (BID) AND ECONOMIC OUTLOOK

The Brazilian BID operated even before the regulatory framework that was formally structured by Law No. 12,598/2012 (Law to promote the BID), historically contributing to national development. In this sense, the promotion and favoring of the industrial ecosystem are pillars that are articulated to promote the national defense industry in the institution of mechanisms for its strengthening, defining strategic companies, special contracting conditions and incentives for RD&I and the development of defense products (BRASIL, 2012).

Recently, Brazil made progress on this topic with the National Policy on the Defense Industrial Base (PNBID), through Decree 11,169/2022, which aims to ensure technological and productive autonomy for the Armed Forces, reducing external dependence and strengthening national sovereignty, which favored the emergence and development of new national companies for the defense sector.

Recently, the Defense Technological, Industrial and Commercial Compensation Policy (PComTIC Defesa), instituted by Ordinance GM-Ministry of Defense (MD) No. 3,990/2023, established an agreed mechanism in government procurement, especially in the defense sector, where the foreign supplier assumes counterparts (investments, technology transfer,

training) to maximize local benefits. In this way, the policy favors the transfer of critical technologies in strategic defense sectors, in favor of strengthening the national industry.

This normative framework resulted in direct benefits for the Brazilian BID, Pacheco and Perdone (2017) list such aspects as tax and fiscal advantages, differentials in bids and contracts, access to financing and R&D activities, in addition to the strengthening of the production chain. Thus, Brazil has been fostering the development of the defense sector and creating an ecosystem favorable to innovation, technological autonomy and the sustainability of the BID.

At the institutional level, the BID encompasses public and private companies, research centers, and military organizations, articulated in production chains that extend from materials and components to complex systems, including segments such as the aeronautics, naval, cybernetic, and remote sensing sectors (BRASIL, 2026).

This legal framework also establishes guidelines to privilege national technological content, encourage partnerships with universities and guide policies of technological compensation agreement (offset), with a view to consolidating technological autonomy and reducing external dependencies in sensitive areas. (PEIXOTO et al., 2025).

Based on open source indicators, we can see that the 2020-2025 panorama of the sector presented:

- Acceleration in investments (2025): the government announced R$ 112.9 billion for the sector by 2026, aiming for 55% mastery in essential technologies (radars, satellites) (BRASIL, 2025).
- Strategic Projects (2025): R$ 2.5 billion were reserved for the Gripen nuclear submarine and fighters (BRASIL, 2025).
- Industry growth: the sector registered a growth of 114% compared to 2023, with exports of US$ 1.31 billion in the first half of 2025 (BRASIL, 2025).
- Total Budget of the Ministry of Finance (2025): authorized at R$ 133.65 billion, with a concentration on mandatory expenditures (BRASIL, 2025).

These figures reinforce Okediji's (2003) argument about the need to harmonize IP laws with the goals of commercial sustainability and long-term technical development (OKEDIJI, 2003, p. 89-98).

In this context, the study by Dias Junior (2025) shows that innovation occupies a central position in the IDB's strategy, not only in the development of new products, but also in incremental adaptations and improvements of processes and systems, in the integration of sensors, in the improvement of the logistics chain, and in cyberdefense, often through cumulative and dual-use technological trajectories.

2.4 DUAL EMPLOYMENT TECHNOLOGIES

Dual-use technologies refer to products, processes, or knowledge that can be applied in both the civilian and military spheres, often involving items that transit between the commercial and defense markets, such as sensors, advanced materials, encryption software, and communication platforms. (VERGUEIRO, 2023).

In this context, *dual-use* constitutes a structural component of contemporary defense innovation regimes, as the boundary between the civil and military domains becomes more porous, and sectors such as aerospace, Information and Communication Technologies (ICT) and biotechnology begin to operate according to hybrid logics of financing, regulation and technology transfer (KILIÇ; BEYAZ, 2025).

From the perspective of the IDB, Moura (2022) highlights that dual employment technologies acquire strategic relevance by enabling business models that combine relatively stable but restricted military demands with expanding civilian markets, allowing for gains in scale and economic sustainability of highly complex production chains, in addition to reducing the government's dependence on resources. Companies in the defense industrial base depend on the regularity of resources, which, in times of crisis, become scarce, which can compromise the performance of these companies, contributing to the scenario of acquisitions and mergers by foreign companies.

It should be noted, however, that the controlled dissemination of dual-use knowledge requires refined strategies for the protection of intellectual property and the sharing of *know-how*, which may include patents, industrial secrets, conditional licenses, and contractual mechanisms for technology transfer, in order to balance the interests of security, competitiveness, and international cooperation (KILIÇ; BEYAZ, 2025).

In the field of patents and dual-use technologies, Acosta et al. (2018) found, based on empirical studies involving large defense companies, that a significant portion of their applications are composed of mixed technologies, classified simultaneously in civil and military codes. This fact confirms the centrality of *dual-use* as a standard of innovation in the sector.

By classifying patents into military, civilian, and mixed based on the International Patent Classification (IPC), these authors also demonstrate that companies with combined revenues in civil and military markets tend to generate more dual-use technologies, reinforcing the importance of intellectual property arrangements capable of capturing value at this intersection. In this case, utility models can be strategically employed in defense supply chains.

Caviggioli et al. (2020) and Acosta et al. (2020) analyzed civil-military patents and suggest that knowledge flows between military and civilian technologies obey asymmetric dynamics. In these dynamics, defense-oriented developments may in some cases radiate to civilian applications, but are also increasingly influenced by capabilities installed in technologically advanced commercial sectors.

Additionally, Sezal (2020) expanded this analysis by examining patents classified as civil, military, and mixed, demonstrating that *mixed patents* occupy a strategic position in knowledge flows. This finding presents a strong parallelism with the potential role of patent BR 202014017157-1 as a dual-use asset, situated on the border between defense operational demands and related civilian markets.

With regard to the identification of *dual-use* inventions, methodological approaches based on patent citation networks have been developed to detect which military innovations generate the greatest probability of spillover to civilian uses, highlighting the weight of characteristics such as technological breadth, geographic reach, and intensity of citations received (CAVIGGIOLI et al., 2023; EUROPEAN COMMISSION - JRC, 2019).

These studies indicate that the incidence of dual uses tends to be heterogeneous between technologies and countries, and that the first civilian applications of military inventions usually occur within national borders themselves. Evidence suggests that patents such as MU BR 202014017157-1 can induce and act as anchors for primarily domestic diffusion trajectories, anticipating eventual international expansions when associated with BID (CAVIGGIOLI et al., 2023; ACOSTA et al., 2018).

Vella (2025), when analyzing the articulation between dual-use research and TRL levels, in recent analyses by the European Union, argues that the framing of R&D projects in scales of technological maturity can facilitate the identification of windows of opportunity for civil-military cooperation, as well as the design of development instruments adjusted to the level of technological risk at each stage.

Another aspect highlighted by this author is the proposition of an integrated reading of innovation, security and industrial competitiveness policies. Vella points out that dual-use technologies located at intermediate levels of TRL are particularly sensitive, as they simultaneously require public support for demonstration in relevant environments and mechanisms to control diffusion. In this context, an MU like this BR 202014017157-1 is inserted in a paradigmatic way. According to Moura (2022), continuous investment in MU acquires strategic relevance by enabling business models that combine stable military demands with expanding civilian markets.

Mamoshina et al. (2022), when analyzing the field of governance and ethical risks associated with the diffusion of *dual-use* technologies, discuss how advances in areas such as biotechnology, AI, and data analytics can generate significant negative externalities if they are not accompanied by robust governance frameworks, including regulation, sectoral self-regulation, and responsible intellectual property instruments.

Although the focus of these authors falls on frontier technological fields, the reflection is applicable to the Brazilian BID and to patents such as BR 202014017157-1. To the extent that its dual-use exploitation must be conceived not only in terms of economic efficiency and technological autonomy, but also in light of the risks of unwanted proliferation and deviant uses of the technology.

In the specifically Brazilian context, Vergueiro (2023) points out that the development of dual-use technologies by the BID can act as a mechanism for economic and scientific development, as long as it is supported by consistent development policies, government procurement, and coordination between public and private actors.

By analyzing the national experience, this author highlights that the articulation between the defense industry, academia and the State, the triple helix model, is capable of transforming dual-use projects into vectors of productive diversification and generation of qualified jobs, which reinforces the relevance of exploring, in a planned way, the dual potential of Utility Models such as BR 202014017157-1.

In a similar vein, Silva and Costa (2021) emphasize that innovation in the BID requires long-term strategies that articulate investments in R&D, institutional strengthening, and the design of governance mechanisms capable of aligning the interests of the Armed Forces, companies, and S&T institutions, with emphasis on the adoption of models such as the *triple helix* (university-business-government).

The development of such technologies by the BID acts as a mechanism for economic and scientific development. The articulation between the triple helix of innovation is capable of transforming projects started in 2023 into vectors for generating qualified jobs.

When transposed to the analysis of patent BR 202014017157-1, these findings suggest that its full exploitation, whether in a restricted, partially open, or hybrid scenario, will depend on the ability to insert the MU in collaborative innovation networks that maximize learning, expand the base of dual-use applications, and consolidate cumulative technological trajectories in the field of defense (SILVA; COSTA, 2021).

3 METHODOLOGY

The research adopts a qualitative approach, of an exploratory nature, structured as a single case study, centered on the analysis of the patent of MU BR 202014017157-1, entitled Modification of a gas-fired pistol for use in shooting simulators, examined in the context of the Brazilian BID.

The choice of the case study is justified because it allows the in-depth investigation of a specific empirical object, enabling the understanding of the mechanisms of innovation, intellectual property protection and potential dynamics of dual use associated with technological development in the defense sector.

This methodological strategy is particularly suitable for exploring phenomena that are still poorly systematized in the national literature, contributing to the generation of *analytical insights* on the interaction between technology, market and public policies within the scope of the BID.

From the point of view of technical procedures, the research is characterized as documentary research, based on the systematic analysis of primary and secondary sources. The descriptive report, claims and drawings of the MU BR 202014017157-1 patent, as made available in public databases of the Brazilian Patent and Trademark Office (BPTO), as well as the relevant national legislation, in particular Law No. 9,279/1996 (Industrial Property Law) and Law No. 12,598/2012, which provides for special rules for purchases, contracting and development of defense products and systems.

In addition, a review of the national and international scientific literature, published from 2018 to 2025, was carried out, addressing topics such as Technology *Readiness Levels (TRL), MU patents and dual-use technologies*, with the aim of contextualizing the case study and supporting the theoretical-conceptual analysis.

The analysis is developed in four main stages, namely:

- Functional analysis of the patent, with emphasis on the proposed technical solution, its operating principles and functional gains in relation to the state of the art;
- Identification of evidence of technological maturity, based on the analysis of descriptions related to tests, prototypes, applications and operational contexts eventually mentioned in the patent documentation;
- Classification of the level of technological readiness (TRL) of the protected technology, using as reference conceptual frameworks adopted by defense agencies, which define nine progressive levels of technological maturity, from the observation of basic principles to the validation of the system in an operational environment; e

- Evaluation of the potential for dual employment and the insertion of technology in the context of the BID, considering both military and civilian applications, as well as its implications for business models, technology transfer and productive sustainability.

It is recognized, as a limitation of the study, the exclusive use of information in the public domain, without access to sensitive operational data or confidential details of contracts, tests and certification processes. This restriction imposes interpretative caution both in the attribution of the TRL and in the inference of future trajectories of development, economic exploitation and institutional insertion of the patent.

4 PATENT ANALYSIS

4.1 IDENTIFICATION AND CONTEXTUALIZATION OF THE PATENT

The object of study is the patent of MU BR 202014017157-1, entitled modification of a gas-fired pistol for use in shooting simulators, deposited and made available in public databases of the BPTO.

The patent was filed with the aim of adapting gas-fired pistols for safe use in shooting simulators, while maintaining functional characteristics of the firing cycle and increasing compatibility with training platforms.

4.2 TECHNICAL CHARACTERIZATION OF THE SOLUTION

The utility model patent MU BR 202014017157-1 consists of a functional modification of the gas actuation mechanism of a pistol, without changing the basic principle of the weapon's operation.

The technical solution focuses on the reorganization of the internal elements of the drive and loading assembly, allowing:

- Faithful reproduction of the firing cycle in simulation environments;
- Integration with controlled training systems;
- Operational safety, avoiding the use of live ammunition; e
- Compatibility with civilian and military contexts (*dual-use*).

The analysis of the independent claim shows that the essential elements are the gas actuation assembly and its interaction with moving components, whose new arrangement allows clear functional gains compared to conventional guns, such as operational stability, safety and integration into simulators.

4.3 STATE OF THE ART AND FUNCTIONAL GAINS

It is an incremental innovation based on functional improvement, as can be seen in the comparison with the **state of the art** that shows:

Table 1

General data of the MU

Aspect	State of the art	Patent MU BR 202014017157-1
Operation	Conventional mechanical cycle	Simulated cycle, adapted for training
Simulator integration	Limited	Expanded compatibility with simulation platforms
Security	Restricted use	Reducing risks in a training environment
Functional gains	None specific to simulation	Stability, cycle fidelity, and security

Source: authors (2026).

The analysis shows incremental innovation typical of utility models, based on functional improvement and rearrangement of existing components (BARROS, 2025).

4.4 EVIDENCE OF TECHNOLOGY MATURITY (TRL)

Based on the public patent documentation, it is possible to infer approximate levels of TRL, considering descriptions of prototypes, tests, and potential applications (NASA, 2013):

Table 2

MU TRL

Evidence	Estimated TRL level	Justification
Theoretical description and change report	TRL 2–3	Observation of principles and detailed design of the utility model
Prototype indication and laboratory tests of gas drive	TRL 4	Benchtop prototype, verified operation under controlled conditions
Possibility of integration with simulators	TRL 5–6	Testing in a semi-realistic context, validation of compatibility with training platforms
Effective operational use in military/civilian training	TRL 7–8	Potentially achievable stage, but not publicly confirmed

Source: authors (2026).

According to Contreras (2025), the documentation indicates that the MU technology is between TRL 4 and 6, validating compatibility in semi-realistic environments.

4.5 DUAL EMPLOYMENT POTENTIAL AND INSERTION IN THE BID

The technology has potential for dual use (SOUZA; PINHEIRO, 2021), and can serve:

- military applications in troop training and instruction in safe fire simulators; e

- civilian applications through shooting instructors, simulation in training academies and safety laboratories.

For Peixoto et al. (2025), from the point of view of the BID, the patent contributes to:

- increasing national capacities in training equipment;
- integration with technological autonomy policies;
- enabling incremental innovation and sustainability of production chains;
- possibility of licensing or technology transfer, respecting dual-use and security standards.

Thus, the feasibility of continuous investment in MU is justified by the speed of territorial protection, protecting tactical functional improvements, which guarantee sovereignty before gaining industrial scale (SUTHERSANEN, 2019).

5 DUAL EMPLOYMENT AND INSERTION IN THE BID

The patent of MU BR 202014017157-1, relating to the modification of a gas-fired pistol for use in shooting simulators, has a high potential for dual use, as it can simultaneously meet civilian and military demands (VERGUEIRO, 2023; HÄHNEL, 2025).

From a military perspective, the technology enables the training of security forces and units of the Armed Forces, through training systems, which faithfully reproduce the firing cycle, without the use of live ammunition, increasing the safety and efficiency of training (FEDARAVIČIUS, 2020).

Military technologies also contribute to the reduction of operational costs, as they allow continuous simulation exercises and tests in controlled environments, which favors the promotion of greater familiarization of users with tactical and operational procedures (STEVENS et al., 2025).

On the other hand, the civilian application of the technology is present in professional and recreational training contexts, such as sports shooting academies, training of private security instructors, and simulation in virtual or augmented reality (TORRES, 2019).

The versatility of the MU patent is evidenced and contributes to the constitution of strategic resources capable of synergistically generating, in different markets, a positive environment for expanding the user base and ensuring economic scalability without compromising the security or original purpose of the technology (VERGUEIRO, 2023).

Thus, the MU patent technology becomes an instrument of incremental innovation, which has the ability to enhance the transfer of knowledge between sectors and reinforce the logic of dual use in the Brazilian context (VELLA, 2025).

With regard to insertion in the BID, the technology protected by the patent in question can be strategically articulated in different dimensions (BID BRAZIL EXHIBITION), such as:

- integration into development programs and national certification, allowing strengthening the productive capacity of public and private companies, qualifying them for differentiated tax regimes, specific bids and R&D activities;
- articulation with universities and technological research centers, enabling the continuous improvement of the device, encouraging innovation and the formation of specialized human capital; e
- The technology meets the objectives of technological autonomy by reducing dependence on external solutions and fostering national competencies in safe, dual-use defense products.

Finally, the development and dissemination of this protected technology can generate positive effects on the competitiveness of the production chain, allowing licensing, partnerships and eventual export of training solutions, simultaneously contributing to the strengthening of the BID and to the consolidation of a national ecosystem of technological innovation oriented to defense (BARROS, 2025). However, it should be noted, in the case of exporting this technology, that not every national jurisdiction recognizes protection by utility model. Therefore, one should seek export to markets that admit protection by utility model and, strategically, claim protection by the Patent Cooperation Treatment (PCT) to guarantee exclusivity in these markets. The PCT admits the strategy of multiple deposits, which lowers the initial deposit costs and also allows time to be gained to select the markets, which will actually be confirmed at the beginning of the national phase. It should be noted that the national phase incurs other costs, being an expensive strategy for exploring international markets, which must be evaluated sparingly.

6 DISCUSSION

The results obtained in the analyses of patents, TRL, dual employment and insertion in the BID are compared with the literature on the economics of intellectual property and dual-use studies.

Patents function prominently both as essential mechanisms for the appropriation of value and as fundamental vectors for the global dissemination of technical knowledge (OECD, 2025).

Historically, the patent regime has evolved from a strictly national logic, linked to nineteenth-century industrialization, to a global architecture regulated by instruments such as the TRIPS Agreement. This transition has intensified the flow of technical information and the

management of exclusive rights in sensitive sectors such as defence and security (OECD, 2025).

In this scenario, the patent of MU BR 202014017157-1 emerges as a strategic asset of the Brazilian BID, as its publication in open databases is part of the global technical collection, while its classification as MU offers specific territorial protection, distinguishing it from the industrial property regimes of countries that do not adopt this modality (SUTHERSANEN, 2019).

The convergence between the MU patent and the technological maturity levels shows that this type of protection is the most suitable for incremental innovations in intermediate maturity stages, usually between TRL levels 4 and 6 (CONTRERAS, 2025).

At this level, the strategic priority shifts from radical scientific discovery to the consolidation of functional improvements in components or subsystems. Such assets are essential for the integration of complex defense systems or to provide critical civilian applications, ensuring the necessary robustness before gaining industrial scale (NASA, 2013).

Unlike invention patents, which often aim to protect disruptive innovations in early stages of development, low TRL, the MU is located at points in the technological trajectory closer to practical application and the market (JEE; HÖTTE, 2024).

In the context of dual-employment technologies, this feature is crucial, as it facilitates licensing and controlled diffusion strategies, allowing the BID to exploit economic synergies between the civilian and military sectors, optimizing the return on investment in RD&I (NASA, 2013; OECD, 2025).

This finding reinforces the need to incorporate the MU as a central analytical category in studies on defense innovation policies. Although the topic is still little explored in the national literature, it is fundamental for countries that seek to consolidate technological capabilities through an incremental mission-oriented trajectory, in which the continuous improvement of components and processes ensures both sovereignty and industrial competitiveness (MAZZUCATO, 2018).

Considering the economics of intellectual property and the historical context of protection regimes, it is possible to outline three evolution scenarios for patent BR 202014017157-1, each with its strategic advantages and disadvantages (OECD, 2025).

Based on the economics of intellectual property and the history of protection regimes, it is possible to outline three evolution scenarios for patent BR 202014017157-1, each with strategic advantages and disadvantages, as summarized in Table 3 (OECD, 2025).

Table 3

Scenarios analysed

Scenario	Features	Strategic advantages	Disadvantages or risks
Patent Restriction	Exclusive use and limited licensing to BID companies in Brazil; Focus on Military Applications and Technology Control	Greater security of sensitive know-how, strengthening of national autonomy, and close alignment with defence policies	Less exploitation of civil markets, limited licensing revenues, risk of underutilization of innovative capacity, inefficient in open innovation environments
Partial Patent Opening	Expanded licensing for civilian markets and select international partners, promotion of collaborative R&D and new derivative patents	Increased licensing revenues, gain in productive scale; Accelerating the innovation cycle, strengthening the patent technology family	Risks of diffusion of sensitive knowledge, need for strict export controls, reliance on sophisticated contractual and regulatory frameworks
Hybrid Model	Combines patent protection with industrial secrecy and conditional technology transfer agreements, selective cooperation with companies and R&D institutions	Greater strategic flexibility, creation of innovation ecosystems, better alignment between security, competitiveness and technological diplomacy	Complexity of contractual governance, need for advanced institutional capacities, and risk of power asymmetry in international negotiations

Source: authors (2026).

These international and national results allow us to qualify the interpretation of the three scenarios of patent evolution. There is evidence that mixed and dual-use patents occupy a central position in the knowledge flows between the civil and military domains, in addition to reinforcing the adoption of a partial or hybrid openness scenario, which tends to generate a higher density of technological spillovers and derived patents, as long as it is accompanied by adequate governance and control regimes (ACOSTA et al., 2018; CAVIGGIOLI et al., 2023; VELLA, 2025).

At the same time, the comparative experience of technology transfers in defense shows that this openness is sensitive to asymmetries of power and institutional capacities. In the Brazilian context, this recommends prudence and a careful design of contracts and institutional arrangements in the choice between the three scenarios proposed for patent BR 202014017157-1 (SILVA; COSTA, 2021; SEZAL; GIUMELLI, 2022; VERGUEIRO, 2023).

7 CONCLUSIONS AND RECOMMENDATIONS

The analysis of patent BR 202014017157-1 confirms that the Utility Model (MU) is an underexplored instrument, but vital for strengthening the Defense Industrial Base (BID). It is concluded that the technology, located in intermediate levels of readiness (TRL 4 to 6), exemplifies mission-oriented incrementalism, where the focus is on the consolidation of functional improvements and immediate practical application. In this sense, it is pointed out

that the strategic use of intellectual property, in the contemporary context, should indicate that protection in the specific case should seek:

a. National Security Protection Patent – when the object is strategic for the Defense Sector (Art 75 of the IP Law).
b. Industrial Secret – when the tacicity of local knowledge is greater than the advantage of disclosure via patent.
c. MU patent – when for *dual-use* innovations, the goal is to achieve commercial scale.

Unlike invention patents, which protect disruptive technologies, that is, the protection of radical innovations, the MU aims to protect incremental innovations, whose applicability is directed to niche markets, whose overflow of *dual-use technologies* is accepted and generates returns. Thus, the BID modernization cycle with an incremental focus aims at the dissemination of dual use in the market and, in the case of protection by utility model, implies lower costs, reduced examination times and focus on the operability of equipment, therefore, functional improvement obtained by the shape of existing objects. In the present case study, the dual employment nature of the asset is evident, integrating demands for secure military training with civilian instruction and simulation markets, which ensures economic scalability and productive sustainability.

To maximize the impact of this asset and future innovations at BID, the following recommendations are proposed:

• Improvement of Institutional Governance: It is imperative to strengthen the capabilities of the Ministry of Defense. It is recommended to adopt regimes that monitor confidentiality and benefit-sharing clauses, especially in international cooperation models, to mitigate risks of power asymmetry.

• Adoption of Hybrid Management Models: Given the porosity between the civil and military domains, it is recommended to prioritize partial or hybrid opening scenarios. These models allow the generation of technological spillovers and *the creation of derived patent families, ensuring that knowledge circulates without compromising sensitive industrial secrets.*

• promotion of the Triple Helix: The MU should be inserted in collaborative networks involving university, company and government. This articulation is capable of transforming dual-use projects into vectors of productive diversification, reducing external dependence by privileging a trajectory of technological learning in the promotion of the generation of national skills in critical areas.

• alignment with Defense Policies: The strategic use of IP must be integrated with the National Policy of the Defense Industrial Base (PNBID) and PComTIC. The goal should be

to convert incremental innovations into assets that ensure technological autonomy and industrial competitiveness in the long term.

In short, the transition from a restrictive "war economy" logic to models of strategic collaboration is essential for Brazilian sovereignty. The planned management of the dual potential of the studied patent serves as a paradigm for the consolidation of a resilient national innovation ecosystem, thus, the success of BID requires that Brazil is not an exporter of raw materials, but captures value via IP to avoid the obsolescence of our technologies and military doctrine. In addition, the spillover of dual technology to the market for companies in the defense industrial base implies less dependence on government resources and, simultaneously, generates greater domestic economic dynamism.

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